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Full Length Research Paper

Responses of some wheat genotypes and their F_2 progenies to salinity and heat stress

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Both heat and salinity cause yield decrease in wheat. Grain yield in wheat has increased as a result of breeding efforts for different stress conditions. However, there are still substantial opportunities to improve grain yield by using conventional breeding under stress conditions, like heat and salt stress. The objective of this study was to investigate heat and salt effects on yield and some agronomic traits of four wheat genotypes and their six half F_2 diallel cross progenies grown in pots. Significant differences were found among the genotypes for grain yield under both heat stress and non-stress condition. There was a mean reduction in yield of 12.6% due to salt stress. The reduction in biomass was higher than grain yield under salt stress while it was lower at heat stress. Grain yield was positively correlated with spike weight, harvest index, grain numbers per plant and biological yield under non stress (NS), heat stress (HS) and salt stress (SS) conditions. Cultivars Seri 82 and Chil's had high yield among parents under both NS and SS. Chil's and its hybrids showed low reduction in yield due to SS; thus, exhibiting salt tolerance. Also, Chil's was found to be good combiner with high General Combining Ability (GCA) effects for grain yield under SS conditions. 84 CZT04 was the most susceptible cultivar under SS. Significant GCA effects of Genç 99 and 84CZT04 provided positive contribution to grain yield under HS. It was impossible to select both heat and salt tolerant genotype with high yield capacity from the used genotypes. However, heat or salt tolerant genotypes can be improved by selection breeding due to genetic variation among genotypes.

Key words: Salt and heat stress, wheat, diallel.

INTRODUCTION

Terminal heat stress is a major restrictive environmental factor in many wheat production areas and salinity problems can frequently result in the consecutive occurrence of both heat stress and salinity on cultivated land, and pose serious problems limiting crop productivity worldwide. One of the reasons for decreasing dry matter production is that transpiration is decreased in a way by closing the stomatas of plant at stress conditions (Mujdeci et al., 2007). Better understanding of physiological changes under each of these conditions is important to improve heat and salt tolerant genotypes.

Genetic variations in the gene pool of a specific character must be found to develop heat and salt tolerant genotypes. Salt tolerance is usually controlled by additive genes. A lot of these genes were not detailed characterized for use in breeding programs (Shannon, 1997a; Shannon and Noble, 1990). Information is lacking on how most genes function in concert with other genes that may have influenced the mechanisms of salt tolerance (Shannon, 1997b). Richards (1995) reported that the productivity is more effective than salt tolerance due to lack of saline soils. Similarly, determination of genetic sources is important to improve heat tolerant genotypes. Tolerance resources for heat stress in wheat may be wild and cultural types of wheat (Khanna-Chopra and Viswanathan, 1999; Dhanda and Munjal 2006; Rehman et al., 2009). The objectives of this study

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Table 1. Effect of salt and heat stress on days to heading, days to maturity, spike weight, shoot weight and spike/shoot ratio in some wheat cultivars and their hybrids.

Parent/crosses	Days to Heading (days)			Days to Maturity (days)			Spike weight (g plant^{-1})			Shoot weight (g plant^{-1})			Spike/Shoot Ratio		
	Non-stress	Salt stress	Heat stress	Non-stress	Salt stress	Heat	Non-stress	Salt stress	Heat stress	Non-stress	Salt stress	Heat stress	Non-stress	Salt stress	Heat stress
Genc 99	130.9	130.1	62.9	170.0	171.6	87.3	5.05	4.48	1.35	3.83	2.59	1.77	1.32	1.72	0.77
Genc 99x84ÇZT04	128.7	129.5	62.3	169.0	169.0	87.0	5.74	5.08	1.57	4.39	3.62	2.14	1.31	1.41	0.75
Genc 99xChil's	131.0	130.8	65.0	169.0	170.6	88.3	5.86	5.32	1.30	4.43	3.41	2.09	1.32	1.56	0.62
Genc 99xSeri 82	129.0	130.8	62.3	169.6	169.6	87.0	5.97	5.12	1.84	4.21	3.21	2.89	1.42	1.61	0.64
84ÇZT04	129.1	129.4	66.3	169.0	169.0	89.3	5.74	4.43	1.32	4.36	2.69	2.46	1.32	1.65	0.57
84ÇZT04x Chil's	128.5	130.6	65.9	168.6	170.0	88.3	5.57	5.12	1.42	4.15	3.23	2.42	1.34	1.58	0.61
84ÇZT04xSeri82	129.3	130.0	63.7	169.3	169.6	88.3	5.95	5.68	1.38	4.30	3.31	2.18	1.38	1.72	0.65
Chil's	134.3	133.6	68.8	171.3	172.0	91.6	5.79	5.09	1.03	4.34	3.33	2.35	1.33	1.52	0.44
Chil'sx Seri 82	131.8	130.1	66.9	170.0	170.6	88.6	5.55	5.50	1.38	4.06	3.22	2.01	1.36	1.76	0.69
Seri82	129.4	129.2	63.8	169.3	168.6	86.3	6.08	4.69	1.36	3.93	2.61	1.65	1.54	1.80	0.82
Mean	130.2	130.4	64.8	169.5	170.1	88.2	5.73	5.05	1.40	4.20	3.12	2.20	1.36	1.63	0.66
$LSD^1_{(\%5)}$	2.2	1.54	1.86	ns	2.04	2.97	0.55	0.74	0.26	ns	0.67	0.65	ns	0.18	0.14
$LSD^2_{(\%5)}$		0.57			0.68			0.17			0.18			0.05	

[1], for genotypes means, [2], for stress means.

were to investigate heat and salt stress effects on yield and some agronomic traits of wheat and to determine combining ability under both stresses.

MATERIALS AND METHODS

The experiment was conducted with four spring wheat cultivars and their half 4 × 4 diallel F_2 populations in 2002-2003 growing season. The bread wheat genotypes of 'Chil's', 'Genç 99', 'Seri 82' and '84ÇZT04' were used as parental lines.

Experiment was arranged in a split plot design with three replications. Main factors were control (normal growth conditions), salt and heat conditions, and genotypes were sub-factor.

Experimental plants were grown in the wire cage under control, salt and heat stress conditions at the Experimental Station of Field Crops Department, Faculty of Agricultural, Cukurova University in Adana-Turkey. Sowing date was 3rd December, 2002 for control and salinity treatment; however, 26th February, 2003 was for heat stress which was constructed by delaying sowing. In the research, 4 g kg of NaCl was added to soil after diluted with water at salinity treatment. The soil was mixed thoroughly and sieved into the pots. 28 seeds were sown per pot (80.0 cm long, 20.0 cm wide and 21.0 cm height) which contain 14 kg mixture of soil, peat, and sand at the rate of 1:1:3, respectively. Also, pH ($CaCl_2$) of the mixed soil was 7.3. At the end of one week, 18 plants per pot were kept. For the control, salt and heat treatments, the water losses caused by evaporation and transpiration was supplied by adding tap water during the experiment. Nitrogen and phosphorus were applied as 200 mg kg^{-1} NH_4NO_3 and 66 mg kg^{-1} P_2O_5 per pot, respectively.

Days to heading and maturity were calculated as the number of days after sowing. Also, other traits were plant height (cm), spike weight (g plant^{-1}), shoot weight (g plant^{-1}), spike/shoot ratio, harvest index (%), spike number (no plant^{-1}), single grain weight (mg), grain number (no spike^{-1}), biological yield (g plant^{-1}) and grain yield (g plant^{-1}). The diallel analyses of Griffing (1956) method 2 (including parents without reciprocal) was conducted by a SAS statistical program.

RESULTS

Mean values

Mean values for spike weight, shoot weight, spike number, grain weight, grain yield and biological yield under salt stress were significantly lower than those under non-stressed conditions (Table 1, 2 and 3). However, spike/shoot ratio, harvest index and grain number per spike were significantly higher under salt stress than non-stress conditions. This showed that the influence of salt stress on shoot weight were higher than spike weight. Genotypes could develop tolerance

Table2. Effect of salt and heat stress on plant height, harvest index, spike number per plant, grain weight and grain number per spike in some wheat cultivars and their hybrids.

Parent/crosses	Plant height (cm)			Harvest index (%)			Spike number (no plant^{-1})			Grain weight (mg)			Grain number (no spike^{-1})		
	Non-stress	Salt stress	Heat stress	Non-stress	Salt stress	Heat stress	Non-stress	Salt stress	Heat stress	Non-stress	Salt stress	Heat stress	Non-stress	Salt Stress	Heat Stress
Genc 99	76.5	72.7	63.5	41.6	46.3	16.8	2.48	2.54	1.78	43.7	40.0	18.5	35.4	32.8	16.0
Genc 99x84ÇZT04	75.2	68.3	65.5	37.1	33.1	15.0	3.29	2.41	1.99	44.4	40.5	14.2	25.7	29.8	19.5
Genc 99xChil’s	80.9	78.8	61.2	40.6	43.2	11.5	2.43	2.55	1.95	44.2	42.4	14.5	38.8	36.6	14.1
Genc 99xSeri 82	73.9	71.2	62.0	39.5	41.2	9.5	2.79	2.29	2.21	42.0	39.6	12.6	34.5	38.1	16.3
84ÇZT04	71.3	73.9	59.4	38.1	41.9	10.4	3.32	2.95	2.27	49.6	38.5	11.4	23.5	26.3	14.9
84ÇZT04x Chil’s	74.7	75.1	62.1	36.4	40.7	11.4	3.20	2.69	2.23	50.3	35.5	12.8	22.1	36.8	15.4
84ÇZT04xSeri82	73.4	74.9	65.1	40.8	42.3	10.4	3.01	2.46	2.04	45.6	46.2	17.7	31.0	33.5	10.5
Chil’s	76.6	70.9	57.4	40.1	43.7	6.5	2.56	2.68	1.99	40.0	37.0	14.0	39.6	36.9	7.9
Chil’sx Seri 82	73.3	70.9	57.6	36.9	43.6	8.6	2.48	2.47	2.22	37.5	37.5	14.0	38.2	38.3	9.6
Seri82	67.9	66.4	55.6	42.9	46.9	9.9	2.93	2.67	2.00	36.0	30.2	11.3	40.9	42.6	13.8
Mean	74.4	72.3	60.9	39.4	42.3	11.0	2.85	2.57	2.07	43.3	38.7	14.1	32.97	35.17	13.80
LSD[1] (%5)	ns	ns	ns	3.07	3.16	1.89	0.59	ns	ns	3.14	4.75	3.55	6.51	8.04	3.73
LSD[2] (%5)		2.68			0.84			0.17			1.17			1.92	

[1], for genotypes means, [2], for stress means.

mechanisms for salt stress after vegetative stages. Days to Heading, days to maturity and plant height were not influenced by salt stress. Mean values of all investigated traits under heat stress were significantly lower than those under non-stress and salt stress conditions. Main reason of these decreases at all traits was late sowing.

Seri 82 and Genc 99 × 84ÇZT04 were early heading genotypes under all test conditions. 84ÇZT04 × Chil’s was earliest heading genotype under non stress (NS) condition, but it lost earliness at both stress conditions. There were no significant differences among genotypes for days to maturity under NS conditions. A slight increase for days to maturity was observed under salt stress (SS) conditions. Spike and shoot weight of genotypes under either stress were significantly reduced in comparison to the NS treatment. Spike/shoot ratio under heat stress (HS) was low due to short grain filling period and adverse effect of severe heat stress at generative stage. There were no significant differences among genotypes for plant height under all tested conditions. Harvest index showed similar pattern with spike/shoot ratio and increased under SS, while it decreased heavily under HS.

Spike number showed wide variation among the wheat genotypes under NS conditions, but there were no significant differences under SS and HS due to adverse effects of stress on the all genotypes. Grain weight significantly decreased under both stress conditions and grain number significantly increased under SS. Genotypes under non stress and salt stress showed 3.1 and 2.8-fold higher grain weight than under heat stress, respectively. The grain number of genotypes showed a 6.8% increase under salt stress (Table 2). Grain yield under both stress conditions showed wide variation within the wheat genotypes, while there was not significant variation under SS. When compared to the non-stress conditions, grain yield reduced by 12.6 % and 89.9 % under SS and HS, respectively. The hybrids of Genc 99 × Chil’s and Genc 99 × Seri 82 had high yield potential under all environments. It was shown that the lowest yield reduction was obtained from Chil’s hybrids Chil’s × Seri 82 (0.3%) and 84ÇZT04 × Chil’s (4.5%) under SS conditions, while Genc 99 × 84ÇZT04 and his parent Genc 99 had the best yield even under heat stress. Although Chil’s hybrids were the most tolerant genotypes to salt conditions, they were not heat tolerant lines. On the contrary, they showed maximum yield reduction under HS

Table 3. Effect of salt and heat stress on grain yield and biological yield in some wheat cultivars and their hybrids.

Parent/crosses	Grain yield (g plant^{-1})					Biological yield (g plant^{-1})				
	Non-stress	Salt stress	Heat stress	Reduction in salt stress (%)	Reduction in heat stress (%)	Non-stress	Salt stress	Heat stress	Reduction in salt stress (%)	Reduction in heat stress (%)
Genc 99	3.70	3.28	0.52	11.4	85.9	8.88	7.07	3.12	19.7	64.5
Genc99x84ÇZT04	3.76	2.87	0.55	23.7	85.4	10.14	8.70	3.71	13.9	63.3
Genc 99xChil’s	4.18	3.78	0.39	9.6	90.7	10.30	8.74	3.39	15.1	67.1
Genc 99xSeri 82	4.03	3.43	0.45	14.9	88.8	10.18	8.33	4.73	17.5	53.2
84ÇZT04	3.85	2.98	0.38	22.6	90.1	10.10	7.12	3.79	29.5	62.5
84ÇZT04x Chil’s	3.56	3.40	0.44	4.5	87.6	9.73	8.35	3.84	13.9	60.4
84ÇZT04xSeri82	4.19	3.81	0.37	9.1	91.2	10.26	8.99	3.56	11.9	65.1
Chil’s	4.06	3.69	0.22	9.1	94.6	10.13	8.42	3.38	16.6	66.5
Chil’sx Seri 82	3.56	3.55	0.29	0.3	91.9	9.61	8.90	3.40	7.3	64.6
Seri82	4.30	3.42	0.30	20.5	93.0	10.01	7.30	3.01	27.0	69.9
Mean	3.92	3.42	0.39	12.6	89.9	9.93	8.19	3.59	17.2	63.7
Parent mean	3.98	3.34	0.36	15.9	89.2	9.78	7.48	3.33	23.5	55.3
Hybrid mean	3.88	3.47	0.42	10.3	87.8	10.04	8.67	3.77	13.6	56.3
LSD 1$_{(\%5)}$	0.49	ns	0.08			0.80	1.33	0.84		
LSD 2$_{(\%5)}$		0.14					0.31			

[1], for genotypes means, [2], for stress means.

conditions. Seri 82 with the highest grain yield under NS did not show its high yield potential under both stress conditions. Mean grain yield of hybrids of Genç 99 were higher than the mean of all genotypes under HS conditions. There were no significant differences between hybrids and parents at salt and heat stress for grain yield, but mean of hybrids had higher grain yield than their parents, while hybrids had lover grain yield than their parents at NS (Table 3).

The reduction in biological yield was higher than that grain yield in salt stress while it was lower at heat stress. The hybrids of Genc99 × 84ÇZT04 and Genc 99 × Seri 82 had high biological yield potential at all environments. Significant decrease was observed at SS with respect to NS conditions. Biological yield of hybrids at all stress conditions had higher than their parents, although significant differences were not found between hybrids and parents (Table 3).

Correlations

Grain yield had significant positive correlation with spike weight, harvest index, grain number per plant and biological yield at all conditions (Table 4). Although significant correlations between grain yield and spike/shoot ratio were observed under NS and HS, there was no correlation under SS. Under the salt stress, shoot weight and spike number were positively correlated with grain yield. High grain yield under NS and SS were not significantly related with heading time, while significant correlation was found at heat stress (Table 4).

Spike weight and shoot weight significantly were related with biological yield under all conditions. Spike shoot ratio showed significant negative correlation with biological yield under both stress conditions. Also, biological yield was positively correlated with plant height, spike number and plant grain number under HS.

Combining abilities

Mean squares for genotypes, parents and hybrids

Table 4. Phenotypic correlation coefficients of grain yield and biological yield with agronomic traits of some wheat cultivars and their hybrids under non- stress, salt and heat stress conditions.

	Grain yield			Biological yield		
	Non-stress	**Salt stress**	**Heat stress**	**Non-stress**	**Salt stress**	**Heat stress**
Heading date	-0.15	0.20	-0.66***	-0.23	0.18	-0.05
Maturity date	-0.10	0.24	-0.34	-0.21	0.08	-0.05
Spike weight	0.80***	0.76***	0.65***	0.89***	0.96***	0.67***
Shoot weight	0.25	0.51**	0.15	0.81***	0.94***	0.93***
Spike/Shoot Ratio	0.51**	0.01	0.37*	0.06	-0.46**	-0.38*
Plant height	-0.21	0.22	0.64***	-0.09	0.06	0.51**
Harvest index	0.77***	0.45*	0.81***	0.03	-0.34	-0.22
Spike number	0.09	0.37*	-0.03	0.43*	0.25	0.61**
Grain weight	-0.19	0.14	0.21	0.04	0.29	-0.28
Grain numbers per spike	0.34	0.31	0.83***	-0.10	0.01	0.33
Grain numbers per plant	0.71***	0.62***	0.77***	0.33	0.27	0.57*
Biological yield	0.66***	0.68***	0.37*			

*, ** and ***, significant at the 0.05, 0.01 and 0.001 probability levels, respectively.

Table 5. Analysis of variance for grain yield and biological yield of 4 bread wheat parents and their 6 hybrids grown under non-stress, salt and heat stressed conditions.

Source of variation	Mean squares						
		Grain yield			Biological yield		
	df	**Non-stress**	**Salt stress**	**Heat stress**	**Non-stress**	**Salt stress**	**Heat stress**
Genotypes	9	0.220*	0.294^{+}	0.031***	0.553*	1.663*	0.697*
GCA	3	0.156	0.444^{+}	0.078***	0.353	0.838	0.155
SCA	6	0.275*	0.160	0.008*	0.622*	1.439	0.968**
Error	18	0.082	0.137	0.002	0.216	0.603	0.336
Cv		7.33	10.82	12.39	4.68	9.48	13.52

$^{+}$, *, ** and ***, significant at the 0.10, 0.05, 0.01 and 0.001 probability levels, respectively.

were found significant for grain yield and biological yield under NS, SS and HS conditions (Table 5). Genetic variation was divided into the general combining ability (GCA), which represents the average performance of a parent in hybrid combinations and the specific combining ability (SCA), which also represents the hybrid deviation from average GCA effects of the two parents. Significant GCA effects were observed for grain yield under SS and HS conditions. Significant GCA effect was not observed for biological yield. Significantly positive SCA effects existed for grain yield and biological yield under NS and HS conditions, but it was not detected under SS (Table 5). The significant SCA effects showed that these traits were mainly mediated by dominance effects. The significant GCA and SCA variance for grain yield under HS revealed that both additive and non-additive gene actions have significant roles that consist of grain and biological yield. The coefficients of variation values were not high for grain yield and biological yield for all conditions (Table 5). These values indicate that reliable information can be obtained to evaluate salt and heat stability from the plants which were taken from small pot experiments.

Hybrids obtaining from parents with high GCA effects (parents Genç-99 and 84ÇZT04) for grain yield under HS should have mostly, high heat tolerance to obtain high yield stability (Table 6). Contrary, hybrids obtaining from parents with negative GCA effects (parents Chil's and Seri 82) should have low heat tolerance at heat stressed environment. Chil's, with significant GCA effects, was characterized by increasing for grain yield at SS, while '84ÇZT04' had decreased GCA effects. Seri 82 was characterized by increasing GCA effect for grain yield under favorable environment. Positive and negative SCA effects were found in hybrids for grain and biological yield (Table 7). The hybrid of Genc 99×Chil's had significant positive SCA effects for grain yield and biological yield under NS. 84ÇZT04 × Chil's had significant heat tolerance for SCA effects at HS. Significant SCA effects were not observed among hybrids under SS.

Table 6. Estimates of general combining ability effects (GCA) for Grain yield and Biological yield of wheat parents under non- stress, salt and heat stress conditions.

Parents	Grain yield			Biological yield		
	Non-stress	Salt stress	Heat stress	Non-stress	Salt stress	Heat stress
(1) Genç-99	-0.05	-0.02	0.07***	-0.20*	-0.03	0.01
(2) 84ÇZT04	-0.05	-0.20*	0.02*	0.10	-0.18	0.12
(3) Chil's	-0.03	0.16*	-0.06***	0.03	0.31	-0.09
(4) Seri-82	0.13*	0.05	-0.04***	0.06	-0.09	-0.04

* and ***, significant at the 0.05 and 0.001 probability levels, respectively.

Table 7. Estimates of specific combining ability effects (SCA) for grain yield and Biological yield of wheat cross under non- stress, salt and heat stress conditions.

Hybrids	Grain yield			Biological yield		
	Non-stress	Salt stress	Heat stress	Non-stress	Salt stress	Heat stress
Genc99x84ÇZT04	-0.05	-0.32	0.05	0.31	0.73	-0.02
Genc 99xChil's	0.35*	0.22	-0.01	0.53*	0.27	-0.13
Genc 99xSeri 82	-0.14	0.04	-0.01	-0.22	-0.36	0.66*
84ÇZT04x Chil's	-0.27	0.02	0.09**	-0.35	0.03	0.23
84ÇZT04xSeri82	0.28*	0.33	-0.07**	0.09	-0.06	-0.16
Chil'sx Seri 82	-0.27*	-0.17	-0.03	-0.31	0.09	-0.08

* and **, significant at the 0.05 and 0.01 probability levels, respectively.

DISCUSSION

Owing to the same sowing time under NS and SS, it is possible to explain differences between two conditions over the effects of SS on the investigated traits. However, it is more meaningful to discuss the heat effects within genotypes than between stresses. Late sowing caused a decrease on productivity besides negative effects of heat stress. Also it is obvious that both stress conditions (SS and HS) had different effects on investigated traits.

In this study, salt tolerance of crops was evaluated with their yield and other agronomic traits in saline versus non-saline conditions. However, some researchers classified wheat genotypes for salt tolerance only at seedling stages (Akhtar et al., 2003; Tahira and Abdussalam, 2006)

The high values of spike/shoot ratio, harvest index and grain number under salt stress explained that salt effects were more effective at early growth stages. Generally, salt stress reduces shoot growth in growing tissues, not in mature tissues (Munns et al., 1982.). Also, high grain number showed that genotypes were not sensitive to salt stress at flowering stage (Table 2). Grain weight and biological yield are highly influenced by salt conditions, as shown in this study as well as the studies by Sinclair and Hoffmann (2003) and Singh and Singh (2000). Grain yield decreased less than biological yield by salinity. Non-significant effects of salt on heading time is similar to the finding of Poustini and Siosemardeh (2004), who worked in pot experiment with 30 wheat genotypes.

Early flowering was determined as one of the marker characteristics of a salt tolerant variety (Colmer et al., 2005). Salt effects were accompanied by delayed heading in half of all genotypes. Late heading was positive effects on the yield under SS conditions; however, it had decreasing effects on the grain yield under NS and HS (Table 4). On the other hand, heading and maturity times were similar under both SS and NS conditions in our experiments, while Shannon et al. (1994) pointed out heading time, anthesis and physiological maturity which occurred at an earlier stage under salt stress conditions.

According to Francois et al. (1994) and Husain et al. (2003), the reduction in tiller number is one of the main cause of the total dry matter production of wheat. In this research, spike number were significantly reduced by salt effects and significantly correlated with grain yield under salt stress. Among yield parameters, grain numbers per spike had major contribution to grain yield with salinity (Singh and Rana, 1985; Maas et al., 1996) Therefore, the correlation with grain numbers per plant is more effective under SS (Table 4). Jafari-Shabestari et al. (1995), did not report significant correlation between grain yield and biological yield and harvest index under salt conditions, while high correlation was found between the same traits in this research (Table 7). In wheat, salt tolerance of F_1

hybrids were found intermediate among parents, but most of F_2 progenies showed lower salt tolerance level than tolerant parent (Muns et al., 2002). They also reported that salt tolerance at the Na^+ accumulation basis mainly mediated two or three genes of major effects and narrow-sense heritability was very high. Similarly in this study, high GCA/SCA mean squares ratio suggested that additive gene action had a major role over these traits (Table 5), although Singh and Singh (2000) reported dominance effects on grain yield and biological yield.

In this study, differences among parental genotypes for grain yield under HS were higher than NS and SS conditions. The genotype Genc 99 had highest grain yield followed by 84ÇZT04. Although Seri 82 which has the highest grain yield at NS conditions were grown in the areas subjected to heat and drought stress, it was not as successful as Genc 99 in heat stress conditions. The variety Genc 99 is of Mexican origin without 1B.1R translocations like Seri 82. Merker (1982) and Villareal et al. (1998) pointed out that 1B.1R translocations could help improve adaptation to stressed environments. However, the superiority of these translocations was not useable in Seri 82 and their hybrids at HS conditions (Table 3).

Genç 99 and 84CZT04 showed a desirable combination of high yield potential under HS. Although Seri 82 and Chil's had high yield potential under NS and SS conditions, they were not favorable for HS environments and the traits contributing to grain yield under normal conditions were similar with the traits at SS conditions, but different from in-heat stress environments.

Significant correlations of grain yield with spike weight, heading time, harvest index and grain number sowed that selection for this traits under HS may contribute to select desirable lines. Grain yield is generally affected by a large number of genes over A, B and D genome and has low narrow sense heritability (Blum, 1988) therefore it is highly influenced by environmental factors, and so it's hard to use grain yield as unique selection criteria (Dhanda et al., 2004).

Plant grain number has more impact to grain yield production than that of grain weight under non-stress and heat stress conditions, as shown by Khanna-Chopra and Viswanathan (1999) and Koç et al. (2008). Grain yield, grain numbers per area, biomass and harvest index were significantly negative in correlation with heat stresses (Koç at al., 2008). Chinnusamy and Khanna-Chopra (2003) also reported significant correlation between grain yield and grain weight at different ploidy levels of wheat species at NS and HS conditions.

Genetic variation for salt and heat tolerance which was evaluated by yield and some yield correlated traits existed in the used material. The genotypes of Seri 82 and Chil's can be used in salt tolerant wheat improvement programs and the genotype of Genc 99 can be used as heat tolerant donor. Due to different tolerance mechanism, it is impossible to select both heat and salt tolerant genotype from the used material. However, improvement of salt or heat tolerant genotypes may be obtained by selection methods in large segregating generations at SS or HS conditions.

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