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Evaluation of tolerance of bread wheat genotypes to water logging stress

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ABSTRACT: Water logging stress is one of the most important factors on product of wheat special in western regions of Golestan province. This experiment was carried out in order to evaluate of six genotypes (N-81-18, Arta, Moghan, N-80-19, URWYT-82-11 and URWYT-82-17) of bread wheat in water logging condition at 2006-2007 cropping season in Gorgan Agricultural Research Station. The experimental design was strip- plot in five replications. Results of ANOVA in two conditions (with water logging stress and with out water logging stress) showed all traits have significant different (P<%1) except of length of spike and number of spikelet per spike. Some traits had significant different between genotypes.
Moghan cultivar and N-81-18 line was identified as maximum genotypes tolerance. Under non-stress condition stress susceptibility index showed positive and highly significant correlation with NO of spike per m2 (r=0.925**). Under stress condition stress susceptibility index showed negative and highly significant correlation with grain number per spike (r=-0.852*), 1000 kernel weight (r=-828*) and harvest index (r=-0.953) . Under non-stress condition stress tolerance index showed positive and highly significant correlation with plant height (r=0.880*). Also stress tolerance index showed positive and highly significant correlation with NO spikelet per spike(r=0.907*) and NO of grain per spike(r=0.891*) under stress condition.

***Keywords*:** Correlation, Stress, Water logging, Wheat

INTRODUCTION

Water logging is an expression to describe the soils that have excess amount of water. This mostly happens in winter and spring and temporarily in summer in tropical areas, due to excessive raining or watering. Reduction in oxygen contents lead o deduction in root and shoot growth. The evaluation of water logging stress in different growth stages (tillering, pollination and heading) in 20 genotypes in water logging situation show that response to water logging in studied genotypes are significantly different from each other. The most reduction occurred in earring stage and the least sensitivity to water logging stress happens in pollination stage. Collaku and Harrison (2002) studied the different wheat genotypes reaction to water logging stress, in field and greenhouse condition. The studied treatments were including 10, 20 and 30 days water logging in 3-4 leaves stage.

They introduced terral, LA 422, pioneer 2691, and shelly as resistant genotypes to water logging situation. In this study coker and FR502W that had high yield in normal situation, had less tolerance to water logging. Collaku and Harrison (2002) expressed that there are too many difference between wheat genotypes responses to water logging stress and adoption to this situation. Lane et al was conducted an experiment in the form of split plot to evaluate 50 wheat genotypes resistance to water logging stress in elongation and earring stages.

The number of spike and grains number in spike significantly affected by water logging stress. According to cluster analyze, 20 genotypes that had high yield selected as resistant genotypes to water logging stress.

Resistant genotypes must be selected by variance analyze and genitival parameters. Water logging tolerance index (WTI) was determined by grain yield, presence of sterile spikelet in main tiller and grain yield in main tiller. Water logging stress in 15, 25 temperatures for 30 days in heading stage of wheat reduced grain yield of 20-70 percent. Physiological reactions and their affection on yield depend on growth stage. Mc Kersie and Haunt (1987) stated that in 2 stages of wheat growth including germination and flowering, the water logging damages was the most. Golestan province with 400,000 hectares of wheat cultivation is one of the most important areas of wheat production in Iran but water logging stress that happen in autumn within lack of drainage and poor soils in some areas in Golestan province lead to late cultivation and low yield.

It is necessary to diagnose the effective characters in resistances to water logging in wheat, inherit these characters and identification the resistant genotypes to water logging to water logging situation.

MATERIALS AND METHODS

This experiment was conducted in Golestan agricultural research center located in 5 kilometer of Gorgan, with 36° and 54 minutes altitude and 54° and 25 minutes longitude. Soils texture was clay-loam with electric conductive (EC) 1-1.5 and ph=7.5-8 and soil depth was 30 cm, height was 5 meter above sea level and rain average was 450 mm. in this experiment 6 cultivar was studied in the form of split plot design with the base of complete randomized in 5 replication. in this study control and water logging treatments placed in 2 horizontal strips and different genotypes cultivated randomize in vertical turn according to climates treatments began from pollination and continued to grain filling.

Each lot included 6 crop rows with 6 meter length and row spaces were 20 cm. There were 12 mail plots in each replication and distances between main plots were one meter.

Three lines with 6 meter length in main plots considered as border lines. After elimination of 3 lines and 50 cm from top and bottom of each line, final plants harvested from 5*1.25 cm area. Biological yield, grain yield, harvest index, plant height, peduncle length, number of spikes in each square meter, grain weight n spike and seed thousand weight were studied.

Finally data were analyzed with SAS software and correlation between studied traits and sensitiveness and resistance index were determined. In order to calculate the sensitiveness and resistance index suggested relation by Rosielle et al were used.

SSI □□[1□□(Ys) /($\overline{Yp}$)] / SI

SI □□[1□□(Ys) /(Yp)]

STI □□[(Yp)□□(Ys) /($\overline{Yp}$)2]

Yp : Yield of each genotype in control situation

Ys : Yield of each genotype in stress situation

: Stress intensity SI

SSI : Sensitivness index to stress

STI: tolerance index to stress

RESULTS AND DISCUSSION

The results of variance analyze show that the effect of water logging stress on biological yield, grain yield, harvest index, plant height, peduncle length, number of spikes in one square meter level, spike length, spike weight and grain weight in spike was significant (table 1). Table 2 show the average amount for each trait in both control and water logging situation.

The studied genotypes show significantly difference in some traits such as plant height, peduncle length, number of spikes in each square meter level, spike weight, number of grains in spike and seed thousand weight. Water logging in stem elongation stage under milky stage lead to yield decrease in 6 genotypes. The most reduction in grain yield was observed URWYT, 82-17 genotypes with 67 percent reduction. Musgrave and Ding (12) also reported 35 percent reduction in harvest index in water logging condition. In water logging condition peduncle length decreased up to 35 percent. Reduction in peduncle length had been reported in other studies. Although when water logging stress happens after stem elongation stage leads to reduction in the number of spikes in each square meter level. Studying of water logging stress affection in different wheat growth stages show that operating stress in heading and pollination sages reduced the number of spikes in each plant. the interaction of water logging and genotypes was significant. it means that spike length differences in different genotypes under water logging condition and control was different and different genotypes had different reactions to water logging stress. Moghan cultivar had the most spike weight in both water logging and control conditions. The least spike weight and te most reduction in spike weight due to water logging stress belonged to URWYT-82-17 line. In control situation Moghan cultivar and in water logging situation N-81-81 had the most average grains number in spike. Collaku and Harrison (2002) also reported reduction in leaves length, grains number in spike and grain yield under water logging condition. Also water logging stress in pollination stage lead to increasing in sterile grains numbers. Musgrave and Ding (1998) expressed that water logging stress with reduction in yield components and mostly through reduction in grains number in spikes and tillers numbers lead to yield reduction.

There was significant difference between 2 environments for seed weight in spike. Water logging stress lead to 36 percent reduction in grain weight in each spike. Seed thousand weight was affected by water logging stress ($p \leq 0.01$). Also the interaction between genotypes and water logging stress for this trait was significant, which state that genotypes had different reaction to environment. Reduction in seed thousand weight was due to reduction in duration of grain filling. Based on grain filling, grain weight stability and durable green leaves, the genotypes that had less sensitivity to water logging stress could be introduced.

In order to determination of tolerance of evaluated genotypes to water logging stress, used the genotypes grain yield in both condition of control and stress and also sensitivity and tolerance index was determined(table 3). According to SSI index, less amounts means that the genotypes had less sensitivity and much more of SSI index, indicating more sensitivity. In normal condition (control) the most grain yield belonged to URWYT, 8211 and Moghan genotypes. According to SSI index, genotypes with less sensitivity have been identified. Mosgrive and ding evaluated 8 wheat genotypes and state that despite of reduction in grain yield in water logging condition, some genotypes seems more tolerant (12).

Use of selection index was a better way than direct select. The evaluation of correlation coefficient tolerance index, sensitivity index and evaluated traits in table 4 show that in normal situation, grain yield had significant positive correlation with number of spike in each square meter. In normal condition, number of grains in spike and peduncle length had high correlation with yield, although the correlation was not significant. Results of yield and sensitivity correlation with evaluated traits in normal condition in table 4 suggest that the sensitivity index had significant positive correlation with number of spikes in each square meter. Also sensitivity index had significant negative correlation with harvest index ($r=0.953^{**}$). It means that with reduction in harvest index, sensitivity to water logging stress was increased. The most reduction in harvest in harvest water logging stress was belonged to URWYT, 8217 with 51 percent reduction and also the most SSI belonged to this genotype.

It could be resulted that lack of ventilation in water logging condition lead to reduction in biomass production. The results of this experiment conform to kay et al results (1984).

Also, in water logging condition, sensitivity index had significant negative correlation to grain yield. Kolaco and Harrison (2002) examined the different genotypes and treatments and studied the water logging stress affection on tiller number, grain weight as traits that are important factor in identification of resistant genotypes. Kolaco and Harrison (2005) also considered seed thousand weight as important factor to select resistant genotypes in water logging stress so that it has significant positive correlation with number of spikelet in each spike and number of grains in spike. According to high genetic variance of tolerance trait and inheritability of this trait, in order to produce certain resistant genotypes, more studying on more genotypes should be done. Then with gene intersection of genotypes with high tolerance and genotypes with high yield produce high yield genotypes with high tolerance to water logging.

Table 1a. ANOVA for different traits of wheat genotypes

S.O.V		df	Biological yield Kg/ha	Grain yield Kg/ha	Harvest index	Plant height cm	Pedancel height cm	Spike/m2
Rep	rep	4	3294273/76 ^{ns}	388833/85 ^{ns}	13/87 ^{ns}	13/91 ^{ns}	0/603 ^{ns}	2093/87 ^{ns}
Water logging stress(wls)	Water logging	1	**213774475/26	**86022365/54	**2316/57	**1485/33	**247/66	**112233/75
Ea (Rep)×(wls)	a	4	3517790/43	918628/54	22/39	42/43	1/46	567/62
Cultivar (C)	cultivar	5	3071530/46 ^{ns}	462083/78 ^{ns}	15/35 ^{ns}	**543/31	**115/15	**23538/13
Eb (R)×(C)	b	20	2778776/16	459879/19	17/90	14/51	2/55	2537/59
Wls×C	Cultivar*stress	5	3092846/18 ^{ns}	547246/71 ^{ns}	41/93 ^{ns}	66/99 ^{ns}	2/58 ^{ns}	8064/35 ^{ns}
Eab (R*wls)×(C)	ab	20	2813590/05	556920/35	20/52	11/172	1/59	2885/62

Table 1b. ANOVA for different traits of wheat genotypes

S.O.V	df	Spike length (cm)	Spike weight (gr)	ss Spikelet/spike	Grain/spike	Grain weight/spike (gr)	Seed thousand weight
Rep	4	0.135 ns	0.119 ns	0.19 ns	2.066 ns	0.089 ns	17.51 ns
Water logging stress(wls)	1	0.352ns	**4.48	0 ns	**252.15	**4.428	**2216.76
Ea (Rep×wls)(	4	0.033		0.79	8/4	0.029	25.66
Cultivar (C)	5	**4.388	*0.31	**11.26	**75.73	0.2*	**97.55
Eb (R×C)	20	0.13	0.04	0.44	4.98	0.26	4.64
Wls×C	5	**0.44	0.02 ns	*2.2	44.83*	0.027 ns	**59.61
Eab (R*wls)×C)	20	0.0919	0.08	0.74	6.98	0.065	8.41

*, ** and ns: Non significant, significant at 5% and 1% of probability levels, respectively

Table 2a. Means comparison of different traits of wheat

Water logging levels						
control	12623/6a	4461/5a	35/26a	95/67a	37a	469/83a
Waterlogging stress	8848/5b	2066/5b	22/83b	85/72b	32/94b	383/33b
genotypes N-81-18	10729a	3340/6ab	29/72a	98/36a	40/16a	406/1b
Arta	9925a	2974/2b	28/82a	79/63d	29/84d	462/5b
Moghan	11308/4a	3609/8a	31/18a	98/61a	33/87c	387b
N-80-19	10525a	3131/7ab	28/64a	86/32c	34/23c	398/6b
URWYT-82-11	11412/5b	3309/8ab	58a	92/71b	35/17bc	396/3b
URWYT-82-17	10516/5a	3219ab	27/9a	88/53c	36/56b	509a

Means followed by similar letters in each column are not significantly different at 5% probability level, according to Duncan's Multiple Rang Test.

Table 2b. Means comparison of different traits of wheat

control	9/1a	1/86a	15/86a	37/84a	1/48	39a
waterogging	8/9b	1/31b	15/86a	33/73b	0/94	27b
genotypes						
N-81-18	8b	1/69b	16/9a	38/2a	1/32	35/03b
Arta	8/75a	1/4c	15/3b	33/9bc	1/04	30/46c
Moghan	9/46b	1/89a	17/3a	39/3a	1/4	35/11b
N-80-19	9/37b	1/58bc	14/5c	31/8d	1/28	38/74a
URWYT-82-11	9/91a	1/53bc	15/9b	35/4bc	1/13	31/93c
URWYT-82-17	8/43a	1/45c	14/5c	36/1b	1/1	31/23c

Means followed by similar letters in each column are not significantly different at 5% probability level, according to Duncan's Multiple Rang Test.

Table3.estimation of tolerance and sensitiveness index to waterlogging for grain yield in bread wheat genotypes

	YP	R	YS	R	SSI	R	STI	R
N-81-18	83/4478	4	2202	3	9470/0	4	940/0	1
Arta	16/4179	6	16/1769	5	0744/1	2	371/0	6
Moghan	33/4652	2	16/2567	1	835/0	6	60/0	2
N-80-19	83/4252	5	2010/5	4	982/0	3	429/0	4
URWYT-82-11	83/4331	4	66/2287	2	879/0	5	497/0	3
URWYT-82-17	16/4874	1	83/1563	6	190/1	1	382/0	5

R (ranking)

Table 4.correlation coefficient between different traits and tolerance index and sensitiveness index to water logging stress and yield

	stress			Control		
	Tolerance index	Sensitiveness index	yield	Tolerance index	Sensitiveness index	yield
Harvest index	0.224^{ns}	-0.953*	-0.322^{ns}	0.222^{ns}	0.417^{ns}	0.926*
height	0.565^{ns}	-0.640nd	-0.702^{ns}	0.88*	-0.512^{ns}	0.448^{ns}
Peduncle length	0.735^{ns}	-0.741^{ns}	0.096^{ns}	0.726^{ns}	0.022^{ns}	0.489^{ns}
Spike number	-0.451^{ns}	-0.374	-0.006^{ns}	-0.449^{ns}	0.925*	0.307^{ns}
Spike length	-0.36^{ns}	0.767^{ns}	0.73^{ns}	-0.343^{ns}	-0.624^{ns}	-0.25^{ns}
Spike weight	0.39^{ns}	-0.269^{ns}	0.469^{ns}	0.575^{ns}	-0.648	0.378^{ns}
Number of spikelet in spike	0.907*	-0.224^{ns}	0.252^{ns}	0.485^{ns}	-0.46^{ns}	0.385^{ns}
Number of grain in spike	0.891*	-0.852*	-0.425^{ns}	0.382^{ns}	-0.253^{ns}	0.864*
Seed weight in spike	0.645^{ns}	-0.556^{ns}	-0.293^{ns}	0.616^{ns}	-0.515^{ns}	0.145^{ns}
Seed thousand weight	-0.74^{ns}	-0.828*	-0.404^{ns}	0.278^{ns}	-0.216^{ns}	-0.164^{ns}

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