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The Study of Seed Yield Stability and Drought Tolerance Indices of Bread Wheat Genotypes under Irrigated and Non-Irrigated Conditions

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Abstract: In order to study and assess the effects of drought stress on yield stability and drought tolerance indices in irrigated and non-irrigated conditions, this experiment was conducted in Sarableh and Mehran towns, Ilam province, in 2004 and 2005. The number of 12 genotypes of bread wheat was cultivated under two conditions, including: Non-stressed (irrigated) and drought stress conditions in a randomized complete design with 3 replications. Morphophysiological traits were measured or calculated depending on the type of each trait. The results indicated that plant height, 1000 kernel weight, Seed yield and harvest index were decreased by drought stress. Under drought stress condition, plant density and 1000 kernel weight had a high positive correlation with seed yield. In irrigated condition seed yield had a high positive correlation with harvest index. Regarding yield in stress and non-stress conditions, drought tolerance indices including MP, GMP, TOL, HARM, SSI and STI were calculated. This study indicated that MP, STI and GMP indices had highest correlation with seed yield and can be used for selecting tolerance variety. According to drought tolerance indices and cluster analysis, Mohammadi, Gahar, Nicknejad and Koohdasht varieties were the best and most tolerance genotypes and had the highest yield.

Key words: Drought tolerance, water stress and yield stability, genotype, bread wheat

INTRODUCTION

Plant growth and development are exposed to environmental conditions permanently. Environmental stresses are the most important yield reducing factors in the world (Ehdaee, 1993; Sarmadnia Koochaki, 1988). Iran is one of the arid and semi arid countries in the world, where water and salt stresses are the most reducing environmental factors of yield. These stresses are most damaging factors. So, this research has been done due to this critical issue.

To increase the yield efficiency and to select tolerant variety, the effective morpho physiological characteristics on yield must be studied (Khodabandeh, 1990; Shiri *et al*., 2001; Noormohamadi *et al*., 2002). These parameters together with seed yield are considered as selecting indices (Ehdaee, 1993; Fernandez, 2000; Rossiel and Hambelen, 1981).

A basic approach to get to these goals is to assess the drought tolerance indices such as MP, GMP, SSI, STI, TOL and HARM by plant breeders.

Shiri *et al*. (2001) suggested that GMP and STI indices are more effective indices for wheat yield forecasting. Naderi (1990) stated that there is high positive correlation between biological yield and seed yield and then he concluded that the variety which produced high dry matter had high seed yield. He added the GMP and STI indices are most desirable indices for better selecting tolerant variety.

While wheat is one of the most important cereals and plays an important role in human feeding, since in Iran the highest sub cultivated land is cultivated by wheat (Khodabandeh, 1990; Noormohamadi *et al*., 2002).

This experiment was conducted in order to study seed yield stability and assess the drought tolerance indices in Sarableh and Mehran towns, Ilam province, in Iran.

MATERIALS AND METHODS

This experiment in order to study the effects of drought stress on yield stability and yield components of

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bread wheat genotypes and make an assess of drought tolerance indices was conducted in Sarableh Town, Ilam province, in 2004-2005.

The cultivation was done by hand in rows. The number of 12 bread wheat genotypes was cultivated under two moisture conditions including: irrigated (non stress) and drought stress condition in a randomized complete design with three replications. The cultivated genotypes consist of Atrak, Chamran, Chanab, Zagros, Sardari, Koohdasht, Showa, Ghalawandi, Ghanari, Gahar, Mohamadi and niknejad. After cultivation, the fields were irrigated and the first irrigated were determined as seeding date. In the first experiment the irrigation was done till physiological maturity stage. In the second experiment the fields was not irrigated until the end of the agronomic season and were only cultivated based on rainfalls.

Morph physiological characteristics including plant height, seed yield, biological yield, harvest index, 1000 seeds weight, seed number per spike, spike number per unit area and drought tolerance indices such as MP, GMP, SSI, STI, TOL and HARM were measured or calculated and the correlation between the seed yield with different traits and also quantitative drought indices were calculated. Regarding yield in stress and non-stress conditions, drought tolerance indices based on related formula (Fernandez, 2000; Rossiel and Hambelen, 1981; Fischer and Maurer, 1978).Were calculated.

$$MP = \frac{Y_P + Y_S}{2} \qquad GMP = \sqrt{(Y_S)(Y_P)}$$

$$SSI = \frac{1 - \left(\frac{Y_S}{Y_P}\right)}{SI} \qquad STI = \frac{(Y_P)(Y_S)}{(\bar{Y}_P)^2}$$

$$TOL = Y_P - Y_S$$

Different statistic analyses were made by MSTAT-C, SPSS and SAS softwares. Correlation between yield and other parameters were calculated and cluster analysis was made based on genetic similarity.

RESULTS AND DISCUSSION

The results showed that the morphological characteristics such as plant height, awn length and spike and peduncle length showed significant difference between varieties. In irrigated condition, Sardari variety

Table 1: Average comparison of 12 wheat genotypes of in non-irrigated conditions (drought stress)

Variety	Peduncle length (cm)	Harvest indices (%)	Beset (kg ha^{-1})	Awn length (cm)	Spike length (cm)	Seed no. of per spike	No. of spike per (m^2)	Biological yield (kg ha^{-1})	1000 seed weight (g)	Seed yield (kg ha^{-1})	No. of spikelet	Plant height (cm)
1	19/33 e	31/13 abc	7779 a	5/56g	9/66fg	35d	510 ab	11317 a	24/22hi	3537/7 ab	17/6b	72/33i
2	34/16bc	30/72 abc	7919 a	7/30d	11/33d e	34/9d	503/3 ab	11417 a	25/61 fg h	3497/3 ab	17/2d	79/66g
3	40/33 ab	27/ abc	7159 a	7/33d	13/66 a	20k	386/6 cd	9860 ab	25/22gh	2700/7bc	15/6g	81/5fg
4	35bc	32/63 ab	6883 a	8/43c	12 cd	25/7i	483/3abc	10218 ab	26/6 e fg	3335/7 ab	15/6g	76h
5	29/83 cd	28/31 abc	8021 a	5/93 f	13/5 ab	24j	496/6 abc	11102 a	33/73 a	3080/7 ab	15/8f	117/83a
6	34/66bc	31/52 ab	8008 a	9/33b	7/16i	38/9b	506/6 ab	11685 a	28/70cd	3686/7 ab	17/6b	87/5 e
7	24/16d e	34/14 ab	7100 a	8/40c	12/33 bcd	27h	478/3 abc	10782 ab	26/90 e f	3681/7 ab	17/5c	70/66j
8	43 a	25/43bc	8140 a	10/40 a	8/83gh	37/4c	401/6 bcd	10902 ab	31/54b	2761/7bc	15/8 f	101/66b
9	31/33cd	20/72 c	6732 a	6/40 e	12/83 abc	30/4 e	363/3d	8410b	20/38J	1708/3c	13/4i	93/83c
10	30 cd	37/49 a	7138 a	6/13 f	10/50 e f	34 e	568/3 a	11363 a	23/26i	4225/7 a	15/03h	82/83 e
11	40 ab	33/34 ab	7473 a	9/50b	7/16i	32/3 f	453/3 bcd	11148 a	27/57d e	3675 ab	19/6 a	71 i
12	27/36 cd	33/97 ab	6831 a	10/56 a	8/16hi	50/6 a	461/6 abcd	10350 ab	29/21c	3519 ab	16/1 e	67/83k

Common letters on each column have same level

Table 2: Average comparison of 12 wheat genotypes of in irrigated conditions, by duncan's method (without drought stress)

Variety	Peduncle length (cm)	Harvest indices (%)	Beset (kg ha^{-1})	Awn length (cm)	Spike length (cm)	Seed no. of per spike	No. of spike per (m^2)	Biological yield (kg ha^{-1})	1000 seed weight (g)	Seed yield (kg ha^{-1})	No. of spikelet	Plant height (cm)
1	22I	37/8 bc	8353 ab	7/93cd	8/13de	35/3d	476/6de	13470ab	33/85ef	5117bcd	22/4a	66/66i
2	39/33 cd	44/6b	7673 ab	7/03d	7/16e	39/8b	617/3abc	13877 ab	35/97de	6204 abcd	16/5h	79/83f
3	39de	39/4 bc	6607 ab	7/03d	12/23b	30/6f	605 abc	10910b	38/34cd	4303d	17/6f	83/5f
4	34g	35/7 cd	10084a	6/93d	10/1c	47/4a	568/3 abcd	15779 ab	36/17de	5695 abcd	16/8g	88/5f
5	44b	37/5 bc	8727 ab	9/70b	10/63c	19/6g	643/3 ab	13978 ab	40/51c	5252 abcd	14/8j	117/50a
6	39de	37/6 bc	9920a	10/96a	5/2f	33/1e	588/3 abcd	15983 ab	41/85bc	6063 abcd	19/2c	88/66e
7	32H	41/1bc	7682 ab	8/83bc	10/16c	38/6c	518/3cde	13108 ab	34/56de	5427 abcd	16/03i	91/5d
8	57a	29/5d	9757a	11/03a	8/20d	18/03h	426/6e	13855 ab	54/05 ab	4098d	18e	108/66b
9	39/16 cd	34/9 cd	9639a	9 bc	13/86a	38/3c	540bcd	14535 ab	29/97f	4896cd	14/6k	93/33c
10	39/66c	445/4b	8619ab	6/96d	11/06c	33/6e	660a	15792 ab	33/80de	7173 abcd	19/5c	91d
11	37f	56/9a	5480b	11/30a	5/23f	20g	565 abcd	13016 ab	36/22de	7537 ab	18/1d	71/33h
12	38/66e	42/4 bc	10477a	9/66b	10/6c	39/5b	603/3 abc	18168a	46/33a	7692a	18/03e	79/33g

Common letters on each column don't show different significant as statistically

Table 3: Drought tolerance indices of 12 wheat genotype based on pooled data of Mehran and Sarabaleh

	Indices							
Variety	GMP	MP	SSI	STI	HARM	TOL	Y_S	Y_P
1	4211.56	4268.44	0.6464	0.5294	4155.54	1387.66	3574.50	4962.16
2	4671.05	4853.16	0.9868	0.6512	4495.77	2634.01	3536.16	6170.16
3	3888.37	4228.25	1.3030	0.4513	3575.81	3321.83	2567.33	5889.16
4	4353.29	4423.11	0.6947	1.5656	4284.68	1546.33	3640.83	5205.16
5	4256.23	4354.66	0.8086	0.5407	4160.01	1841.33	3434.01	5275.33
6	5188.24	5280.33	0.7248	0.8034	5097.77	1963.66	4298.50	6262.16
7	3838.17	4134.66	1.2530	0.4397	3562.93	3075.06	2597.16	5672.16
8	3389.17	3502.25	0.9304	0.3428	3279.91	1764.83	2619.83	4384.66
9	4046.46	4377.75	1.2760	0.4887	3740.24	3341.16	2707.16	6048.33
10	4604.92	4628.75	0.4254	0.4329	4581.21	983.16	4159.66	5097.35
11	6538.72	6592.75	0.5237	1.2760	6485.14	1684.50	5750.50	7435.03
12	4699.12	4800.41	0.7844	0.6591	4599.97	1961.83	3819.50	5781.32

Table 4: The correlation of tolerance indices with seed yield in stress and non-stress conditions

Indices	Y_P	Y_S	MP	GMP	TOL	HARM	STI	SSI
Y_p	1							
Y_s	0.585 *	1						
MP	0.871 **	0.908 **	1					
GMP	0.799 **	0.955 **	0.991**	1				
TOL	0.313	-0.587 *	-0.194	-0.320	1			
HARM	0.730 **	0.980 **	-0.971 **	0.944 **	-0.419	1		
STI	0.803 **	0.946 **	0.988 **	0.994 **	-0.306	0.987 **	1	
SSI	0.017	-0.798 **	-0.478	0.584 *	0.951 **	-0.665 *	0.562	1

*, ** Different letters on each column show significance at 0.05 and 0.01statistical levels respectively

had the longest plant height (117.5 cm) and Atrak was the shortest variety (66.6 cm). In non irrigated condition again Sardari had the highest plant height and Showa produced the shortest plant height (Table 1 and 2).

Plant height is the result of the vegetative activity and nod number in the plant and internod length. Water deficiency decreases internod length and plant height. Plant height is one of the variety dependant traits and water stress intensifies the decreasing of plant height (Ehdaee, 1993; Sarmadnia and Koochaki, 1988; Noormohamadi *et al*., 2002).

Seeds are the final sinks in the plants. Yield consists of many attributes including seed weight, seed number per spike and spike number per unit area (Sarmadnia and Koochaki, 1988; Noormohamadi, 2002). Results showed that in normal condition 1000 seed weight has significant difference between the varieties. Niknejad and Ghanari had the highest (46.33 g) and lowest (29.9 g) weights. In drought condition Sardri produced the highest 1000 seed weight (33.73 g) and Ghanari had the lowest 1000 seed weight (20.38 g).

Seed number per plant is an important factor of yield determining in cereals that because of the ease of the study and yield assessment was taken in to consideration (Naderi, 1990; Ehdaee, 1993).

Spike number per meter square is also an important determining yield factors in crops. This parameter depends on the tillering potential of genotypes. Atrak and Chanab produced the highest and lowest spike number per unit area in drought stress condition. In non stress condition Sardari had the highest spike number per meter square.

Seed yield in cereal crops forms the final commercial production which depends on yield components (Sarmadnia and Koochaki, 1988). Gahar produced the highest yield (4225.7 kg ha^{-1}) while Ghanari which had the lowest 1000 seed weight also produced the lowest yield (1780 kg ha^{-1}). In irrigated cultivation, Niknejad and Ghalavandi produced the highest (7692 kg ha^{-1}) and the lowest yield (4098 kg ha^{-1}), respectively.

Harvest index represents the efficiency of crops which shows how much assimilates are transferred from the photosynthetic sources to the final sinks that are seeds (Khodabandeh, 1990; Naderi, 1990; Sarmadnia and Koochaki, 1988; Rossiel *et al*., 1981). In this study Mohammadi had the highest HI (56.9%) and Ghalavandi produced the lowest HI (29.5%) in irrigated fields. In drought condition Gahar and Ghanari produced the highest (37.5%) and the lowest (20.7%) HI respectively. In stress and non-stress conditions, seed yield had the highest correlation with harvest index. Under drought stress there was a high negative correlation between 1000 kernel weight and spike length which indices when the spike length increase the seeds the seeds compete on assimilate absorption which decreases their weight, but under irrigated condition this state was not observed.

Based on seed yield in stress and non-stress conditions drought tolerance indices including MP, GMP, SSI, STI, TOL and HARM indices were calculated using Fischer and Maurer (1978), Rossiel and Hambelen (1981) and Fernandez (2000) formulas (Table 3).

This study indicated that MP, GMP and STI indices had the highest correlation with seed yield and can be used for selecting tolerant variety (Table 4).

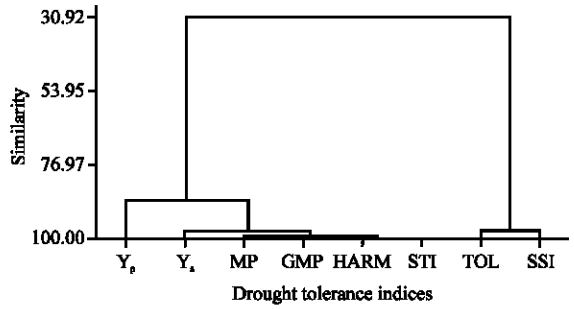

Fig. 1: Cluster analysis of based on drought tolerance indices

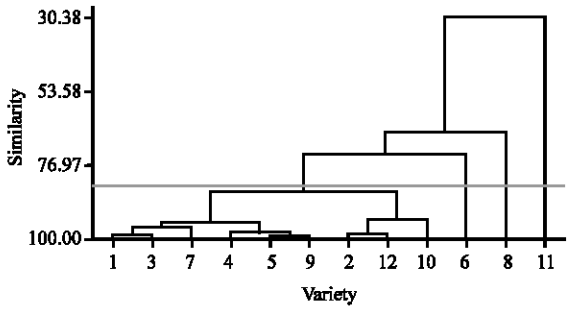

Fig. 2: Cluster analysis of 12 bread wheat genotypes based on MP and STI indices

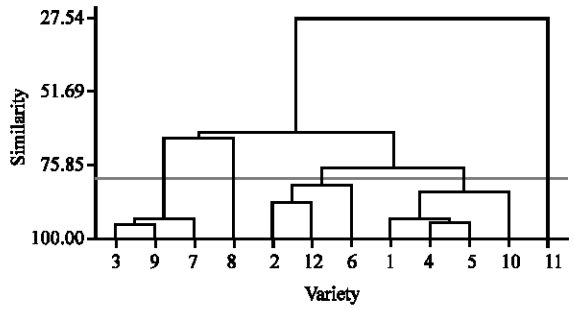

Fig. 3: Cluster analysis of 12 bread wheat genotypes based on drought tolerance indices

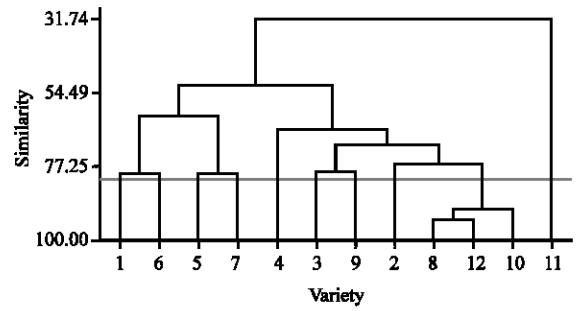

Fig. 4: Cluster analysis of 12 bread wheat genotypes in non-irrigated (drought-stress) conditions

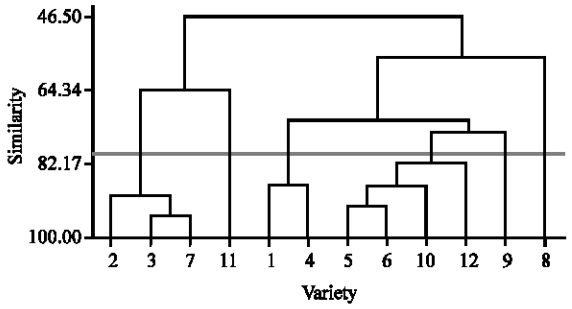

Fig. 5: Cluster analysis of 12 bread wheat genotypes in irrigated (non-stress) conditions

In this study based on MP, GMP and STI can conclude that Gahar, Mohammadi and Niknejad were the most tolerant and Ghanari and Ghalavandi were the most susceptible genotypes. Genotypes cluster analysis was done based on genetic similarity and Mohammadi was determined to be in a separate cluster (Fig. 1-5).

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