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Full Length Research Paper

Evaluation of 14 winter bread wheat genotypes in normal irrigation and stress conditions after anthesis stage

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In order to evaluate wheat genotypes in terms of tolerance to drought stress after anthesis stage, some experiments were conducted using 14 winter bread wheat genotypes in a randomized complete block design with three replications in normal irrigation and drought stress conditions at the research stations of Ardabil, Bilesavar and Namin in the 2009 to 2010 cropping years. Evaluation of genotypes for drought tolerance was performed by indices including stress tolerance index (STI), stress sensitivity (SSI), tolerance (TOL), mean proficiency (MP), the geometric mean (GMP) and the mean rating (mean R), and also by the earlier mentioned indices for all the genotypes and relevant biplot drawing. The results of the combined variance analysis of grain yield showed that the effect of location was meaningful under normal irrigation conditions; this was obtained under drought stress conditions. The interaction of genotype with location in normal irrigation conditions was meaningful in a probability level of 5, while it was not meaningful under drought stress. The effect of genotypes was not meaningful under normal irrigation conditions, while it is significant under drought stress. Considering indices correlation with yields of two normal and stress conditions, indices MP and STI were identified as the best indices. Using biplot graphic method, comparison of indices amounts and mean rating of indices for each genotype observation of placing position of genotypes in the biplot of genotypes 6, 10, 7 and 13 were identified as tolerant genotypes. However, genotype 14 was identified as the most sensitive genotype to end drought stress.

Key words: Bread wheat, drought stress, grain yield, drought tolerance and drought sensitive indices, biplot.

INTRODUCTION

Undoubtedly, bread wheat (*Triticum aestivum* L.) is one of the most important plants that are cultivated widely as a food source and it has probably a pivotal role to start farming (Harlan, 1981). Wheat provides over 20% of calories needed by the world's population (Bushuk and Rasper, 1994). It is also a basic source of essential calories and protein in Iran, so it comprises 75% protein and 65% calories for each person receiving it daily (Mostafavi et al., 2005). Alive and non-alive stresses lead to decreasing yield of agricultural plants every year and preventing yield potential occurrence. Of the non-alive environmental stresses, drought stress is one of the most important factors that decrease yield in most cultivated areas (Emam and Seghatoleslami, 2005). Of the 2.3 million hectares of irrigated wheat land in the country, about 900,000 hectares were located in cold regions and the irrigated wheat varieties are cultivated in those areas; so in those areas, most farmers do not obtain desirable results from cultivation of promising varieties due to lack of enough water as a result of allocation of end-season irrigation waters to summer farming. Thus, wheat farming suffers end-season drought stress. Therefore, introduction of cultivars that can produce more reliable production in both normal irrigation and end-season

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drought stress is crucial. A tolerant genotype is defined as a genotype with above-average yield in a condition that limits environmental factors, such as access to water (Narayan and Misra, 1989).

Annicchiarico et al. (2000) suggested that in reducing stress damages, we can modify drought tolerance varieties while observing points such as stress identification, identification of related traits to drought tolerance and evaluating the correlation of these traits with yield, selection of appropriate varieties from gene stress points by observing, identifying traits associated with drought tolerance and solidarity of the performance traits, selection of suitable varieties of gene pool, and selection of proper traits and their recombination with other desirable traits. In researches that were related to drought tolerance, a system was suggested to breeding wheat and other crops in dehydration conditions, while the experiments and selection of plant materials were done in both normal irrigation and low-water stress conditions, and lines which have better performance in both conditions were selected. In this case, if lines that appeared good in low-water stress conditions are intro-duced as new varieties, they can produce an acceptable and high-quality yield in low-water conditions and show high potential in normal conditions with sufficient water for irri-gation and then produce greater yield (Uddin et al., 1992).

Effect of drought stress is very obvious on grain filling stage, because potential yield is dependent on 1000 seed weight to accumulate photosynthesis materials in seeds. Materials gathered in the grains come from two sources, one is through photosynthesis and the other is through transfer of food materials from other plant parts or grain. A part of the photosynthetic material is made before pollination and is saved in the plant stem or other plant organs. Afterwards, it is transferred to the seeds that are formed, but the major part of the formed materials in grains is made after pollination (Gupta, 1995).

It has been demonstrated that drought stress reduced the transfer of food materials from the leaves to grains and given that drought accelerates the maturity of grains, the reaction of photosynthesis reduction also help to reduce cereals yield (Sarmadnia and Koochaki, 1997). Reynolds et al. (1999), by evaluation of different wheat in CYMMIT, concluded that there is a linear relation between drought stress and grain yield in wheat. This shows that wheat is relatively tolerant to drought. Mustafa et al. (1996), by evaluation of the effect of drought treatment at different growth stages of spring wheat showed that drought treatment in tillering stage had no effect on grain number and in the heading stage leads to a reduction of the number of grain per spike, and results in decreasing yield. They also expressed that grain was not influenced by any drought treatment.

Fisher and Maurer (1978), in an experiment which was conducted to evaluate drought tolerance of some tall and short varieties of spring wheat in dry environments, concluded that the entire drought treatments reduced yield significantly. In their study, the smoother drought treatments lead to relative reduction of much grain weight as compared to the number of grain. So, severe drought reduced the number of grains relatively. They expressed that drought tolerance criterion is the position of grain yield under drought conditions, but the situation of relative yield of genotypes under drought and irrigation conditions was considered as a starting point to identify traits related to drought tolerance and select genotypes to breeding in dry environments. The yield of one variety in stress conditions may be independent on its function in optimal condition.

In order to determine how different genotypes reacted in both stressed and non-stressed conditions, Fernandez (1992) divided genotypes into four categories (A, B, C and D). Different indices are presented to evaluate the reaction of genotypes in different environmental conditions and to determine their strength and susceptibility. In Fernandez's (1992) opinion, the most appropriate criterion is the index that can recognize the genotypes of group A from those of other groups.

Rosielle and Hamblin (1981) introduced tolerance indices (TOL: tolerance) and the arithmetic mean (MP: mean productivity), while Fisher and Maurer (1978) offered stress susceptibility index (SSI: stress susceptibility index). As another indices of drought susceptibility index (DSI) was reported by Bahar and Yildirim (2010). They reported that genotypes with high DSI values were evaluated as drought susceptibility.

Fernandez (1992) introduced stress tolerance index (STI: stress tolerance index) and the geometric mean productivity index (GMP: geometric mean productivity). Geometric mean productivity has less susceptibility to different values of yield in non-stressed and stressed (Y_s) conditions, if geometric mean productivity index is based on an arithmetic mean. When there is a large relative difference between yield in non-stressed (Y_p) and stressed (Y_s) conditions, there will be large oblique towards yield in non-stressed (Y_p) conditions (Fernandez, 1992).

MATERIALS AND METHODS

This study was conducted to evaluate and review the effect of drought stress after anthesis stage on 14 winter wheat genotypes in a mean comparison experiment in three cold research stations of the country (Ardabil, Bilesavar and Namin) in both normal irrigation and stop watering conditions after anthesis stage in 2009 to 2010 cropping years. All the genotypes were examined for grain yield in the form of statistical randomized complete block design with three replications. In this experiment, each genotype was planted in a plot with dimensions of 1.2 x 6 square meter with 30 cm removal considered from each side of the court. The rate of seed consumption was identified on the basis of 450 seed per square meter, as well as by considering 1000 seed weight for each genotype. The irrigation was conducted by the irrigation flooding method in normal experiments. It consisted of one time fall irrigation and four times spring irrigation. Irrigation of stress experiments included one time fall irrigation and two times spring irrigation before anthesis stage. In the experiments related to drought stress, with the aim of creating end-season stress, irrigation operations

Table 1. Parentage of the genotypes.

Genotype code	Name / Parentage
1	Viking/5/Gds/4/Anza/3/Pi/Nar//Hys/6/Spn/Mcd//
2	Bkt/90-Zhong
3	ATAY/GALVEZ87
4	Aghbugda/90Zhong87/4/Spn/Mcd//Cama/3/Nzr
5	Azar2
6	ID800994. W/ VEE/3/ URES/JUN// KAUZ/ 4BUL 5052.1
7	Basswood/ Mv17
8	LFN/STDY//LOV24(ES8424)/5/
9	PYN/BAU/3/AGR1/BJY//VEF
10	Gds/4/ Anza/3 Pi/ Nar// Hys/5/ Vee/ Nac/6/ Gascogne
11	Fenkan
12	Alvd/90-Zhong 87
13	BILINMEYEN-6
14	Viking/5/Gds/4/Anza/3/Pi/Nar//Hys/6/Spn/Mcd//

Table 2. Combined analysis of variance for grain yield in normal and drought stress conditions in different locations in the 2009 to 2010 seasons.

S.O.V	d.f	MS	
		Normal	Drought stress
Location	2	67400354.45**	56842346.103**
Rep / Location	6	2337455.56	1625363.99
Genotype	13	818858.31ns	1100484.64**
Genotype **x** Location	26	1633221.1*	335048.522ns
Error	78	921528.68	435332.63
C.V.%		15.73	16.58

*, ** Significant at 5 and 1% probability levels, respectively; ns, not significant.

stopped after anthesis stage and irrigation was not done until harvesting. To clear off broad leaf weeds and narrow leaf weeds, a mixture of Grown Star and Puma super was used for 20 g and 1 l/ha tillering to stem elongation stages, respectively.

After observing sufficient time to physiological maturity and drying and preparation of crop to harvesting, all the experiments were harvested in order to determine grain yield in different regions. After collecting data, a combined variance analysis was performed in both experiment conditions to determine the main effects related to location, genotype and interactions between genotype and location. Evaluation of genotypes was carried out for drought tolerance using indices TOL, MP (Rosielle and Hambling, 1981), SSI (Fisher and Maurer, 1978) and STI (Fernandez, 1992), and the mean rating (mean R) was calculated for these indices, in which the low amount of mean rating showed that the under-study genotypes were superior. Simple correlation coefficients between grain yield (in both conditions) and the indices were also calculated. In order to draw by-plot, a data matrix of five indices and 14 genotypes was conducted and then it was drawn by principal component analysis and biplot, based on the two first components. For statistical calculations, software such as SPSS-16, Minitab-15 and MSTAT-C were used.

RESULTS AND DISCUSSION

Profile and pedigree of under-study wheat genotypes are shown in Table 1. Table 2 shows the combined variance analysis of grain yield in normal and drought stress conditions in the three locations in the 2009 to 2010 farming years. The effect of place was meaningful in normal irrigation conditions, and this was achieved in drought stress conditions. The interaction between genotype and location was meaningful in normal irrigation condition in a probability level of 5%, while it was not meaningful in drought stress conditions. In a like manner, the effect of genotypes was not meaningful in normal irrigation conditions. In fact, there was no meaningful difference between genotypes in normal conditions, but this effect was meaningful in drought stress conditions in a probability level of 1%. Thus, this suggests meaningful differences among genotypes and indicates that the genetic ability of genotypes has been the differences in

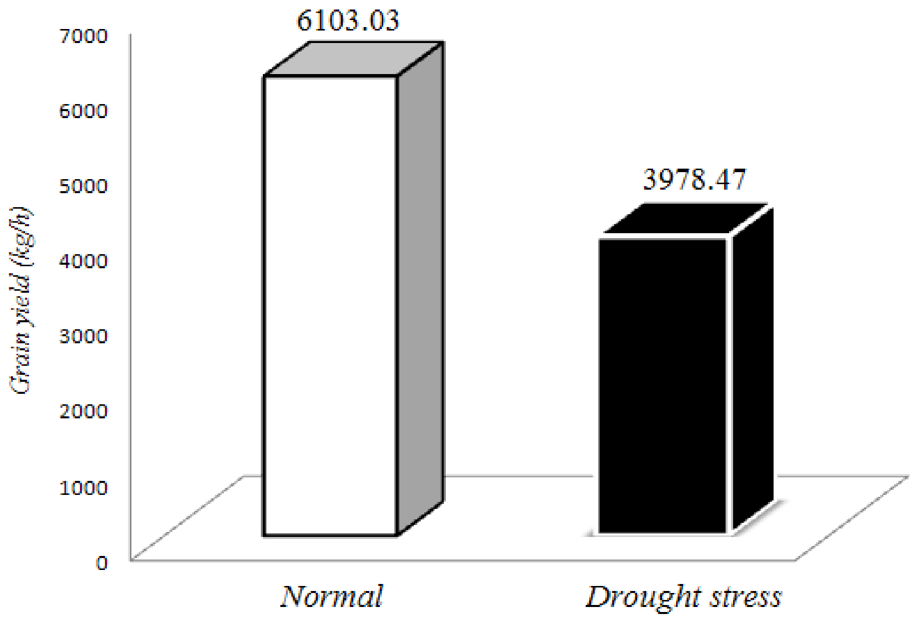

Figure 1. Average of genotype yield in normal and drought conditions of irrigation farming in the three locations.

grain yield occurrence.

Ahmadi et al. (2000), Parvizi et al. (1997), Aflatooni and Daneshvar (1993), Abdemishani and Jafari (1988) and Ehdaei (1995), in their studies, reported that effect of genotype was meaningful in drought stress conditions. In cases when interaction between genotype and location was recognized to be meaningful in normal irrigation condition showed that the genotypes studied in the experiment locations had different reactions, and the average of grain yield was not equal in all the places statistically; but in cases when interaction between genotype and location was not recognized to be meaningful in drought stress conditions, showed that genotypes studied in the experiment locations did not have different reactions and the average of grain yield was equal in all places, statistically. Mean yield of genotypes in normal irrigation conditions was equal to 6103.21 $kgha^{-1}$ in the three locations in 2009 to 2010 farming years, so that in stress conditions, this mean was equal to 3978.47 kg/ha and the grain yield decreased by 34.81% as a result of stress (Figure 1).

For the fact that the highest and lowest average in normal irrigation conditions did not belong to a constant genotype, the calculation of stress tolerance and stress sensitive indices was essential in assessing and identifying genotype(s). Table 3 shows drought tolerance and drought sensitive indices for grain yield (average of three locations). Based on stress tolerance index (STI), the greater the difference between the yield found in normal and stress conditions, the smaller the amount of stress tolerance index. Therefore, unlike drought sensitivity index, the higher amounts of the aforementioned index showed more tolerance of genotypes to stress (Fernandez, 1992). Calculation of stress tolerance index (STI) for genotypes represents the greater tolerance of genotypes 6, 13, 7, 10 and 4 than other genotypes (Table 3). Genotypes were mentioned by the highest office in the STI index values between the studied genotypes, in terms of average performance and stresses in high-yielding genotypes. Also, genotypes 4, 6 and 13 in normal conditions were among the high yielding genotypes. Genotype number 14, which was also based on this index as the most sensitive genotype was identified. The genotype of the average yield in stress conditions showed that the product was of a low genotype (Table 3). According to what was stated to be the result of stress tolerance index, genotypes had high performance in both normal and stress conditions.

The results also showed that the correlation coefficients in the STI index and drought conditions had a significant positive correlation with normal irrigation conditions and STI index had positive correlation with grain yield (Table 4). Moghaddam and Hadizadeh (2000) and Ahmadzadeh (1997) associated stress tolerance desirability index (STI) with the selection of tolerant genotypes in their reports.

Stress susceptibility index (SSI), applied in the removal of most sensitive genotypes, were used for each genotype and the higher values of the index allocated to it was more sensitive to stress (Fisher and Maurer, 1978). The calculated stress susceptibility index (SSI) showed that genotypes 6, 10, 5 and 7 in comparison with other genotypes were less sensitive. These genotypes also took a small amount of these mentioned indicators, in terms of average yield stress in the group with high-

Table 3. Mean grain yield, drought tolerance and susceptibility indices, and their ranking in different locations (average of 3 locations) in 2009 to 2010 seasons.

Genotype	Yp	R	Ys	R	STI	R	SSI	R	TOL	R	MP	R	GMP	R	Mean R
1	5934	10	3768	11	0.617	11	1.077	8	2166	8	4851	10	4728	11	9.6
2	6392	3	3842	8	0.678	7	1.177	11	2550	13	5117	8	4956	7	9.2
3	6328	4	3776	9	0.659	9	1.190	13	2553	12	5052	9	4888	9	10.4
4	6284	5	4130	5	0.716	5	1.012	7	2155	7	5207	4	5094	5	5.6
5	5583	14	4008	6	0.617	10	0.832	3	1575	2	4796	11	4730	10	7.2
6	6096	8	4690	1	0.789	1	0.681	1	1407	1	5393	1	5347	1	1
7	6171	7	4338	3	0.739	3	0.877	4	1833	4	5255	3	5174	3	3.4
8	6422	2	3917	7	0.694	6	1.151	9	2505	11	5169	6	5015	6	7.6
9	5925	11	3596	13	0.588	12	1.160	10	2329	9	4761	12	4616	12	11
10	5972	9	4387	2	0.723	4	0.783	2	1585	3	5179	5	5118	4	3.6
11	6636	1	3623	12	0.663	8	1.340	14	3013	14	5129	7	4903	8	10.2
12	5888	12	3519	14	0.572	13	1.187	12	2369	10	4704	13	4552	14	12.4
13	6185	6	4337	4	0.740	2	0.882	5	1848	5	5261	2	5179	2	3.2
14	5629	13	3768	10	0.585	14	0.976	6	1861	6	4699	14	4606	13	10.6
Mean	6103.2		3978.5		0.67	-	1.023	-	2124.87	-	5040.9	-	4922.02	-	-

Yp, Yield in normal condition; Ys, yield in stress condition; SSI, stress susceptibility index; STI, stress tolerance index; TOL, tolerance; MP, mean productivity; GMP, geometric mean productivity; R, rank; Mean R, mean of rank for 5 indices. Table 1 shows the names of genotypes.

Table 4. Correlation coefficient between tolerance and susceptibility indices, Y_p and Y_s, of the 14 genotypes in three locations in the 2009 to 2010 seasons.

Parameter	Yp	Ys	STI	SSI	TOL	MP
Ys	0.011ns	1				
STI	0.483ns	0.881**	1			
SSI	0.475ns	-0.873**	-0.539*	1		
TOL	0.648*	-0.754**	-0.353ns	0.977**	1	
MP	0.657*	0.761**	0.977**	-0.350ns	-0.147ns	1
GMP	0.494ns	0.875**	1**	-0.528ns	-0.341ns	0.980**

*, **Significant at 5 and 1% probability levels, respectively; ns, not significant.

yielding genotypes (Table 3). The results confirmed that the correlation coefficients were the same, so that the SSI index and negative correlation found with strong performance in stress condition was normal, but in terms of performance, they showed a significant correlation (Table 4).

Nourmand Moayed (1997) confirmed the correlation coefficients in order to test the variability of quantitative traits, and determine the best indicators of drought tolerance in bread wheat. As such, he reported the correlation between the SSI index Y_p (in terms of yield stress) which was positively significant (r = 0.43 **) and Y_s (in terms of yield stress) which was negatively significant (r = -0.56**). Considering the tolerance index (TOL) as the difference between performance in normal and stress conditions, it is considered to be the tolerant genotype such that the lower values of these indices are allocated to it (Rosielle and Hambling, 1981).

Evaluation of genotypes' tolerance using TOL index (three locations) showed the superiority of genotypes 6, 10, 5 and 7 when compared with other genotypes. The average performance of the four genotypes in the stress group was high-yielding genotype. Also, four genotypes 11, 3, 12, 8 and two genotypes were identified as the most sensitive genotypes by achieving the highest amounts of TOL index. The four genotypes, in terms of stress, did not have good performance in the genotype groups where the product was low (Table 3). It seemed that the index of successful genotypes such as their performance in terms of stress was good. Genotypes based on TOL index were consistent with the SSI index and index like SSI had a significant negative correlation with yield under stress, but significant positive correlation with performance in normal conditions (Table 4). This indicator in identifying genotypes that have both normal and environmental stress was not similar to that of the findings of Naderi et al. (2000).

Based on the average productivity index (MP), the sum

Table 5. Vectors and Eigen values for five tolerance and susceptibility indices in 14 genotypes.

Component	Eigen value	Variance (%)	Ys	Yp	TOL	STI	SSI	MP	GMP
1	4.542	64.885	0.978	0.220	-0.600	0.960	-0.753	0.880	0.957
2	2.456	35.084	-0.209	0.975	0.800	0.279	0.657	0.476	0.291

of the average yield under normal and stress conditions was defined, and some genotypes were more tolerant to higher levels of these indicators (Rosielle and Hambling, 1981). Accordingly, genotypes No. 6, 13, 7 and 4 were evaluated as the most tolerant genotypes, respectively.

Nourmand Moayed (1997) had also previously reported that the average productivity index of the genotype that had the highest potential performance and tolerance of other indicators of stress which were more successful was introduced. According to this index, genotypes 12 and 14 were identified with the least amount of gain as the index with the most sensitive genotypes. As can be seen, the genotype productivity index selection for both normal and stress conditions of the average yield was high (Table 3). Correlation coefficients results also confirmed this issue. This indicator, like STI, indicated significant positive correlation with grain yield in both normal and stress conditions (Table 4). Therefore, MP indicator can be a good indicator for determining the drought tolerant genotypes used because according to the recommendations of Fernandez (1992) and Richards (1996), indicators that have a high correlation with grain yield in both environments, where there is no tension and stress, are available as the best indicators. Moghaddam and Hadizadeh (2000), in a research on corn conducted between average productivity and performance indicators in terms of stress, did not see a positive correlation with the results obtained as against those obtained in this investigation. Mollasadeghi (2010), in the plot of 12 bread wheat genotypes made between the average productivity index and grain yield in both normal and stress conditions, concluded that positive and significant correlation can be observed in the results obtained.

Based on geometric mean performance index (GMP), the more tolerant genotypes that were considered to have larger amounts of the aforementioned indicators were acquired (Fernandez, 1992). The index calculated for the genotypes in the drought season finale suggested more tolerance of genotypes 6, 13, 7 and 10. With this index, two genotypes (12 and 14) were identified as the most sensitive genotypes (Table 3). This index had a positive correlation with grain yield in both stress and normal conditions, but this correlation was only significant in stress conditions (Table 4). These results match the findings of some researchers (Nourmand Moayed 1997; Nikkhah, 1999; Shafazadeh et al., 2004; Mollasadeghi, 2010). Fernandez (1992) also stated that due to less sensitivity to the index values of tension and performance in normal conditions, this index has a MP that is superior to it.

Having a table with different genotypes and indices of sensitivity and drought tolerance, the relations between genotypes and indices in a single shape (biplot) that was simply mapped by the structure of such large matrices were assessed bilaterally. In this case, the principal components analysis was conducted on five indicators and the two traits in the 14 genotypes of Yp and Ys. As can be seen, the most desired changes between the two first PC data were expressed as 99.97% (Table 5) and therefore a biplot was drawn based on the two main components (Figure 2). Since the two elements can explain the changes independently, they can be oriented perpendicular to both the display and genotypes based on these two elements in areas identified by the chart. In this study, 64.88% of the total change of data was explained by the first component having a high positive correlation with performance in terms of stress (Ys) indicators GMP, STI and MP. Also, it had a weak positive correlation with performance in normal conditions (Yp), but was correlated with the component indices of SSI and TOL which were negative (Table 5). Considering the desirability of the high level indicators of GMP, STI and MP, if the first component has a high rate of genotypes that are selected with high performance in both conditions, especially in stressful situations, MP, GMP and STI are high. Hence, the first component can be sustained as a component of grain yield and drought tolerance (Table 5 and Figure 2). The second component shows about 35.08% of the total changes in the data. The components of a high positive correlation with performance in normal conditions (Yp), and SSI and TOL indices had a weak positive correlation with indicators of GMP, STI and MP and a very weak negative correlation with yield under stress (Ys). Therefore, the second component as a component of yield potential in normal conditions and susceptibility to stress of genotypes with low yield stress, in terms of other genotypes, was separated and determined (Table 3 and Figure 2). Considering that high levels indicators of GMP and STI and low values of SSI, MP and TOL are desirable, the amount of the second component can be lowered; thus, the figures are chosen with high performance and low tension of GMP, STI, MP, TOL and SSI. Genotypes within the groups identified are related to the average yield and stress tolerance.

Considering that genotypes 6, 10, 7 and 13 shown in the upper right graph were high, the first PC and the second component was high, so these genotypes with a stable region in terms of performance drought and low sensitivity to drought were functional, but genotype 4 was

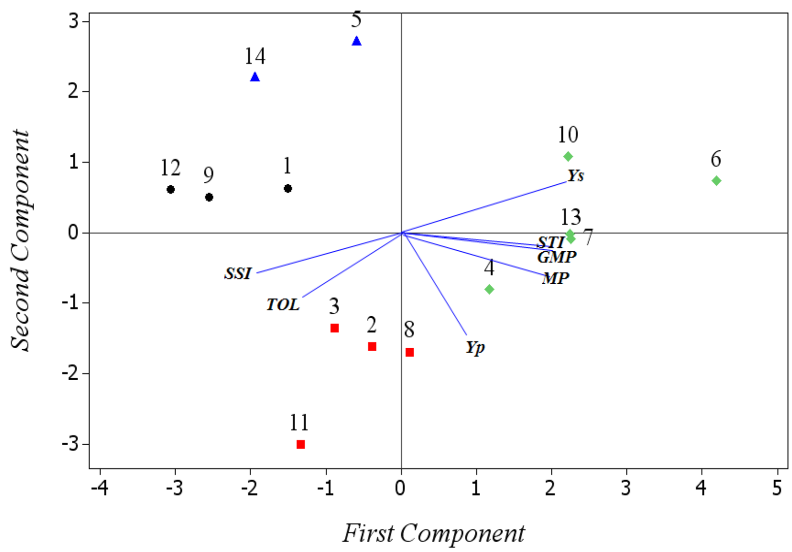

Figure 2. Biplot for five tolerance and susceptibility indices in the 14 genotypes of wheat on the basis of first and second components. Tables 3 and 1 show the abbreviations and genotypes names, respectively.

also high in the normal conditions. Genotypes 3, 2 and 11 (bottom left chart) in the area with lower performance in terms of lower sensitivity to drought stress were studied, while genotypes 1, 5, 9, 12 and 14 (upper left graph) indicated high performance in normal conditions and were highly sensitive to drought.

Overall, according to indicators of tolerance and sensitivity to stress and the average rating (Mean R) indices, as well as the results and biplot situation observed in the two genotypes, genotypes 6, 7, 13 and 10 were evaluated as the most tolerant genotypes. These genotypes, with an average rating of 3.4, 3.2 and 3.6 (the lowest average rating) respectively, were allocated to the relative stability of good indicators. However, the genotype had 14 as the most sensitive genotype. This genotype was recognized by almost all indicators as the most susceptible genotype with an average rating of 10.6 allocated to the bi-plot drawn in areas with low yield stress conditions (low yield stress) and was highly sensitive to drought (Figure 2 and Table 3). MP and STI index having a significant positive correlation with grain yield in both conditions (normal irrigation and irrigation) were better than other indicators which seemed to be selected as high values of this indicator; as such, they were used to obtain high performance irrigation and drought in the usual condition. Therefore, based on the results of the study, the most appropriate indicators to assess stress tolerance indexes are MP and STI. Similar results were also obtained by different researchers who were of the opinion that MP and STI are appropriate and efficient indicators to assess drought tolerance. Shafazadeh et al. (2004), Nikkhah (1999), Haghparast (1995) and Shafazadeh et al. (2004), in their studies on bread wheat varieties, concluded that indices STI, GMP and MP have highly meaningful and positive correlation with yield of varieties in drought stress conditions, and for this reason, the suitable indices to screening varieties are drought tolerance and high yield potential. Results from this study with the findings and results of other studies are very similar. Another point in this study is that the high similarity indexes of TOL, SSI and STI indicators were partially superior to MP and GMP in genotypes.

Genotypes based on indicators that TOL and SSI were identified as tolerant genotypes in terms of performance were highly stressful. More so, the genotype based on indicators of STI, MP and GMP was selected as the tolerant genotype, in both normal and stress conditions with relatively high performance. Mozaffari et al. (1996), in their investigation into the similarity indices of MP, STI and GMP and the dissimilarity of the two indicators, pointed out SSI and STI.

REFERENCES

Abdemishani S, Jafarishabestari J (1988). Evaluation of tolerance to drought in wheat varieties. Iranian J. Agricultural Sci. 19 (1-2): 37-42.
Aflatooni M, Daneshvar M (1993). Effect of water deficit on grain of four grain sorghum cultivars in Isfahan. Iranian J. Agric. Sci. 24 (3-4): 29-45.
Ahmadi J, Zaymali Khaneghah H, Rostami MA, Choukan R (2000). Study on drought tolerance in late maturity grain corn hybrids. Iranian J. Agric. Sci. 31 (4): 891-907.
Ahmadzadeh A (1997). Determination of the most appropriate drought resistance index in corn lines. MSc. Thesis, College of Agric. Univ. of Tehran, Iran. p. 238
Annicchiarico P, Pecetti L, Boggini G, Doust MA (2000). Drought resistance in cereals. Crop Sci. 40: 1810-1820.
Bahar B, Yildirim M (2010). Heat and drought resistance criteria in spring bread wheat: Drought resistance parameters. Sci. Res. Essays S (13): 1742-1745.
Bushuk W, Rasper VF (1994). Wheat production, properties and quality.

Blakie Academic and professional. An imprint chapman and Hall. pp 273-310.
Ehdaei B (1995). Variation in Water-use efficiency and its components in wheat: I. Pot and field experiments. Crop Sci. 35: 1617-1626.
Emam Y, Seghatoleslami MJ (2005). Crop yield: Physiol. and processes. Shiraz Univ. Press. 593 pp.
Fernandez GCJ (1992). Effective selection criteria for assessing plant stress tolerance. In Proceeding of the Symposium. Taiwan, 13-16 Aug. pp. 257-270.
Fisher RA, Maurer R (1978). Drought resistance in spring wheat cultivars: I. Grown yield responses. Aust. J. Agric. Res. 29: 897-912.
Gupta VS (1995). Production and Improvement of Crop for Drylands. Oxford and IBH Publication Co. New Delhi. P. 431
Haghparast R (1995). Selection for resistance to drought in wheat. MSc. Thesis, College of Agric. Univ. of Tabriz, Iran.
Harlan JR (1981). The early history of wheat**.** pp. 1-19. In: Evans, L.T. and Peacock, W.J. (eds.) wheat Science Today and Tomorrow. Cambridge Univ. Press, Cambridge, UK.
Moghaddam A, Hadizadeh H (2000). Use of plant density in selection of drought tolerance varieties in corn. Iranian J. Crop Sci. 2(3): 25-38.
Mollasadeghi V (2010). Effect of potassium humate on yield and yield components of wheat genotypes under end seasonal drought stress condition. Thesis of in plant breeding. Islamic Azad Univ., Ardabil branch.
Mostafavi KH, Hosseinzadeh AH, Zeinali Khanegah H (2005). Genetics analysis of yield and correlated traits in bread wheat (*Triticum aestivum*). Iranian, J. Agric. Sci. 36 (1) 187-197.
Mozaffari K, Arshi Y, Zeynali Khaneghah H (1996). Study of drought stress on some of morpho-physiological traits and yield components of sunflower. Seed and Plant 12(3): 24-33.
Mustafa MA, Boersma L Kronstand WE (1996). Response of four spring wheat cultivars to drought stress. Crop Sci. 36: 982-986.
Naderi A, Majidi HeravanE, Hashemi DesfuliA, Rezaeii AM, Normohammadi G (2000). Assessment of tolerance indices to environmental stresses and introducing of new index. Seed and Plant 15: 390-402.
Narayan D, Misra RD (1989). Drought resistance in varieties of wheat in relation to root growth and drought indices. Indian J. Agric. Sci. 59: 595-598.
Nikkhah HR (1999). Study on heritability of resistance to drought in bread wheat. MSc. Thesis, College of Agric. Univ. Tehran, Iran.
Nourmand Moayed F (1997). Study on quantitative trait and their relationship with yield in bread wheat under irrigated and dryland conditions and determination of the most appropriate drought resistance index. MSc. Thesis, College of Agric. Univ. Tehran.
Parvizi Almani MS, Abdemishani S, Yazdi Samadi B (1997). Study on drought tolerance in different sugar beet genotypes. Iranian J. of Agric. Sci. 28 (3): 15-24.
Reynold M, Skovmand B, Tre Thowan R, Pfeiffer W (1999). Evaluating a conceptual model for drought tolerance. Workshop on Mol. Approaches for the Gene. Improvement of cereals for Stable Prod. in Water-limited Environ. CIMMYT Mexico DF Mexico.
Richards RA (1996). Defining selection criteria in improve yield under drought. Plant Growth Regul. 20: 157-166.
Rosielle AA, Hambling J (1981). Theoretical aspects of selection for yield in stress and non-stress environments. Crop Sci. 21: 943-946.
Sarmadnia G, Koochaki A (1997). Crop Physiology. Jihad-e-Daneshgahi Mashhad Publications, Mashhad, Iran, p. 467
Shafazadeh MK, Yazdanswpas A, Amini A, Gannadha MR (2004). Study of terminal drought tolerance in promising winter and facultative wheat (Triticum aestivum L.) genotypes using stress susceptibility and tolerance indices. Seed and Plant 20: 57-71.
Uddin N, Carver BF, Clutter AC (1992). Genetic analysis and selection for wheat yield in drought –stressed and irrigated environments. Euphytica 62: 89-96.