Journal of Biology and Today's World
ISSN 2322-3308
Journal home page: http://journals.lexispublisher.com/jbtw/

Received: 03 November 2012 • Accepted: 15 November 2012

Research

doi:10.15412/J.JBTW. 01020205

Evaluation of drought tolerance indices bread wheat genotypes in end-season drought stress conditions

Vahid Mollasadeghi*

Department of Agronomy and Plant Breeding, Ardabil branch, Islamic Azad University, Ardabil, Iran

*correspondence should be addressed to Vahid Mollasadeghi, Department of Agronomy and Plant Breeding, Ardabil branch, Islamic Azad University, Ardabil, Iran; Tell: +98; Fax: +98; Email: vahidmollasadeghi@gmail.com.

ABSTRACT

One of the most important wheat breeding strategies under Mediterranean climate is to achieve genotypes that are potentially capable of producing desirable yield while encountering water limitation during their flowering stage. 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 12 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. By analyzing to main components based on drought tolerance indices, the two main components accounted for 99.54% of the variations. Saratovskaya-29 was identified as the weakest genotype in the region both at stressed and normal conditions.

Key words: drought stress, tolerance index, bread wheat

1. INTRODUCTION

Apart from being important commercially, it is also an increasingly functional tool in political and international relations all around the world. Although Iran boasts nearly 1% of world population, it consumes roughly 2.5% of wheat produced worldwide. Wheat is a strategic good like energy and considered one of the most important indices for agriculture (1, 2). 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 (3, 4). 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 (5). Iran is situated in desert belt of the world so it 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 (5, 6). 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 (7). Stress Tolerance Index (TOL) and Mean Productivity (MP) were proposed by Roselle and Hamblin 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 (8). 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, (5) 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. Mollasadeghi et al, (9) in their experiment on 14 wheat genotypes concluded that based on correlation of the indices with yields in two stressed and normal condition, MP and STI are the most efficient indices. Curiously, this study was conducted in order to investigate and select genotypes tolerant to terminal drought stress using multivariable statistics.

2. 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 12 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 (1). 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 Snagit-8, Minitab-15, SPSS-18, MSTAT-C software, whereas diagrams were drawn using Excel program.

3. 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*	*Number*	*Genotypes*
1	Gascogne	5	Gobustan	9	4061
2	Sabalan	6	Saratovskaya-29	10	4041
3	4057	7	MV17/Zrn	11	Sissons
4	Ruzi-84	8	Sardari	12	Tous

3.1. 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, 4041 and 4057 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. According to Fernandez (8), the most efficient selection criteria are those that are capable of identifying genotypes that give an equal indication of yield under both environments (group A). 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 (5). Cluster analysis (Figure 1) classified 12 study genotypes in two groups, while analysis of discriminant function verified this classification of study genotypes. In order to have a good understanding of these indices on yield of the genotypes and to determine the best genotypes, indices were analyzed into two main components (Table 4 and Figure 2). 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 (10). 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 (5). Moghaddam and Hadizadeh (11) 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. Mollasadeghi (6) in his study on 12 bread wheat genotypes observed a positively significant correlation between MP index and grain yield under both stressed and normal conditions, which is consistent with results of the present study.

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

Number	Genotyoe	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	Gobustan	3.73	2.75	0.72	3.2	3.24	.98	1.35
6	Saratovskaya-29	3.09	2.27	0.49	2.66	2.68	.82	1.37
7	MV17/Zrn	3.62	3.25	0.82	3.43	3.435	.37	.53
8	Sardari	3.93	3.09	0.85	3.48	3.51	.84	1.10
9	4061	3.67	3.16	0.81	3.41	3.415	.51	.71
10	4041	3.88	3.53	0.96	3.7	3.705	.35	.46
11	Sissons	3.46	2.73	0.66	3.07	3.095	.73	1.09
12	Tous	4.00	3.93	1.10	3.96	3.965	.07	.09

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
For genotypes name see Table 1.

Table 3. Mattress 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

The first component accounting for 57.33% of variance in data mattress had a high correlation with GMP, MP, Yp and STI. Since, for a better efficiency this component must have a higher numerical value, it may be designated as component of yield potential and drought tolerance. This component distinguishes drought tolerant genotypes with high yield potential from susceptible genotypes with low mean yield. The second component accounted for 42.20% of overall variation and produced a high correlation with SSI and TOL. Thus, second component can be referred to as component of stress susceptibility. Positive correlation of these indices with the second component, which their low numerical values lead to selection of more tolerant genotypes, must have lower numerical values. Because, this component distinguishes genotypes producing low yield under stressed condition and with higher SSI and TOL. These results are consistent with findings by (12). Farshadfar et al, (13) 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. Fischer (8) also in his three-year long study conducted under normal and low water stressed condition realized that there was a significant correlation between indices of stress susceptibility and grain yield. Results of this research are in line with findings of Nourmand Moayed et al, (14). They reported a positively significant correlation between GMP and STI, and yield of wheat. Haghparast (15), Nikkhah (16) and Shafazadeh et al, (17) 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.

Table 4 . Vectors and Eigen values for five tolerance and susceptibility indices in 12 genotypes

Component	Eigen value	% of Variance	Yp	Ys	STI	GMP	MP	TOL	SSI
1	4.013	57.333	0.982	0.704	0.904	0.853	0.934	-0.08	**-0.28**
2	2.955	42.208	0.189	-0.672	-0.420	-0.500	-0.357	0.997	**0.959**

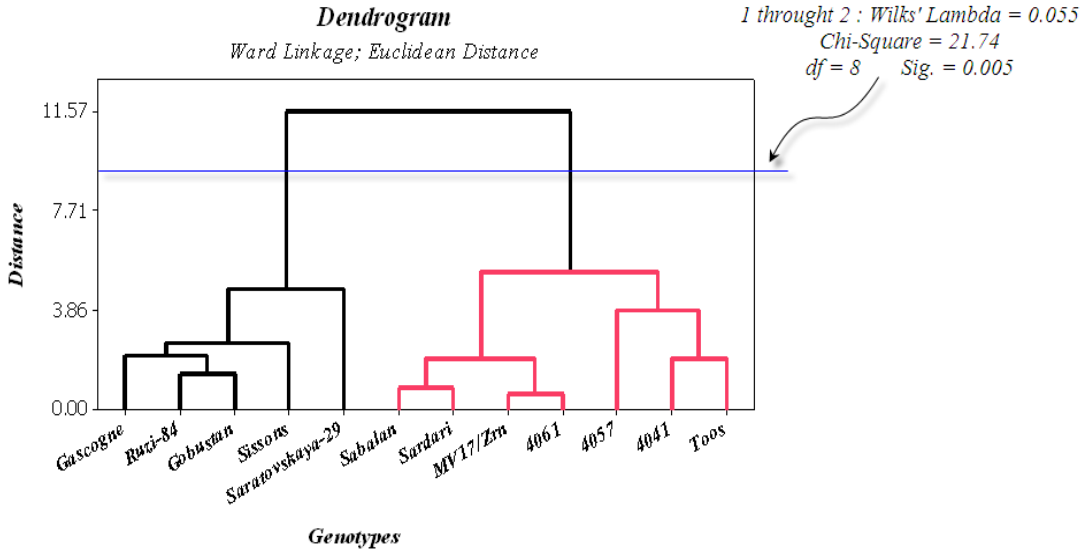

Figure 1. Genotype dendrogram cluster analysis based on indicators of drought tolerance

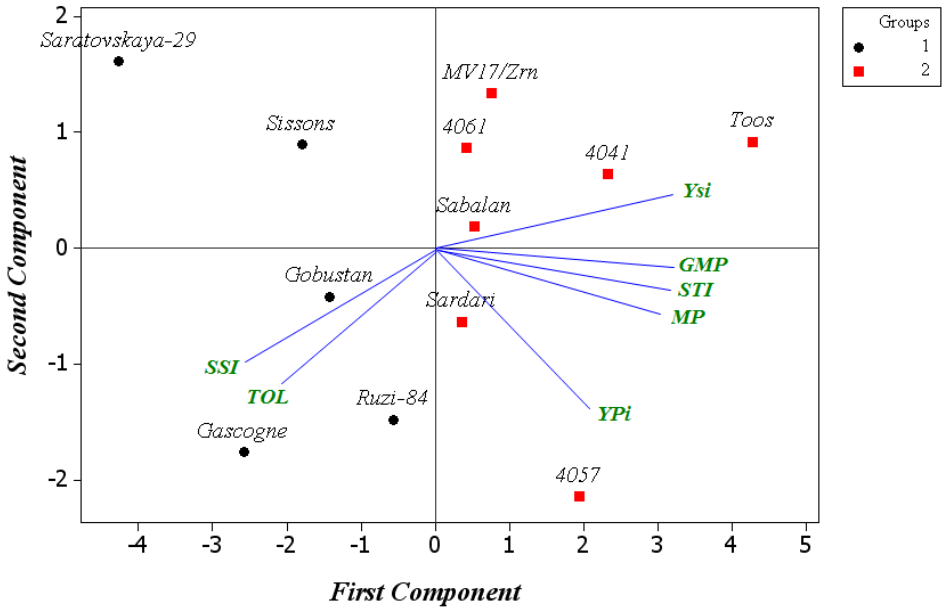

Figure 2. Biplot for five tolerance and susceptibility indices in 12 genotypes of wheat on the basis of first and second components

4. 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. According to results from analysis to main components, GMP, MP and STI were designated as the best indices in the region. Based on these indices, genotypes such as Tous and 4057 were more efficient than the rest of the genotypes in terms of both yield and tolerance to drought, so are recommendable as desirable cultivars for cold and temperate regions.

Funding/ Support

Not mentioned any Funding/ Support by authors.

ACKNOWLEDGMENT

Not mentioned any ACKNOWLEDGMENT by authors.

AUTHORS CONTRIBUTION

This work was carried out in collaboration among all authors.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interests with respect to the authorship and/or publication of this article.

REFERENCES

1.AKBARI L JB, CHAGHA-MIRZA K, FARSHADFAR AA . Evaluation of response of durum wheat genotypes to drought stress in immature embryo culture. The 11th Crop Science and Plant Breeding Congress, Iran. 2010. p. 410-2.
2.SHAHRYARI R MB, MOLLASADEGHI V, KHAYATNEZHAD M Genetic Diversity in Bread Wheat for Phonological and Morphological Traits under Terminal Drought Stress Condition. Advances in Environmental Biology. 2011;5(1):169-72.
3.Komeili H, RashedMohassel M, Ghodsi M, ZarefeizAbadi A. Evaluation of modern wheat genotypes in drought resistance condition. Agricultural researches. 2008;4:301-12.
4.Ober E, Luterbacher M. Genotypic variation for drought tolerance in Beta vulgaris. Annals of Botany. 2002;89(7):917-24.
5.Mollasadeghi V, Valizadeh M, Shahryari R, Imani AA. Evaluation of drought tolerance of bread wheat genotypes using stress tolerance indices at presence of potassium humate. American-Eurasian J Agric & Envirin Sci. 2001;10(2):151-6.
6.Mollasadeghi V, Valizadeh M, Shahryari R, Imani AA. Evaluation of end drought tolerance of 12 wheat genotypes by stress indices. World Applied Sciences Journal. 2011;13(3):545-51.
7.ANONYMOUS. Meteorological Report. Meteorological Organization of Islamic Republic of Iran
2004.
8.Fischer R, Maurer R. Drought resistance in spring wheat cultivars. I. Grain yield responses. Crop and Pasture Science. 1978;29(5):897-912.
9.Mollasadeghi V, Gizilasheg YM, Hazejan RH, Mazhabi H. Evaluation of 14 winter bread wheat genotypes in normal irrigation and stress conditions after anthesis stage. African Journal of Biotechnology. 2013;10(54):11188-95.
10.Naderi A, Majidi-Heravan E, Hashemi-Dezfuli A, Rezaie A, Nour-Mohamadi G. Efficiency analysis of indices for tolerance to environmental stresses in field crops and introduction of a new index. Seed and Plant. 2000;15(4):Pe390-Pe402, en37.
11.Moghadam A, Hadizadeh M. Use of plant density in selection of drought tolerance varieties in corn. Iranian Journal of Crop Sciences. 2000;2(3):25-38.
12.Rosielle A, Hamblin J. Theoretical aspects of selection for yield in stress and non-stress environment. Crop Science. 1981;21(6):943-6.
13.FARSHADFAR A MZM, MATLABI M, IMAM JOME A . Selection for drought tolerance in pea lines. Iranian agriculture sciences Journal. 2001;32(1):65-77.
14.NOURMAND MOAYED F RM, GHANNADHA MR. Evaluation of drought tolerance indices in bread wheat. Iranian agriculture sciences Journal. 2001;32(4):795-805.
15.R. H. Selection for resistance to drought in wheat. MSc. Thesis, College of Agriculture, University of Tabriz, Iran 1995.
16.HR N. Study on heritability of resistance to drought in bread wheat. MSc. Thesis, College of Agriculture, University of Tehran, Iran. 1999.
17.Shafazadeh M, Yazdan Sepas A, Amini A, Ghanadha M. Study of terminal drought tolerance in promising winter and facultative wheat genotypes using stress susceptibility and tolerance indices. Seed and Plant Improvment Journal. 2004;20(1):57-71.