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Assessment of post anthesis drought tolerance in bread wheat genotypes by stress indices

Seied Mehdi Mirtaheri[1], Farshid Hasani[2] and Reza Monem[3]

[1]Department of Agronomy, Islamic Azad University Roudehen Branch, Roudehen-Iran
[2]Seed and Plant Certification and Registration Institute (SPCRI)
[3]Department of Agronomy and Plant Breeding, Islamic Azad University Shahr-e- Rey Branch, Shahr-e- Rey. Iran

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ABSTRACT

Drought, especially after anthesis, is one of the main stresses in wheat production in Mediterranean regions. An experiment was conducted for assessing tolerance of 5 bread wheat genotypes to terminal drought. Experimental design was split plot on the basis of randomized complete block in four replications in Research Farm of agricultural and natural resources university of Ramin in Ahvaz, Iran. Three levels of irrigation include S1 (mild stress), S2 (severe stress), and S- (without stress) as main plots, and 5 genotypes of bread wheat including G1 (Chamran), G2 (Falat), G3 (Verinak), G4 (Kavir), and G5 (Shole) as sub plot. Four drought tolerance indices, stress tolerance (TOL), Stress Tolerance Index (STI), Stress Susceptibility Index (SSI) and Mean Productivity (MP) were used. Whereas the indicates that have the most correlation with grain yield in different conditions are the best index for selection of tolerance genotypes against drought stress, there for (STI) and (MP) was selected for classify of genotypes. There was a significant and positive correlation of (Yp) and (Ys_1) and (Ys_2) with (MP and STI). Totally based on these indices genotypes of Chamran were the most desirable genotypes for both mild stress and severe stress environments.

Key words: Drought stress, bread wheat, tolerance indices, Principal Component

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INTRODUCTION

A terminal drought, with the exception of southern areas in the country, and drought stress is the most important limitation for wheat yield and some other crops. One of the approaches to identify tolerant genotypes to dry environment, some drought stress indices or selection criteria has been suggested by different researches [10, 7]. Selection of different genotypes under environmental stress conditions is one of the main tasks of plant breeders for exploiting the genetic variations to improve the stress-tolerant cultivars [1]. Rosielle and Hamblin (1981) 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 [8]. Fischer and Maurer (1978) proposed a stress susceptibility index (SSI) of the cultivar [3]. Fernandez (1992) 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 [2]. In present study, tolerance level to post-anthesis drought conditions of five bread wheat genotypes were investigated based on some tolerance indices in three irrigation regimes.

MATERIALS AND METHODS

This experiment was conducted in Ramin University between 2005 and 2006. Five cultivars of wheat (Chamran, Flat, Verinak, Kavir and Shole) was grown in three irrigation program which were I1 (post anthesis mild water stress), I2 (post anthesis sever stress) and I3 (normal conditions with enough irrigation). The experiment was randomized complete block design with four replications which treatment consisted of irrigation as main plots and genotypes as sub plots. To determine to soil characteristics 20 samples from 0-30 cm depth and 30-60 cm depth were collected and analyzed by Ramin University soil testing laboratory for basic soil physical and chemical properties (Table 1). P and N fertilizer were applied according to recommendation soil testing laboratory of Ramin University in form of ammonium phosphate urea respectively. Plots sown on 5 December 2005 were 2 m long and 2 m wide in 10 rows. To determine the irrigation time 50% water exhaustion from available soil moisture was used.

Table 1 soil properties of the experimental plots

Depth of sampling (cm)	K(solvable) (ppm)	P(solvable) (ppm)	N(solvable) (ppm)
0-30	128	7	6.3
30-60	73	3	5.8

Drought resistance indices were calculated using the following relationships:

Stress Susceptibility Index [3]:
$SSI = 1 - (YS \div YP) \div 1 - S\ P\ (Y \div Y)$

Tolerance (Rosielle and Hamblin, 1981):
$TOL = YP - YS$

Mean Productivity [8]:
$MP = (YP + YS) \div 2$

Stress Tolerance Index [2]:
$STI = (YP \times YS) \div (P)\ 2$

Where YP is mean yield of the genotype under non-stress condition,
YS is mean yield of the genotype under stress condition,
P mean yield of all genotypes under non-stress condition and S mean yield of all genotypes under stress condition.

Data was analyzed with SAS methods. All data was first analyzed by ANOVA to determine significant ($p \leq 0.05$) treatment effects. Significant differences between individual means were determined using a multiple grouped test in Duncan comparison.

RESULTS AND DISCUSSION

Correlation analysis revealed that yield potential (Yp) and stress yield (Ys1 and Ys2) had highly significant positive correlation coefficients with stress tolerance index (STI) (Table 3 and 4). This results according to Fernandez et al (1992) which reported that STI can be used to identify genotypes that produce high yield under both stress and non-stress conditions [2]. (STI) able to discriminate of high yield genotypes in drought and normal conditions [2] and higher degrees of STI are notation of higher tolerance of genotype against drought conditions. According to this index can classify these genotypes based on drought tolerance respectively: Verinak, Chamran, Falat, Kavir and Shole in mild stress and Chamran, Falat, Verinak, Kavir and Shole in sever stress conditions (Table 2).

MP in
dex in terms of high correlation with grain yield in stress conditions was in second rank, while this index had high correlation with grain yield in the enough irrigation conditions. In the classification of these cultivars, Chamran genotype in both conditions stress was in the first rank (Table 2).

Table 2 Resistance indices of 5 bread wheat genotypes under mild stress, and sever stress environments

Level of stress	Level of genotype	N	mp		sti		ssi		tol	
			Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
i1	G1	4	9067.41	776.51	1.07	0.23	-2.41	0.98	1385.06	1183.42
i1	G2	4	8431.49	391.82	0.99	0.09	-3.22	0.35	365.80	356.81
i1	G3	4	9053.07	1032.96	1.08	0.26	-2.38	0.50	1390.96	629.69
i1	G4	4	7579.40	1272.50	0.73	0.22	-3.40	2.29	635.45	2119.49
i1	G5	4	4284.31	582.87	0.23	0.05	-2.04	0.53	907.23	450.04
i2	G1	4	8809.90	682.03	1.01	0.18	-1.71	0.45	3563.33	3640.37
i2	G2	4	8573.35	290.40	0.98	0.06	-2.17	1.32	223.94	223.06
i2	G3	4	8080.15	424.48	0.79	0.11	-0.52	1.48	2363.88	1172.96
i2	G4	4	7120.10	2075.63	0.68	0.32	-2.04	1.53	1094.76	1577.63
i2	G5	4	5060.16	943.99	0.34	0.13	-2.80	1.08	131.38	620.79

Table 3 Correlation between drought tolerance indices with grain yield under mild drought stress conditions
ns, *and **means non-significant, significant at 5 and 1% levels of probability, respectively

	MP	STI	SSI	TOL	YS_1
STI	0.980^{**}				
SSI	-0.149^{ns}	-0.180^{ns}			
TOL	0.097^{ns}	0.029^{ns}	0.939^{**}		
YS_1	0.863^{**}	0.880^{**}	$-.612^{**}$	0.419^{ns}	
Yp	0.885^{**}	0.837^{**}	0.313^{ns}	0.548^{*}	0.530*

Table4 Simple correlation between drought tolerance indices with grain yield under sever drought stress conditions
ns, *and **means non-significant, significant at 5 and 1% levels of probability, respectively

	MP	STI	SSI	TOL	YS_1
STI	0.979^{**}				
SSI	-0.179^{ns}	-0.072^{ns}			
TOL	0.324^{ns}	0.276^{ns}	0.476^{*}		
YS_2	0.755^{**}	0.825^{**}	$-.421^{ns}$	-0.102^{ns}	
Yp	0.522^{*}	0.477^{*}	0.245^{ns}	0.329^{ns}	0.256^{ns}

Two indices of drought resistance, STI and MP were allocated the highest correlation between the indices with more than 98%, and also showed significant correlations at 1% level (tables 3 and 4). The other hand, the negative relationship between stress tolerance index (STI) and stress susceptibility index (SSI) is another reason that shows stress tolerance index is an appropriate criterion for drought tolerance cultivars selection.

Principal component analysis

Principal component analysis (PCA) is a better approach than a correlation analysis such as a biplot for identifying the superior genotypes for both stress and non-stress environments [10]. Screened plot in Fig 1 and Table 5 demonstrated that an increase in the number of the components was associated with a decrease in eigenvalues, which is an important indicator in general genetics and very valuable for evaluating crop tolerance of drought stress. This trend reached its maximum at three factors which all together accounted for 87.5% of the total variation of grain yield so that PC1 accounted for about 55.4% of the variation in grain yield; PC2 for 19.4% and PC3 for 12.7% (Table 5). Results showed that PC1 correlated moderately well with STI and SSI. So, the PC2 correlated moderately with Mp and STI. The next component (PC3) contained Mp and TOL (Table 5).

According to this method a significantly positive correlation was found between STI and MP, indicating that these indices are able to select tolerate genotypes (G1, G3, and G2). These indices had a negative correlation with, SSI and TOL, indicating that these indices are able to select susceptible genotypes (i.e. G5) (Figures 2 and 3). In these figures has been shown distribution of genotypes based on the first and second components. The first component explained 55% of the index changes. While the second component explained

Table 5 Eigenvalue of the correlation matrix for the estimated genotypes of wheat using the principal component procedure

	Princ 1	Princ 2	Princ 3	Princ 4	Princ 5	Princ 6	Princ 7
MP	-.349116	**0.392540**	**0.478427**	-.093465	-.499562	0.477091	-.096046
STI	**0.459754**	**0.180618**	0.064267	0.546653	0.060057	0.162409	-.650431
SSI	**0.482098**	0.073051	0.135249	0.362920	-.118088	0.251734	0.731386
TOL	0.319057	0.066640	**0.741614**	-0.373187	0.378389	-.246568	-.022967
Ys1	-.369597	0.484159	0.127128	0.481767	0.074284	-.594100	0.149175
Ys2	-.426538	-.213029	0.165960	0.289126	0.663864	0.463769	0.075839
Yp	0.118286	0.723685	-.393688	-.325209	0.378781	0.231959	0.065242
Eigen value	3.388	1.358	0.886	0.401	0.337	0.119	0.019
Proportion	0.554	0.194	0.127	0.057	0.048	0.017	0.002
Cumulative	0.554	0.748	0.875	0.932	0.980	0.997	1.000

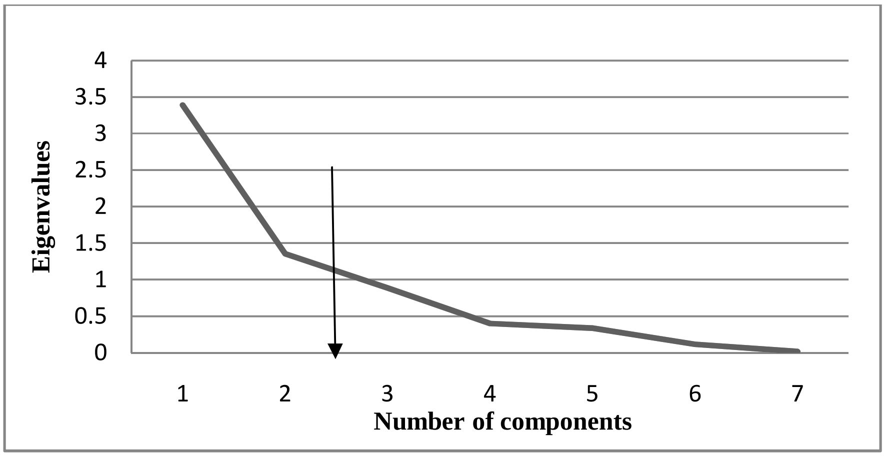

Fig.1 Screened plot showing eigenvalues in response to number of components for the estimated Genotypes of wheat

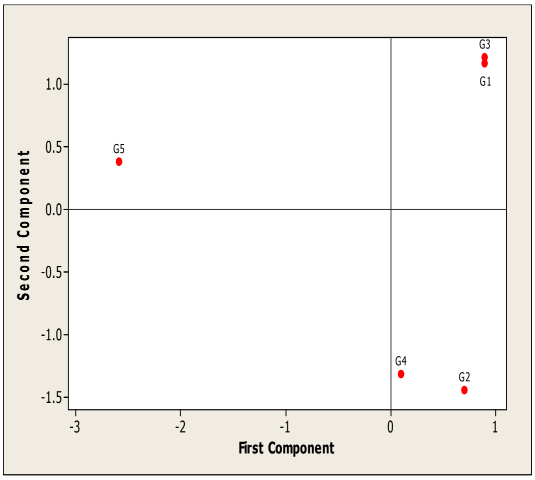

Fig 2. Principal component analysis of genotypes In mild drought stress conditions

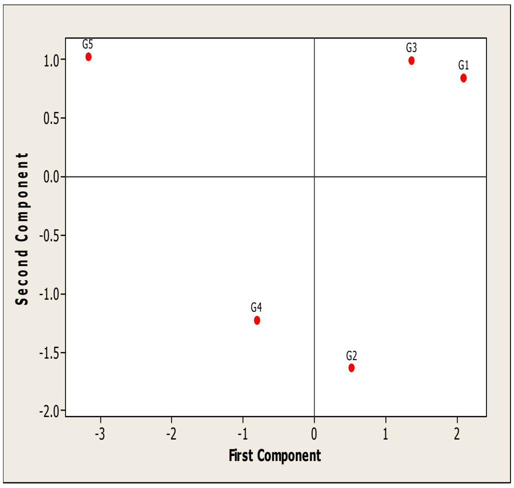

Fig 3. Principal Component analysis of genotypes in severe drought stress conditions

more than 74 percentage of the index changes. Sio-Se Mardeh et al., (2006) and Golabadi et al., (2006) obtained similar results in multivariate analysis of drought tolerance in different crops [9, 4]. According to results of Principal component analysis (Figures 2 and 3) in both of drought conditions, G1 and G2 were tolerate genotypes.

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