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Evaluation of Drought Tolerance of Bread Wheat Genotypes Using Stress Tolerance Indices at Presence of Potassium Humate

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Abstract: In order to evaluate grain yield and some morphological traits of bread wheat genotypes under low-water stress condition and also with presence of potassium humate (EDAGUM®SM), an experiment was performed in the form of split plot on the basis of completely randomized block design with three replications; and in two stressful conditions (stopping irrigation after anthesis and stopping irrigation after anthesis with potassium humate) and without drought stress at the Research Station of Islamic Azad university, Ardabil branch. ANOVA showed that under-study genotypes had meaningful differences for all traits other than straw yield. Genotypes Toos and 4057 have highest grain yield in both stressed and non-stressed conditions. Genotypes Toos and 4057 have highest grain yield in optimal and stopping irrigation conditions after anthesis stage, while genotypes Toos, Gascogne, 4057 and Ruzi-84 had the highest grain yield in the same conditions with potassium humate and they were identified as the most tolerant genotypes to drought. But stress and tolerance indices identified genotypes Toos, Gascogne and 4057 as tolerate after anthesis water deficit at presence of used humic fertilizer. Application of EDAGUM®SM in the condition of after anthesis water deficit produced higher 1000 grain weight, biological yield, straw yield, economical yield. EDAGUM®SM decreased stress intensity of this research condition by 12%.

Key words: Drought · Humic materials · Grain yield · Wheat · Stress tolerance indices

INTRODUCTION

Drought is one of the most important factors to limit agriculture crops including wheat in the world and especially in Iran. Importance of this issue is clear when we have known that more than one quarter (1/4) of the earth is dry and semidry [1, 2]. In areas like Iran in which rainfall is low and its distribution is variable during the year, it's difficult to forecast rainfall. Grain yield also show high oscillations during successive years in such conditions [3]. On the other hand, we observed effectiveness of humic materials with natural source under alive and non-alive stress conditions [4].

Potassium humate increases the crop quality significantly and it increases stability of plant against alive and non-alive stresses [5].Young *et al.* [6] suggested that humic materials can affect physiologic processes of plant growth directly or indirectly. Their direct effects include increasing of permeability of cellular membrane, breathing, biosynthesize nucleic acid, ionic absorption, enzymic action and pseudo-enzymic action. Humic acid minimized fertilizer consumption amounts and it stabilized the plant against heat stresses, drought, coldness, illness, insects and other kinds of agricultural and environmental pressures. Also, production of plant (entirely) indicated that the yield is increased and also it stabilized peduncle as well [7].

Fischer and Maurer [8] proposed two stages in producing drought tolerance variances. In stage one, varieties are sieved according to grain yield under stressed condition and in stage two, the remaining samples are sieved on the basis of morphologic traits which are related to yield and are effective in drought tolerance. Winkle [3] perceived that the most critical stage to drought stress is distance between clustering to anthesis and varieties which can produced high biomass before anthesis and also increased assimilate reserve in the stem, are drought tolerance varieties. In reviewing breeding programs to select better materials, the variety which is stable and high-yield is ideal one. In other words,

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it has high compatibility with environment. It is essential to analyze consequences to study compatibility under both stressed and non-stressed conditions [9]. Different researchers conducted experiments in both conditions and eventually perceived that the variety is optimal which has an excellent response in both stressed and non-stressed conditions and we use from indices like stress sensitive (SSI), tolerance (TOL), mean proficiency (MP) and geometry mean (GMP) to select tolerant and stable genotype [8, 10-12]. In general, it's elicited that one of the executive strategies to increase grain yield in areas under drought stress is application of stress tolerance varieties.

With respect to above discussions, the purpose of this research is studying effect of potassium humate in evaluating its effectiveness rate to reduce stress intensity in farm conditions and finally is introducing drought tolerant genotypes at presence of this natural fertilizer.

MATERIALS AND METHODS

This investigation was conducted in Research Station of Islamic Azad University, Ardabil branch in 2008-2009 agricultural year. This experiment was performed in the form of split plot on the basis of randomized block design with 3 replicates. Stress treatments in three levels of limited and unlimited irrigation are related to main plots (stopping irrigation after anthesis stage and stopping irrigation after anthesis stage with potassium humate) and 12 bread wheat genotypes are related to sub-plots. Each experimental plot included three rows at a distance of 20 cm between each other and with three meter in length. Dimensions of each experimental plot were 7×3 square meter. In order to remove margin effect, 0.5 m was omitted of plot from up to down and the samples were taken from competitive plants.

Liquid humic fertilizer based on peat with commercial name of EDAGUM®SM (produced by Spetsosnastka M Service Ltd in Russia) was applied for pre-planting seed treatment (220 ml in 10 l of water for 1 ton of seed) and treatment of vegetating plants (400 ml of fertilizer in 50 l of water for 1 ha) according to recommendations. Treatment of vegetating wheat plants were done during tillering stage, stem elongation stage and flowering.

In addition to irrigation treatments, the free raining had been performed as snow and rain during plant growth. Under-study traits were included grain yield (ton/ha), harvest index, straw yield (g), grain weight per spike(g), number of grain per spike, spike weight (g) and spike length (cm). Data variance analysis and their mean comparisons (Duncan's multiply range test) performed by softwares like SPSS and MSTAT-C. Drought tolerance indices were calculated individually for each genotype by follow formulas [9]:

$$MP = (YPi + YSi) / 2 \quad TOL = (YPi - YSi)$$
$$STI = (YPi \times YSi) / Yp2 \quad GMP = \sqrt{YPi \times Ysi}$$

Ypi refers to yield of each genotype in non-stressed condition, YSi is yield of each genotype in stressed condition and yield of each genotype in stressed condition at presence of potassium humate, Yp is yield mean of genotypes in non-stressed condition and finally Ys is yield mean of genotypes in stressed condition and yield mean of genotypes in stressed condition at presence of potassium humate [9].

RESULTS AND DISCUSSION

Results from variance analysis show that there is meaningful difference for stress levels between one-thousand grain weight, biological yield, straw yield and grain yield (Table 1). Results also indicated that there is meaningful difference for overall traits (other than straw yield) between genotypes. But there is no meaningful difference between any traits for effect of stress levels. Garsia *et al.* [13] reported a meaningful difference between their under-study genotypes for grain yield, number of grain in spike and one-thousand grain weight. Zaharieva *et al*. [14], Komeili *et al*. [1] and Moghadasi *et al*. [15] also suggested the same results.

Means comparison of stress levels (Table 2) showed that stopping irrigation conditions at presence of potassium humate produced the highest 1000 grain weight by 58.21 g; normal and stopping irrigation without application of potassium humate had the lowest 1000 grain weight respectively by 55.67 and 55.79 g. So, it was obvious that potassium humate led to increasing 1000 grain weight under drought stress conditions.

For biological yield, normal condition with mean of 8.24 ton/ha is related to maximum of this character and stopping irrigation condition with mean of 6.54 ton/ha is related to minimum of biological yield. It is essential to say that the biological yield amount is higher under stopping irrigation condition with potassium humate than the same condition without potassium humate and this indicated increasing of biological yield amount if we use potassium humate.

Table 1: Variance analysis of traits in bread wheat genotypes on the basis of split plot experiment

		Mean of Squares								
Source	df	Spike length	Spike weight	Seed number per spike	Grain weight per spike	1000 grain weight	Biological yield	Straw yield	Harvest index	Grain yield
Replication	2	3.83**	0.496**	44.226*	21.57**	81.013**	17.915**	0.171**	49.05 ns	1.99**
Stress levels	2	0.046ns	0.05 ns	22.412 ns	2.981 ns	73.834*	25.97**	0.177**	4.758 ns	5.019**
Error a	4	0.818	0.04	1.742	2.395	48.61	3.378	0.05	32.522	0.303
Genotypes	11	1.219**	0.536**	231.7**	28.92**	390.13**	2.832*	0.03 ns	76.47**	1.033**
Genotype × Stress levels	22	0.195ns	0.053 ns	10.64 ns	2.84 ns	13.98 ns	1.48 ns	0.02 ns	24.39 ns	0.262 ns
Total error	66	0.161	0.048	11.497	2.827	15.63	1.554	0.024	27.58	0.252
C. V %										

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

Table 2: Comparison of mean stress levels for some traits of under-study genotypes

	Traits			
Stress levels	1000 grain weight (gr)	Biological yield (ton/ha)	Straw yield (gr)	Grain yield (ton/ha)
N	55.668 b	8.244 a	0.6251 a	3.786 a
S	55.788 b	6.546 c	0.4852 b	3.05 c
SK	58.207 a	7.432 b	0.5464 b	3.528 b

Differences between averages of each column which have common characters are not significant at probability level of 5%.

Table 3: Comparison of mean of under-study genotypes on the basis of Duncan' s Multiple Range Test

	Traits							
Genotype	Spike length (cm)	Spike weight (gr)	Seed number per spike	Grain weight per spike (gr)	1000 grain weight (gr)	Biological yield (ton/ha)	Harvest index (%)	Grain yield (ton/ha)
Gascogne	7.54 cde	1.89 a	28.59 bc	17.71 a	62.47 b	7.09 b	49.99 a	3.541 abc
Sabalan	8.1 ab	1.65 ab	28.50 bc	15.40 bcd	54.12 def	7.39 ab	48.86 ab	3.596 abc
4057	7.73 bcd	1.81 a	31.37 ab	16.85 ab	54.13 def	8.03 ab	48.72 ab	3.916 ab
Ruzi-84	7.30 ef	1.54 b	26.84 cd	14.82 cde	53.33 de	7.08 b	46.93 ab	3.338 c
Gobustan	7.69 b-e	1.53 b	23.84 de	14.49 de	61.05 bc	7.54 ab	43.32 bc	3.257 c
Saratovskaya-29	7.08 f	2.28 c	22.95 e	13.21 e	57.70 cd	6.80 b	40.45 c	2.736 d
MV17/Zrn	7.92 bc	1.69 ab	32.30 a	16.98 ab	52.86 ef	6.76 b	50.96 a	3.444 bc
Sardari	7.59 cde	1.04 d	15.51 f	11.42 f	73.78 a	6.92 b	48.75 ab	3.369 c
4061	8.344 a	1.80 a	30.90 ab	16.31 abc	52.56 ef	7.69 ab	45.76 ab	3.323 c
4041	7.41 def	1.70 ab	30.18 abc	15.63 bcd	51.97 ef	7.77 ab	47.97 ab	3.722 abc
Sissons	7.28 ef	1.73 ab	32.60 a	16.62 ab	50.99 f	7.14 b	47.36 ab	3.214 c
Toos	7.9 bc	1.79 a	32.29 a	16.58 abc	51.27 ef	8.65 a	46.31 ab	4.001 a

Differences between averages of each column which have common characters are not significant at probability level of 5%.

Fischer and Maurer [8] achieved meaningful reduction in biological yield wheat which is compatible with results of present research without application of potassium humate. Straw weight, normal condition with mean of 0.6251 g had the maximum straw yield amount and stopping irrigation condition with mean of 0.4852 g and the same condition with potassium humate with mean of 0.5464 g had the minimum straw yield amount. Also, potassium humate in stopping irrigation after anthesis caused relative increasing of straw yield amount.

For economical yield, normal condition with mean of 3.79 ton/ha had the maximum yield and stopping irrigation condition after anthesis with mean of 3.05 ton/ha had the minimum yield. The note point is about increasing of yield rate by 3.53 ton/ha in stopping irrigation condition after anthesis with potassium humate. Foulkes *et al.* [16] and Austin *et al.* [17] reported that the yield in stress condition in anthesis stage and after that has significant reduction relative to non-stressed condition. Means comparison of genotypes (Table 3) showed that Toos with 4.00 ton/ha have higher yield than other genotypes for grain yield, 4057, 4041, Sabalan and Gascogne had no meaningful difference with these genotypes. While Saratovskaya-29 with 2.74 ton/ha had the lowest yield among genotypes. Genotypes MV17/Zrn and Gascogne gave 50.96 and 49.98 ton/ha, respectively, giving the highest percent for harvest index and Sabalan, Sardari, 4057, 4041, Sissons, Ruzi-84, Toos and 4061 had no meaningful difference with these genotypes.

Table 4: Drought tolerance indices in under-study bread wheat genotypes

		Grain yield			drought tolerance indices		
Stress treatments	Genotype	Yp	Ys	TOL	MP	GMP	STI
stopping irrigation after pollination	Gascogne	3.87	2.47	1.41	3.17	3.08	1.03
	Sabalan	3.80	3.16	0.64	3.48	3.46	1.29
	4057	4.38	3.39	0.99	3.88	3.58	1.59
	Ruzi-84	4.00	2.87	1.13	3.44	3.39	1.24
	Gobustan	3.73	2.75	0.97	3.24	3.20	1.10
	Saratovskaya-29	3.09	2.27	0.83	2.68	2.64	0.75
	MV17/zrn	3.62	3.25	0.37	3.44	3.43	1.27
	Sardari	3.93	3.09	0.84	3.51	3.48	1.30
	4061	3.67	3.16	0.51	3.42	3.41	1.25
	4041	3.88	3.53	0.35	3.70	3.70	1.47
	Sissons	3.46	2.73	0.73	3.10	3.07	1.02
	Toos	4.00	3.93	0.08	3.97	3.96	1.69
stopping irrigation after pollination with humate potassium	Gasgogne	3.87	4.28	-0.41	4.08	4.07	1.33
	Sabalan	3.80	3.83	-0.04	3.82	3.81	1.17
	4057	4.38	3.98	0.40	4.18	4.17	1.40
	Ruzi-84	4.00	3.14	0.87	3.57	3.54	1.01
	Gobostan	3.73	3.29	0.44	3.51	3.50	0.98
	Saratovskaya-29	3.09	2.85	0.25	2.97	2.97	0.71
	MV17/Zrn	3.62	3.46	0.16	3.54	3.54	1.01
	Sardari	3.93	3.09	0.84	3.51	3.48	0.97
	4061	3.67	3.14	0.53	3.40	3.39	0.92
	4041	3.88	3.76	0.12	3.82	3.82	1.17
	Sissons	3.46	3.45	0.01	3.46	3.46	0.96
	Toos	4.00	4.07	-0.07	4.04	4.04	1.31

The minimum about this trait is related to saratovskaya-29 which is 40.45%. Ehdaee [18] suggested that yield increasing in short varieties in recent years is due to increasing harvest index by selection in suitable agricultural conditions.

Austin [19] believed that the grain yield can be increased up to 20% by selection of high harvest index. For number of grain per spike, genotypes Sissons, MV17/Zrn and Toos had the maximum amounts with 32.60, 32.30 and 32.29 grain per spike, respectively; and 4057,4061 and 4041 had no meaningful difference with these genotypes. The minimum amount for this trait is related to Sardari. According to Elhafid *et al.* [20] drought leads to reducing inoculation of flower and this affects number of produced grain. Caldrini *et al.* [21] believed that increasing of grain yield in recent years is primarily indebted of increasing of number of grain per spike and this component of yield is more important than grain weight, although both factors cause limitation of yield, evidences show that the storage is much more limitable even for new lines of wheat. For one-thousand grain weight, Sardari with mean of 73.88 g has the maximum weight among other genotypes and Sissons with mean of 50.99 has the minimum and genotypes Toos, 4041, 4061 and MV17/Zrn have no meaningful difference with these genotypes. Genotype 4046 had the maximum spike length and Saratovskaya-29 had the minimum and also genotypes Toos, 4061, 4057 and Gascogne had the maximum spike weight and Sardari had the minimum.

In this research, the stress intensity (SI) in stopping irrigation condition after anthesis and in the same condition with presence of potassium humate have been estimated equal to 19% and 7%, respectively. It is essential to say that this index is just calculable to measuring drought stress intensity in experiment and it is not applied to measuring stress intensity in varieties [8].

In Table 4, amounts of STI, GMP, MP and TOL indices evaluated susceptibility or tolerance rate of under-study genotypes. For TOL index, which its lower amounts meant relative stress tolerance; genotypes Toos, 4041 and 4061 in stopping irrigation conditions after anthesis without humate and genotypes Toos, Gascogne, Sabalan and Sissons in the same condition with humate were identified as tolerant genotypes. Mp, GMP and STI indices, which their high amount indicating stress tolerance, introduced Toos,4041 and 4057 as tolerant genotypes without humate and it also introduced Toos, 4041, Gascogen and 4057 with humate as tolerant genotypes. These indices identified Saratovskaya-29 with yield of 2.27 ton/ha without humate and with 2.85 ton/ha with humate as the most susceptible genotype under after anthesis drought stress conditions of Ardabil region. According to researchers [22-24] the best index to select varieties is stress tolerance index (STI), since it can separate the varieties which have high yield in both stressed and non-stressed conditions.

It is concluded that application of EDAGUM®SM in the condition of after anthesis water deficit produced higher 1000 grain weight, biological yield, straw yield, economical yield. EDAGUM®SM decreased stress intensity of this research condition by 12%. Finally, genotypes Toos, Gascogne and 4057 were tolerate to after anthesis water deficit at presence of humic fertilizer.

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