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Evaluation of drought tolerant genotypes in bread wheat using yield based screening techniques

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ABSTRACT

In order to evaluate drought tolerance in bread wheat genotypes, a factorial experiment based on completely randomized block design with three replications under two water stress and irrigated conditions was used. The experiment was carried out in the greenhouse of Campus of Agriculture and Natural Resources of Razi University in crop season 2011. The results obtained from correlation analysis between drought resistance indices (based on grain yield under stress and non-stress environments) showed positive significant correlation between geometric mean productivity (GMP), mean productivity (MP), harmonic mean (HARM) and stress tolerance index (STI) with grain yield . A significant positive correlation was also observed between these indices indicating their similar pattern for identification of drought tolerant genotypes. Genotypes no 4, 7 and 8 had the highest STI values, therefore they are suitable for stress and non-stress conditions with high grain yield. The genotypes no 3 and 7 exhibited the lowest TOL and SSI values and no. 4 and 8 revealed the highest HARM index hence they are desirable for drought prone condition. Screening drought tolerant genotypes based on all indices using mean rank, standard deviation of ranks and rank sum (RS) distinguished genotypes 7, 8 and 3 as the most drought tolerant.

Key words: Common wheat, drought stress, screening techniques, rank sum method

INTRODUCTION

Wheat production in Mediterranean region is often limited by sub-optimal moisture conditions. Visible syndromes of plant exposure to drought in the vegetative phase are leaf wilting, a decrease in plant height, number and area of leaves, and delay in accuracy of buds and flowers [4]. Among all the factors limiting wheat productivity, drought remains the single most important factor affecting the world security and sustainability in agricultural production. For improving yield under dry land conditions, the development of new wheat cultivars with high grain yield potential through identifying drought tolerance mechanism is of great significance [21]. Drought stress at the grain filling period dramatically reduces grain yield [7]. Breeding for drought resistance is complicated by the lack of fast, reproducible screening techniques and the inability to routinely create defined and repeatable water stress conditions when a large amount of genotypes can be evaluated efficiently [22]. Various quantitative criteria have been proposed for selection of genotypes based on their yield performance in stress and non-stress environments. Based on these indicators genotypes are compared in irrigated and rainfed conditions or in different levels of irrigations [25]. Drought resistance is defined by [17] as the relative yield of a genotype compared to other genotypes subjected to the same drought stress. Drought susceptibility of a genotype is often measured as a function of the reduction in yield under drought stress [3], whilst the values are confounded with differential yield potential of genotypes [22]. Rosielle and Hamblin [23] defined stress tolerance (TOL) as the differences in yield between the stress (Ys) and non-stress (Yp) environments and mean productivity (MP) as the average yield of Ys and Yp. Fischer and Maurer [12] proposed a stress susceptibility index (SSI) of the cultivar. Geometric mean productivity (GMP) is often used by breeders interested in relative performance, since drought stress can vary in severity in the field environment over years [22]. Fernandez [11] defined a new advanced index (STI = stress tolerance index), which can be used to identify genotypes that produce high yield under both stress and non-stress conditions. Fischer and Wood [13] introduced another index as relative drought index (RDI). Yield stability index (YSI) also was computed and suggested by Bouslama and Schapaugh [5]. This parameter is calculated for a given genotype using grain yield under stressed relative to its grain yield under non-stressed conditions. The genotypes with high YSI is expected to have high yield under stressed and low yield under non-stressed conditions [19]. Clarke et al. Clarke et al. [6] used stress susceptibility index (SSI) for evaluation of drought tolerance in wheat genotypes and found year-to-year variation in SSI for genotypes and their ranking pattern. In spring wheat cultivars, Guttieri et al. [14] used SSI criterion and suggested that SSI more than 1 indicated above-average susceptibility to drought stress. Lan [18] defined new index of drought resistance index (DI), which was commonly accepted to identify genotypes producing high yield under both stress and nonstress conditions. The DI and STI consider not only the ability of genotypes to grow well under stressed environments, but also good performance in non-stressed environments. Indices ATI and SSPI are able to separate relative tolerant and non tolerant genotypes better than previousindices [20].

The objectives of the present investigation were: (i) screening quantitative indicator of drought tolerance and (ii) identification of drought-tolerant bread wheat genotypes.

MATERIALS AND METHODS

Eight genotypes of bread wheat (*Triticum aestivum* L.) listed in Table 1 were assessed in a randomized complete block design with three replications under two irrigated and water stress conditions during 2011 growing season in the experimental greenhouse of the College of Agriculture, Razi University, Kermanshah, Iran (47° 9_ N, 34° 21_ E and 1319m above sea level). The seed samples were planted in the plastic pots with 15 cm diameter and 20 cm height and filled with 3kg soil containing sand and animal fertilizer, as 1: 1: 1. In the 3 leaves stage, there were 5 bushes in each pot. The pots were kept in the planting capacity area through regular watering (irrigation), the damp of the pots were maintained about 40 percent of the farm capacity in the stress environment.

Drought resistance indices were calculated using the following relationships:

1-Stress susceptibility index = $SSI = \frac{1-(Y_S/Y_P)}{1-(\bar{Y}_S/\bar{Y}_P)}$ [12].

2- Relative drought index = RDI= (Ys/Yp)/($\bar{Y}$s/$\bar{Y}p$) [13].

3-Tolerance = TOL = YP - YS [23].

4- Mean productivity = $MP = \frac{Y_S + Y_P}{2}$ [23].

5- Stress tolerance index = $STI = \frac{Y_S \times Y_P}{\bar{Y}_P^{\,2}}$ [11].

6- Geometric mean productivity = GMP = $[(Yp)(Ys)]^{0.5}$ [11].

7- Yield index = $YI = \frac{Y_S}{\bar{Y}_S}$ [15].

8- Yield stability index = $YSI = \frac{Y_S}{Y_P}$ [5].

10- Drought resistance index (DI) = Ys × (Ys/Yp)/ $\bar{Y}$s [18].

12- Abiotic tolerance index = $ATI = \left[\frac{(Yp-Ys)}{(\bar{Y}p/\bar{Y}s)}\right] \times \left[\sqrt{Yp \times Ys}\right]$[20].

13-Harmonic mean= $HARM = \frac{2(Y_p \times Y_s)}{Y_p + Y_s}$ [2].

Rank sum (RS) = Rank mean ($\bar{R}$) + Standard deviation of rank (SDR) and SDR= $(S^2i)^{0.5}$.

Statistical analysis
Correlation analysis and ranking method were performed by SPSS ver. 16.

RESULTS AND DISCUSSION

The results of correlation analysis (**Table 3**) between drought tolerance criteria and Yp and Ys showed positive and significant correlation between the indices GMP, MP, HARM and STI with the yield under stress and non-stress environments. Meanwhile there was positive and significant correlation between the mentioned indicators therefore, these criteria distinguish drought tolerant genotypes in a similar pattern and are able to discriminate group A (genotypes that express uniform superiority in non-irrigated and irrigated conditions) [11]. Our results are in agreement with the reports of Abdli and Saeidi [1], Sio-Se Mardeh et al. [24] and Golabadi et al. [16]. Farshadfar et al. [8] reported positive and significant correlation between GMP, MP, HARM, YI, RDI and STI under stress and non-stress conditions. Farshadfar et al. [10] believed that the most suitable indices are those having association with yield under stress and non-stress environments. Results of correlation analysis also exhibited positive and significant relationship between TOL and SSI. These indicators showed negative association with Ys and positive correlation with Yp (**Table 3**) hence, selection based on these indicators will decrease grain yield in the stress condition [24]. Ehdaei et al. [7] stated that there isn't any positive and significant relationship between grain yield in the non-stress condition and SSI.

Genotypes with the low values of TOL and SSI showed low difference in grain yield under irrigated and drought conditions. Genotypes 3, 8 and 7 with low SSI and TOL (**Table 2**) were identified as drought resistant genotypes and desirable for stress condition. Genotype 4 with high STI was discriminated as drought tolerant with high grain yield for stress and non-stress environments (**Table 2**). HARM index had positive and significant correlation with GMP, MP and STI and discriminated genotypes 8 and 4 as group A (uniform performance under stress and no-stress conditions) [11]. YSI displayed negative and significant correlation with SSI and TOL and positive and significant association with RDI. Concerning YSI genotype 3 had highest value and genotype 4 had lowest value. YI indicator had positive and significant relationship with Ys. This indicator, can't recognize genotypes of the group A. DI criteria had positive and significant correlation with Ys and revealed no positive and significant association with Yp. ATI and SSPI indicated positive and significant relationship with Yp and negative correlation with YSI, RDI and Ys, hence they are not suitable criteria for discriminating drought tolerance genotypes. According to STI, MP and GMP genotype 4 was identified drought tolerant with high Ys and Yp (group A) (**Table 2**).

Biplot analysis
In the biplot diagram (**Fig. 1**) the angle between Ys, Yp, GMP, HARM, MP and STI is acute angle, therefore they have positive correlation which confirmed by correlation analysis (**Table 3**). Genotypes 4 and 8 are located near the vectors of these groups hence, they are discriminated as drought tolerant with high performance for stress and non-stress environments (group A). Comparison between genotype 4 and 8 shows that genotype 8 is more suitable for stress environment, while genotype 4 is more desirable for non-stress condition. Genotypes 2 and 5 indicate a semi-sensitive (resistance) to drought.

Cluster analysis
Using cluster analysis with UPGMA and based on drought tolerance criteria (**Fig. 2**), the genotypes classified in three groups. Group 1 (drought tolerance) consisted of genotypes 4, 8 and 7, group 2 (semi-resistance) included genotypes 1 and 6 and group 3 (drought sensitive) discriminated genotypes 2, 3 and 5. As group 1 an 3 showed maximum between group variance, therefore they are recommended for the genetic analysis using diallel or scaling test and QTLs mapping of drought tolerance indices.

Ranking method
The estimates of *in vivo* indicators of drought tolerance (**Table 2**) indicated that the identification of drought-tolerant genotypes based on a single criterion was contradictory. Different indices introduced different landraces as drought tolerant. To determine the most desirable drought tolerant genotypes according to the all indices mean rank, standard deviation of ranks and rank sum (RS) of all *in vivo* drought tolerance criteria were calculated. With regard to all indices, genotype 7 with least RS was the most drought tolerant followed by genotype 8, while genotypes 1, 2 and 6 were identified as the most drought sensitive.

Table 1. Name and codes of genotypes

code	Genotype
1	Bahar
2	Pishtaz
3	Vrinak
4	Yavaros
5	S-80-18
6	Crasalborz
7	Santor
8	D-79-15

Table 2. Ranks (R), ranks mean ($\bar{R}$) and standard deviation of ranks (SDR) of drought tolerance indicators

Genotypes	Yp	R	Ys	R	SSI	R	STI	R	GMP	R	TOL	R
1	0.707	8	0.54	8	0.938	5	0.389	8	0.618	8	0.167	4
2	0.933	5	0.557	7	1.605	7	0.53	6	0.721	6	0.377	7
3	0.897	6	0.82	4	0.34	1	0.75	4	0.857	4	0.077	1
4	1.463	1	0.84	3	0.694	8	1.254	1	1.109	1	0.623	8
5	0.947	4	0.653	5	1.232	6	0.631	5	0.786	5	0.293	6
6	0.733	7	0.61	6	0.669	4	0.456	7	0.669	7	0.123	2
7	1.04	3	0.89	2	0.573	2	0.944	3	0.962	3	0.15	3
8	1.204	2	1.017	1	0.618	3	1.249	2	1.106	2	0.187	5

Table 2 continued

Genotypes	MP	R	HARM	R	RDI	R	YI	R	YSI	R	DI	R
1	0.623	8	0.612	8	1.021	5	0.729	8	0.764	5	0.557	7
2	0.745	6	0.697	6	0.797	7	0.751	7	0.596	7	0.448	8
3	0.858	4	0.857	4	1.222	1	1.107	4	0.914	1	1.012	3
4	1.152	1	1.067	2	0.767	8	1.134	3	0.574	8	0.651	5
5	0.8	5	0.773	5	0.922	6	0.882	5	0.69	6	0.608	6
6	0.672	8	0.666	7	1.111	4	0.823	6	0.832	4	0.685	4
7	0.965	3	0.959	3	1.143	2	1.201	2	0.856	2	1.028	2
8	1.11	2	1.102	1	1.128	3	1.372	1	0.845	3	1.159	1

Table 2 continued

Genotypes	ATI	R	SSPI	R	R-mean	RS	SDR
1	0.077	3	8.4	4	6.36	7.78	1.42
2	0.203	7	19	7	6.64	6.98	0.34
3	0.049	1	3.9	1	2.79	4.23	1.44
4	0.517	8	31.5	8	4.64	5.89	1.25
5	0.173	6	14.8	6	5.43	5.55	0.12
6	0.062	2	6.2	2	5	6.39	1.39
7	0.108	4	7.6	3	2.64	2.74	0.1
8	0.155	5	9.4	4	2.57	4	1.43

Yp: Potential Yield, Ys: Stress Yield, SSI: Stress Susceptibility Index, STI: Stress Tolerance Index, GMP: Geometric Mean Productivity, TOL: Tolerance, MP: Mean Productivity, RDI:Relative Drought Index, YI: Yield Index, YSI: Yield Stability Index, DI: Drought Resistance Index, ATI: Abiotic Tolerance Index, SSPI: Stress Susceptibility Percentage Index.

Table 3. Correlation coefficients between drought tolerance criteria

	Yp	**Ys**	**SSI**	**STI**	**GMP**	**TOL**	**MP**
Yp	1						
Ys	0.694	1					
SSI	0.395	-0.372	1				
STI	0.927**	0.907**	0.036	1			
GMP	0.922**	0.918**	0.018	0.997**	1		
TOL	0.711*	-0.013	0.912**	0.401	0.383	1	
MP	0.947**	0.888**	0.086	0.996**	0.997**	0.447	1
Harm	0.891**	0.945**	-0.053	0.993**	0.997**	0.315	0.990**
RDI	-0.395	0.372	-1.000**	-0.037	-0.019	-0.912**	-0.086
YI	0.694	1.000**	-0.372	0.908**	0.919**	-0.013	0.889**
YSI	-0.394	0.373	-1.000**	-0.035	-0.017	-0.912**	-0.085
DI	0.276	0.883**	-0.758*	0.606	0.625	-0.479	0.57
ATI	0.840**	0.205	0.779*	0.59	0.571	0.966**	0.627
SSPI	0.711*	-0.012	0.912**	0.402	0.384	1.000**	0.448

Table 3 continued

	Harm	RDI	YI	YSI	DI	ATI	SSPI
Harm	1						
RDI	0.052	1					
YI	0.945**	0.371	1				
YSI	0.054	1.000**	0.373	1			
DI	0.68	0.758*	0.883**	0.759*	1		
ATI	0.51	-0.779*	0.205	-0.778*	-0.271	1	
SSPI	0.316	-0.912**	-0.012	-0.911**	-0.478	0.967**	1

,:significant at o.05 and 0.01 level of probability, respectively.*

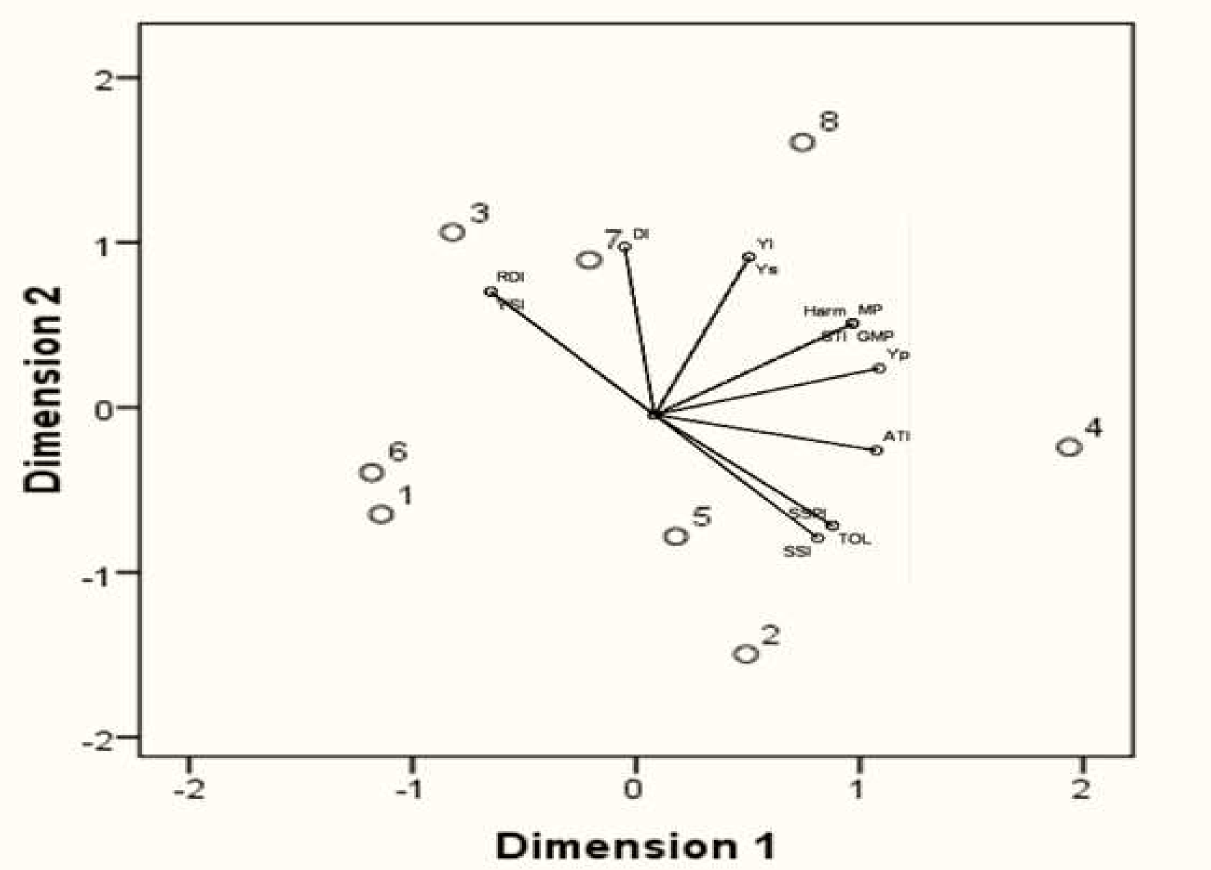

Fig. 1. Biplot based on first and second components of drought tolerance indices

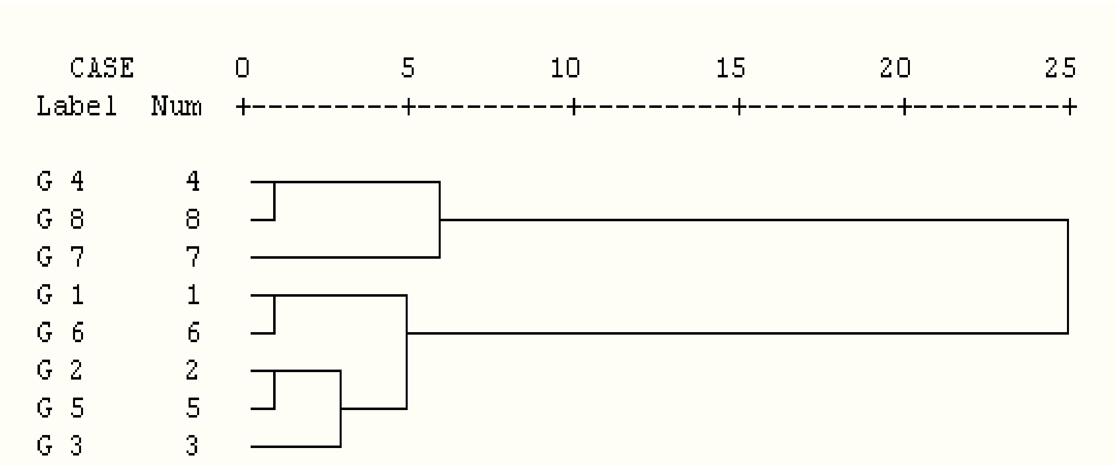

Fig. 2. Dandogram resulted from cluster analysis based on drought tolerance indicators

REFERENCES

[1] Abdli M, Saeidi M, **2012**. *Annals of Biological Research*, 3 (3): 1322-1333.
[2] Azizi-Chakherchaman S.H, Kazemi-Arba H, Yarnia M, Mostafaei H D, Hassanpanah Dadashi MR, Easazadeh R, **2008**. *International Meeting on Soil Fertility, Management and Agroclimatology*. Turkey, Pp 749-755.
[3] Blum, A, **1988**. *Plant Breeding for Stress environments*. CRC Press Florida 212
[4] Boyer JS, **1982**. *Science*, 218:443-448.
[5] Bouslama M, Schapaugh WT, **1984**. *Crop Sci*, 24:933–937.
[6] Clarke JM, DePauw RM, Townley Smith TF, **1992**. *Crop Sci*, 32:723–728.
[7] Ehdaie B, Shakiba MR, **1996**. *Cereal Res Commun*, 24:61-67.
[8] Farshadfar E, Jamshidi B, Aghaee M, **2012**. *Int J Agric and Crop Sci*, 4 (5):226-233.
[9] Farshadfar E, Jalali S, Saeidi M. **2012**. *Euro. J. Exp. Bio*, 2 (4): 1181-1187.
[10] Farshadfar E, Zamani M, Matlabi M, Emam-Jome E, **2001**. *Iranian J of Agric Sci*, 32 (1): 65–77 (in Farsi).
[11] Fernandez GCJ, **1992.** In: Kuo CG (ed), *Proceedings of the international symposium on adaptation of vegetables and other food Crops in temperature and water stress publication*, Tainan, Taiwan.
[12] Fischer RA, Maurer R, **1978**. *Aust J Agric Res*, 29:897-912.
[13] Fischer RA, Wood JT, **1979**. *Aust J Agric Res,* 30:1001–1020.
[14] Guttieri MJ, Stark JC, Brien KO, Souza E, **2001**. *Crop Sci*, 41:327-335.
[15] GavuzziP, Rizza F, Palumbo M, Campaline R.G, Ricciardi GL, Borghi B, **1997**. *Can J Plant Sci*, 77: 523-531.
[16] GolabadiM, Arzani A, Mirmohammadi Maibody SAM, **2006**. *Afric J Agric Res*, 1 (5): 162-171.
[17] Hall AE, **1993.** *Plant Responses to cellular dehydration during environmental stress*, (Eds): TJ Close and EA Bray 1-10.
[18] Lan J, **1998**. *Acta Agric Bor-occid Sinic*, 7:85–87.
[19] Mohammadi R, Armion M, Kahrizi D, Amri A, **2010**. *Int J Plant Product*, 4 (1):1735-8043.
[20] Moosavi SS, Yazdi Samadi B, Naghavi MR, Zali AA, Dashti H, Pourshahbazi A, **2008**. *Desert*, 12:165-178.
[21] Rajaram S, Braun HJ, Ginkel MV, **1996**. *Euphytica*, 92:147-153.
[22] Ramirez P, Kelly J.D, **1998**. *Euphytica*, 99: 127-136.
[23] Rosielle Hamblin JDJ, **1981.** *Crop Sci*, 21 (6): 943-946.
[24] Sio-Se Mardeh A, Ahmadi A, Poustini K, Mohammadi V, **2006**. *Field Crop Res*, 98: 222- 229.
[25] Taghian AS, Abo-Elwafa A, **2003**. *Assiut J. Agric. Sci*, 34: 1-24.