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EVALUATION OF DROUGHT TOLERANCE INDICES AND THEIR RELATIONSHIP WITH GRAIN YIELD IN WHEAT CULTIVARS

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Abstract
To illustrate the effect of drought stress on grain yield of 8 wheat cultivars and evaluation of drought tolerance and susceptible ones, two trials were established using randomized complete block design with three replications at research field of University of Mohaghegh Ardabili, Iran. In the first trail, drought was aplplied and irrigation was done once in order to seed germination, but in the second trail, regional normal irrigation regime was used. Wheat cultivars were Azar2, Agostave, Phinican, Sardari, Soysonz, Gaspard, Gascogen, and MV17. Results showed that according to the Fernandz grouping, Azer 2 was suitable for both stress and non stress conditions. MV17, Gascogen and Gaspard were recommended for optimum environment. Sardari cultivar was identified suitable for severe stress environment. Finican, Soysonze and Agostave cultivars had few grain yields in both stress and non stress conditions.

Key Words: Grain yield; Drought stress; Drought tolerance; Wheat.

Introduction

Wheat (*Triticum aestivum* L.) as the most important crop as well as it has specific situation in Iranian food and diets. It is reasonable to assume that wheat is predominantly considered as the most important aspects. Wheat is cultivating about in 228 million hectare around the world. Iranian farmers cultivate an average 6.6 million hectares of wheat each year of which about 4.2 million hectares is rain fed (drought stressed) and remaining of total wheat areas is irrigated or under irrigation [1]. Wheat cultivation after potato crops taking into account as the second crop in Ardabil. In the way that cultivated areas during 2003-2004 were about 344446 hectares of which about 263332 hectares were rain fed but remaining irrigated [2]. Water deficit is a major constraint for wheat production in the rainfed uplands in Ardabil province because large amount of water used for potentially crops, potato for example or raining absence is leading to drought stress in wheat crop and the drought occurred mainly during the stem stage. Drought stress and water shortage is expected to cause significant losses in Ardabil. Water stress caused by drought is a major factor limiting plant growth and crop productivity in Ardabil.

Thus Ardabil agriculture lands are being affected by drought stress conditions or plants may frequently encounter drought stress. Furthermore developing the drought tolerant varieties of wheat could be the main goal of breeding programs to reach reasonable yield. By developing such tolerant varieties may be help to prevent or overcome water loss especially in Ardabil as well as reach to reasonable yield. The use of drought tolerant varieties in the Arbabil can reduce the likelihood of plant injury due to drought stress. Different indices suggested for genotype selecting based on their yield in the stress or non-stress conditions [3]; [4]. Ahmadi et.al [5] in drought tolerant investigations of 10 bread wheat varieties, reported that they distinct the STI, GMP and MP indices of high yield cultivars at both stress and non-stress conditions. According to their researches 3 varieties of 5593/2-3, 6452-6 and 7007/2-6; 4varieties of Falat, Omid, Sardari and 5806-3 and finally 3 varieties of Ghods, Azadi and Roushan, considered as susceptible, semi-susceptible and tolerant respectively. Indices are

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mentioned above were used in drought tolerant varieties of bread wheat [6-8] and native lentil cultivars [9] to finding the best tolerant varieties. Farshadfar & Mohammadi [10] have been reported that the STI is good index in wheat for selecting drought tolerant lines.

We are aiming to a higher production level. The aim of this research was comparing of 8 common wheat varieties in Ardabil province at the full stress and without stresses (well irrigated) conditions and investigating them in the view of stress resistance as well as determining or identifying the drought resistant varieties.

Materials and Methods

This trial was conducted based on two separated experiments. The experiment was arranged in a completely randomized block design with three replications. The study was carried out in research field of agronomy college of Mohaghegh Ardabili University (Altitude, 1350 m. Longitude, 48° 20' E. Latitude, 38° 15' N) during 2006 growing season in order to investigating drought stress effect on 8 different varieties and comparing their ability against drought stress. We are going to identify which one is resistant variety. Wheat verities were composed: Azar2, Agostave, Phinican, Soysonz, Gaspard, Gascogen and MV17.

At the first trial, drought was conducted and irrigation was done only one time just for seed germination but in the second trial, well watering was considered and it was continued until the end of growing season [7]. For determining seed final yield, 2 m^2 plot center was harvested at the end of experiment in the physiology ripening stage. Stress tolerance index (STI), geometric mean production (GMP) [11], drought tolerance (TOL), mean production (MP) [3], stress sensevity index (SSI) [4], , and harmonic mean (HM) [12] indices have been calculated based on yield in the stress and non-stress conditions as follows:

$TOL = Yp - Ys$ $\quad STI = (Yp*Ys) / (Yp)^2$

$SSI = 1-(Ys-Yp)/SI$ $\quad SI = 1-(Ys/Yp)$

$MP = (Ys+Yp)/2$ $\quad GMP = (Ys*Yp)^{1/2}$

$HM = 2(Ys*Yp)/Ys+Yp$

Therefore Yp and Ys were the yield of each cultivars, stressed and non-stressed respectively. Ŷp and Ŷs were also means of total variety that subject to drought and irrigated conditions respectively. Statistic calculations carried out by using SAS software but graph drawing by SPSS.

Results and Discussions

Comparing of seed yield averages of wheat cultivars under drought and well watering conditions (control) are shown in the table1. Comparing averages at both conditions are shown separately. This indicates that cultivar differences against drought were clear than control. So that in the stress condition, according to independent group comparing by 5% confidences, cultivars divided into two groups. The first group is high yield group for example: Azar2, Gaspard, Gascogen and MV17. But the second group is low yield group for example Agostave, Phinican, Soysonz and Sardary. However under drought stress verities could be divided into more groups (Table 1).

Table 1. Means comparison of yield in wheat cultivars in stress and non-stress conditions separately and indices (indices no variance analysed).

cultivar	Cultivar No.	Yp	Ys	Decrease(%)	SSI	TOL	MP	STI	GMP	HM
MV17	1	7552 a	1137.3 c	58	1.18	6414.7	4344.7	0.22	2930.7	1976.9
Gascogen	2	6995.7 a	1266.3 c	81	1.15	5729.3	4131	0.23	2976.3	2144.4
Gaspard	3	7288.7 a	1818bc	75	1.05	5470.3	4553.5	0.34	3640.5	2910.5
Phinikan	4	5216 b	1078.7 c	79.3	1.11	4137.3	3147.3	0.14	2372	1887.7
Soysonze	5	5675.2 b	1652 c	71.3	0.99	4050.3	3650.2	0.23	3036.8	2526.6
Sardari	6	5298 b	2668.3ab	49.3	0.69	2612.7	3991.7	0.36	3771.8	3564.1
Agostave	7	4815 b	1818.3 bc	62	0.78	2996.7	3316.7	0.22	2985.9	2639.7
Azar2	8	7256.3 a	3186.3 a	61	0.85	4469.7	5121.5	0.54	4607.9	4145.9
Average	---	6274.6	1789.5	---	0.98	4485	4032	0.28	3287	2712

Means with similar letters in Yp and Ys column are not significant different.

Table 2. Matrices of correlation coefficient of studied indices and yields

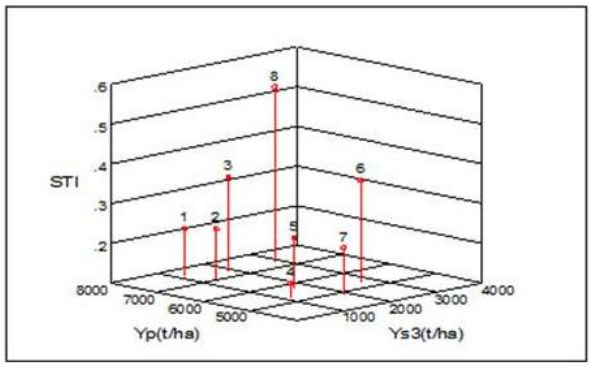
Treats	Yp	Ys	SSI	TOL	MP	STI	GMP
Ys	-0.011	1					
SSI	0.451	-0.884**	1				
TOL	0.858**	-0.523	0.839**	1			
MP	0.854**	0.509	-0.070	0.467	1		
STI	0.604*	0.898**	-0.519	-0.117	0.814**	1	
GMP	0.409	0.903**	-0.604	0.115	0.821**	0.994**	1
HM	0.120	0.120	-0.806*	-0.405	0.615	0.951**	0.954**

Based on response to drought stress it seems that there are significant differences among verities. High yielding or yield declining at drought stress could be physiologically considered as a tolerance criterion (Ahmadi et.al, 2005). According to this criterion at both stress and non-stress, verities tolerance declining with high yield can be arranged as follows: Azar 2, Gascogen and MV17. Their yield declining at the stress as compared with control was 61, 75, 81, and 85 percent respectively. In contrast with MV17, Sardari has the

minimum yield declining (49.3%) in the drought stress condition. As a matter of fact under these circumstances, satisfactory and profitable yields of wheat can be achieved (Table1).

As indicated in table 2, under stress and non-stress conditions there is negative correlation between cultivars yield (r=-0.01). While it has positive correlation with TOL-MP and STI indices and significant interaction 86%, 85% and 60% respectively. This is in agreement with Sanjari et.al (2006) findings. Yield has positive correlation with STI and GMP indices under drought stress (Ys) and significant interaction (86% and 90% respectively). It is demonstrate, these indices are good instruments to identification and anticipation of high yield cultivars in genotypes located under drought stress. In these conditions, seed yield shows negative correlation with SSI and TOL. Thus SSI index is suitable factor to identification wheat with low yield and resistant to drought because under drought stress, yield decreased with increasing SSI value (Table 2) [8].

Fig. 1. Selection of drought tolerant cultivars based on Fernandez model



There is no significant correlation between TOL index with MP, STI, GMP and HM. However it has positive correlation and very significant interaction with SSI (94%). It seems that SSI and TOL have same ability in showing tolerance against drought stress. Although STI index and cultivar yield have positive and significant correlation in both stress and non- stress conditions, was used for drawing three dimension graph to determine drought resistant cultivar (Figure 1). According to Fernandez [11] and Arnon [13] classification, studied cultivars divided as follows:

1- Cultivar No.8 (Azar2) located in group A and functionally had high yield in both stress (rainfed) and non- stress.

2- Cultivars No. 1, 2 and 3 (Gaspard, Gascogen and MV17) located in group B and it was having maximum yield just in non-stress.

3- Cultivar No.6 (Sardari) located in group C. It has shown relative profitable yield in complete stress (rainfed).

4- Cultivars No. 4, 5 and 7 (Agostave, Phinican, Soysonz) located in group D. These have shown low yield in both conditions.

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