

# Evaluation of drought tolerance of bread wheat genotypes by use of stress tolerance indices

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**ABSTRACT:** In order to identify traits effective on the yield and determine the best and most efficient drought tolerance indices for bread wheat in cold region of Ardabil, an experiment was conducted on 8 bread-wheat genotypes (treatment) based on complete randomized block design with three replications at experimental farm of Islamic Azad University, Ardabil Branch, in 2010. Examination of drought tolerance indices revealed that indices such as STI, GMP and MP were highly correlated with Yp and Ys, which were designated as the most efficient indices. Moreover, genotypes such as Tous and 4041 by producing the highest yield were the most tolerant genotypes. Saratovskaya-29 was identified as the weakest genotype in the region both at stressed and normal conditions.

**Keywords:** *Triticum aestivum* L, drought stress, tolerance index

## INTRODUCTION

Wheat is a strategic good like energy and considered one of the most important indices for agriculture (Shahryari et al., 2011). Drought is one of the most important factors limiting crop production such as wheat production in the world as well as in Iran. This problem is more highlighted with the fact that over a quarter of land area on the earth is considered as arid and semiarid regions (Komeili et al., 2008). Iran is located in a region where the precipitation rate is low and its distribution varies from one year to another, which makes it hard to predict the rate and distribution of the precipitation. Consequently, under such a condition grain yield also shows many fluctuations in consecutive years [Mollasadeghi et al., 2011]. Iran is situated in desert belt of the world so has an arid and semiarid climate. The mean precipitation rate in the country is as low as about 250mm, which is one third of global mean precipitation, while it covers 1.2% of dry lands on the earth. Furthermore, out of 18.5 million hectares of arable lands in the country, 6.2 million hectares (33.5%) are under Diem cultivation, while approximately 1.2 million hectares of which receive more than 400mm of rainfall [Mohammadi et al., 2006]. The 40 years long statistic indicate that precipitation rates in provinces such as West Azerbaijan, East Azerbaijan, Khorasan, Ardabil, Zanjan and Hamadan are 301, 347, 386, 310, 438 and 340mm, respectively, which mainly occurs during autumn, winter and early spring (Anonymus, 2004). Stress Tolerance Index (TOL) and Mean Productivity (MP) were proposed by (Rosielle and Hamblin, 1981) for determining drought tolerance. MP indicates the mean yield of the cultivar in the two environments and this mean value will be erroneous if the two yields are different from each other, so Fernandez proposed Geometric Mean Productivity (GMP), which did not have the disadvantages of MP. In addition, another index called Stress Tolerance Index (STI) was proposed by Fernandez, which is related to high yield of plant in both environments (Fisher and maurer, 1978). One of the other proposed indices is Stress Susceptibility Index (SSI) that only is capable of selecting high yielding plants under stressed

condition. Asad in his experiment to evaluate drought tolerance indices, observed that SSI, yield under stressed conditions (Ys), yield loss ratio index (Yr), drought tolerance index were selectable during the experiment.

(Mollasadeghi et al, 2011) reported that indices such as MP, GMP, STI and MSTI, which exhibited highest correlation with yield under normal irrigation and drought stress conditions, were designated as the most efficient indices. Curiously, this study was conducted in order to investigate and select genotypes tolerant to terminal drought stress using multivariable statistics.

## MATERIALS AND METHODS

The experiment was conducted in research farm of Islamic Azad University, Ardabil Branch in year 2010, as complete randomized blocks design, with three replications, on 8 bread wheat genotypes in an attempt to identify genotypes tolerant to drought and the associated traits. The study was done as two separate experiments involving normal irrigation and terminal drought stress. With drought stress condition, the irrigation ended in anthesis stage. Based on statistics of Meteorological Station of Ardabil, throughout the cropping season the precipitation rate was 242.3mm, and the minimum and maximum heat occurred during January/February (-1.5 °C) and July/August (25.01 °C) months, respectively (Anonymus, 2010). Seed usage was based on weight of 1000 grains and on use of 450 seeds per square meter, which were sown as linear. For investigation and measurement of the traits, after eliminating margins 10 plants were selected randomly from each plot and labeled. Statistical calculations were done using SPSS-18, MSTAT-C software, whereas diagrams were drawn using Excel program.

## RESULTS AND DISCUSSION

Profile and genealogy of the wheat genotypes being studied, are given in Table 1.

Table 1 . List of study genotypes in this investigation

Number	Genotypes	Number	Genotypes
1	Gascogne	5	Saratovskaya-29
2	Sabalan	6	4041
3	4057	7	MV17/Zrn
4	Ruzi-84	8	Tous

### **Drought tolerance indices:**

Susceptibility and tolerance of the cultivars against drought were studied using 5 indices namely: STI, TOL, GMP, MP and SSI. High values for indices such as GMP, MP and STI represent the higher tolerance and potential yield of the genotypes. Thus, these indices are capable of distinguishing group A from groups B and C. Based on Table 2, genotypes such as Tous and 4041 had the highest values in terms of all three mentioned indices, which suggests they have produced acceptable yield and are of higher tolerance under normal conditions. As for stress susceptibility indices such as TOL and SSI, their low values represent higher tolerance against drought and vice versa, which genotypes 4041, Mv17/zrn and Tous produced the lowest values for these indices and so they were designated as tolerant cultivars. Selection criteria for determining the best selection index are those that maintain a high correlation with yields under both environments. Based on Table 3, GMP, MP and STI had a positively significant correlation with Ys and Yp, whereas SSI and TOL had a negatively significant correlation with Ys and negative correlation with Yp. These results are consistent with the findings of some of the authors in the field (Hagparast, 1995, Mollasadeghi, 2010 and Mollasadeghi et al., 2011).

Evaluation of genotypes by using SSI, classifies the materials of experiment only based on their tolerance and susceptibility to stress, i.e. by using this index, one can identify susceptible and tolerant genotypes without noticing their yield potential (Naderi et al., 2004). Stress susceptibility index is measured based on comparison of ratio of yield for each cultivar under stressed condition to that under non-stressed condition with this ratio for all cultivars. Thus, two cultivars with either high or low yield in both environments may produce equal SSI; for this reason, selection based on this index, confuses the breeders (Naeimi et al., 2008).

(Moghaddam and Hadizadeh ,2000) in their researches on maize did not observe any positive correlation between MP and yield under stressed condition, which this is in contrast with results obtained from the present study

Table 2 . Tolerance and susceptibility estimation for wheat genotypes using relevant indices

Number	Genotype	YP	YS	STI	GMP	MP	TOL	SSI
1	Gascogne	3.87	2.47	0.67	3.09	3.17	1.40	1.86
2	Sabalan	3.80	3.16	0.84	3.46	3.48	.64	.87
3	4057	4.38	3.39	1.04	3.58	3.885	.99	1.16
4	Ruzi-84	4.00	2.87	0.80	3.39	3.435	1.13	1.45
5	Saratovskaya-29	3.09	2.27	0.49	2.66	2.68	.82	1.37
6	MV17/Zrn	3.62	3.25	0.82	3.43	3.435	.37	.53
7	4041	3.88	3.53	0.96	3.7	3.705	.35	.46
8	Tous	4.00	3.93	1.10	3.96	3.965	.07	.09

Yp: Yield in normal condition  
 SSI : Stress Susceptibility Index  
 TOL : Tolerance  
 GMP : Geometric Mean Productivity  
 Ys: Yield in stress condition  
 STI :Stress Tolerance Index  
 MP : Mean Productivity  
 For genotypes name see Table 1

Table 3 . Matrix of simple correlation coefficients between drought tolerance indices and grain yield under two stressed and non-stressed conditions

	Yp	Ys	STI	GMP	MP	TOL
Ys	0.600*	1				
STI	0.809**	0.953**	1			
GMP	0.740**	0.964**	0.971**	1		
MP	0.850**	0.932**	0.996**	0.971**	1	
TOL	0.109	-0.729**	-0.493	-0.564	-0.431	1
SSI	-0.095	-0.852**	-0.656*	-0.717**	-0.605	0.978**

\* and \*\* Significantly at  $p < 0.05$  and  $< 0.01$ , respectively

(Farshadfar et al, 2001) in their study on pea reported that all the indices had a positively significant correlation with the yield under non-stressed condition, whereas the correlation between TOL and yield was negatively insignificant under stressed condition. Results of this research are in line with findings of (Nourmand Moayed et al., 2001). They reported a positively significant correlation between GMP and STI, and yield of wheat. (Haghparast ,1995), (Nikkhah ,1999) and (Shafazadeh et al., 2004) also in their study on wheat genotypes reported that yield under stressed condition had a positive and highly significant correlation with MP, GMP and STI, whereas yield under non-stressed condition had a positively significant correlation with all the indices of drought tolerance and susceptibility. They argued that the positive and significant correlation of the indices with yield under both stressed and non-stressed conditions suggests that these indices are efficient for evaluation of genotypes' drought tolerance.

### CONCLUSION

Genotypes such as Tous, 4041 and Mv17/zrn were designated as tolerant cultivars in terms of TOL and SSI indices. However, apart from Tous, other cultivars did not produce optimal yield, nevertheless because of their tolerance they are desirable for arid and semiarid regions.

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