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EVALUATION OF DIALLEL WHEAT CROSSES UNDER DROUGHT TOLERANCE

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ABSTRACT

A half diallel cross among eight parents of wheat (Triticum aestivum L.) was evaluated under recommended irrigation and drought stress in RCBD with three replications. Mean squares for genotypes, parents, crosses and parent vs. crosses were significant for the most measurements in both irrigation treatments as well as the combined analysis. The highest mean values were detected under stress condition and combined analysis by parents P_4, P_6, P_8, P_7, P_1 and P_8 for stomatal conductance (SC), net photosynthesis rate (Pn), protein percentage, ash percentage, carbohydrate percentage and grain yield/plant, respectively. Meanwhile, the highest mean values were recorded under stress condition and combined analysis with crosses P_1 x P_6, P_5 x P_8, P_3 x P_4, P_3 x P_4 and P_2 x P_5 for stomatal conductance (SC), net photosynthesis rate (Pn), protein percentage, ash percentage, carbohydrate percentage and grain yield/plant, respectively. Superiority percentage relative to check variety Sahel 1 for grain yield/plant was obtained by crosses; P_2 x P_5, P_2 x P_4, P_2 x P_7, P_1 x P_3, P_3 x P_6 and P_5 x P_7 under normal and stress irrigations and for the combined analysis. The mean squares were significant for the most measurements in both irrigation treatments as well as the combined analysis for general combining ability (GCA) and specific combing ability (SCA). GCA/SCA ratio, which exceeded the unity was obtained for LT, protein percentage, carbohydrate percentage, ash percentage and grain yield/plant in both irrigations treatments and the combined analysis. For chemical measurements (protein, carbohydrate and ash percentages) and grain yield/plant the ratio of SCA x I/SCA was much higher than the ratios of GCA x I/GCA. The parental lines P_1, P_2 and P_3 for SC and P_5, P_6 and P_7 for grain yield/plant, exhibited significant positive "$\hat{g}_i$" effects under stress irrigation treatment. The most desirable "$\hat{S}_{ij}$" effects were recorded by the cross P_3 x P_4 under stress irrigation for LT, TR, Pn and carbohydrate percentage, P_1 x P_5 and P_4 x Gem.9 in the combined analysis for stomatal conductance; P_4 x P_5 and P_5 x P_8 under normal, stress irrigation treatments and the combined analysis for protein percentage.

Key words: ***Triticum aectivum, General combining ability (GCA), Specific combining ability (SCA), Heterosis, Drought, Wheat, Randomized Complete Block Design(RCBD) .***

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important cereal crop in Egypt. Increasing wheat production to narrowing the gap between production and consumption is considered the main goal in Egypt as well as in most countries all over the world. Differential characterization between Egyptian old varieties genetic resources in different geographical regions, represent an important genetic resource that can be used to improve modern varieties by introducing new alleles or combinations of genes. The old varieties may include genetic sources of biotic and a biotic stress resistance, quality, yield and resistance genes to drought, especially in environments not tested in major breeding programs. Drought is a worldwide issue that impacts seriously on the security of food production. Global climate change makes this even worse (Elisabeth *et al.* 2009). The increase in stomatal resistance under water stress condition was due to the stomatal closure Bousba *et al.* (2009) and Changhai *et al.* (2010). A high net photosynthesis rate is considered to be one of the most important breeding strategies for better adaptation to stressful environments (Austin *et al.*1980 and Austin 1989). The photosynthetic activity of flag leaves is especially important during grain filling when the older leaves begin senescing (Loss and Siddique 1994, Turner 1997). The main objectives of the present investigation are to assess the variations among wheat genotypes and available crosses for drought tolerance characters, to estimate the magnitude of superiority, general combining ability (GCA) and specific combining ability (SCA) to improve wheat under drought conditions and to determine suitable measurements for drought resistance in wheat genotypes.

MATERIALS AND METHODS

The breeding materials used herein included eight parents i.e. five promising landraces (P_1, P_2, P_3, P_4 and P_5) for drought tolerant selected by National Gene Bank and Genetic Resources according to IPGRI (International of Plant Genetic Resources Institute) descriptor and three cultivars wheat (Gemmeiza 9 (P_6), Sahel 1 (P_7) and Yacora Kojo (P_8)). In 2008/2009 growing season, in Sids Agricultural Research Station, grain from each of the eight parental genotypes were sown at various planting dates in order to overcome the differences in time of heading during this season. All possible cross combinations (without reciprocals) were made among the eight genotypes, giving seeds of F_1 28 crosses. In 2009/2010 season, two experiments were conducted at Al-Gemmeiza Agricultural Research Station, Gharbia Governorate, Egypt. Each experiment included the eight parents and their 28 possible crosses in a randomized complete block design (RCBD) with three replications. The planting date was 24th of November. The first experiment was irrigated only two irrigations (sowing irrigation and next one after 25 days) after which irrigation was stopped till the end of the season. The second experiment was normally irrigated by giving the recommended number of irrigations (5). Each plot consisted of one row, of 1.5 meters long and 30cm wide. Grains were individually sown in hills at 20cm space between plants within row. The other cultural practices of growing wheat were properly practiced. Data were recorded from each plot for physiological traits; leaf temperature (^{0}C), transpiration rate (milimol/m^2/s), stomatal conductance (milimol/m^2/s) and net photosynthesis rate (µmol/m^2/s). All data for physiological measurements have been taken by the CI-340 Ultra-Light Portable Photosynthesis System.

Chemical analysis; protein, carbohydrate and ash percentages were determined by near infra analyzer (NIR) (g/100g of the seeds) according to Zhao *et al*. (2004). Data for grain yield/plant (gm) yield was recorded on ten guarded plants chosen at random from each plot. Normal performance plants were obtained in all hybrids except those of the two crosses (P_3xP_4 and P_4xP_8) where all plants were subjected to partial necrosis phenomenon. The decrease of yield was detected in both crosses. Monthly average temperature and amount of rainfall and mechanical and chemical analysis of experimental soil are shown in Table (1) and (2).

Table (1): Meteorological date at Al-Gemmeiza location during 2009/2010 growing season.

month no.	Max. Temperature (ºC)	Min. Temperature (ºC)	Max Relative Humidity (%)	Min Relative Humidity (%)	Wind Speed (m/s)	Rainfall rate
Nov.2009	28.0	12.8	85	37	5.4	**20mm**
Dec.2009	24.3	11.9	86	36	6.3	
Jan.2010	26	11	85	28.7	6.2	
Feb.2010	29.7	9.4	84.3	23.5	6.4	
Mar.2010	34.9	11.8	83.2	34	7	
April.2010	32.3	13.1	86.4	22.4	5.9	
May 2010	36	13.4	88.2	22.3	5.2	

Table (2): Mechanical and chemical analysis of experimental soil in 2009/ 2010 seasons at Al-Gemmeiza Agricultural Research Station.

Mechanical analysis	
Clay %	45.50
Silt %	29.40
Sand %	24.50
Organic mater %	0.58
Textural class	Clay
Chemical analysis	
Available N PPM	30.4
Available P PPM	5.86
Available K PPM	400

The obtained data were statistically analyzed using computer statistical program MSTAT.C. General and specific combining ability estimates were estimated according to Griffing's (1956) diallel cross analysis designated as method 2 model 1 for each experiment. The combined analysis of two experiments was carried out whenever homogeneity of error variance was detected (Gomez and Gomez, 1984). Superiority of grain yield was calculated for individual cross as the percentage deviation of F_1 mean performance from check variety Sahel1 average value.

RESULTS AND DISCUSSION

Drought measurements

Mean squares for leaf temperature during flower (LT), net photosynthesis rates (Pn), transpiration rate during flower (TR) and stomatal conductive during flower (SC), protein percentage, carbohydrate percentage, ash percentage and grain yield/plant for each of normal and stress environments as well as the combined analysis are presented in table (3).

Mean squares for genotypes, parents, crosses and parent vs. crosses were found to be significant for the eight measurements in both irrigation treatments as well as the combined analysis except genotype mean square and its components for LT in stress condition , parent mean square for LT in separate environments as well as the combined data, cross mean square for LT in stress condition and TR in stress condition, and parent vs. crosses for ash percentage in both environmental and the combined analysis , Pn and SC in stress and combined analysis and non-stress conditions, respectively, indicating that wide diversity between the parental used in the present study for these traits. Genotypes x irrigation, parent x irrigation, F_1 x irrigation and parents vs. cross x irrigation mean squares were found to be significant for all traits except parent x irrigation for LT and Pn and parent vs. crosses x irrigation for TR, Pn, carbohydrate and ash percentage. Such results indicated that the tested genotypes varied from one to anther and ranked differently from normal to stress irrigation treatments.

Results in table (4) showed the average of drought and chemical measurements at both irrigation treatments. It is clear that LT, SC, protein and ash percentage increased significantly with stress compared with non-stress condition. While, the Pn, TR and carbohydrate percentage decreased significantly to stress compared with non-stress conditions, indicating that selection for stress tolerance should gave a positive yield response under stress. Also, the results indicated that selection under irrigated environment would be less effective for improving grain yield under drought stress than direct selection in the stress condition, Atlin and Frey (1989) demonstrated that grain yield in stress or low- productively environments were not controlled by same genes, making indirect selection unattractive. The result also indicated that mean values of normal environment for yield and its components were high than these of stress condition.

Mean performances

The results in table (4) clearly show that during occurrence of water stress, stomatal conductance (SC) increased considerable. The highest mean values of SC under stress condition were recorded with parent P_4 followed by P_2 and then by P_7 (Sahel$_1$). Meanwhile, the lowest values recorded with P_5 followed by P_3 and P_6 (Gemmeiza$_9$). Also, the highest values were obtained from crosses P_1 x P_6 followed by P_1 x P_8 and P_3 x P_5, meanwhile, the lowest SC was obtained with P_3 x P_4, P_5 x P_6, P_1 x P_4, P_2 x P_3 and P_1 x P_7. Seropian and Planchon (1984), Mahgoub (1996), Bousba *et al.* (2009) and Changhai *et al.* (2010) mentioned that, the increase in stomatal resistance under water stress condition was due to the stomatal closure. This is commonly found in many species and may indicate a control of stomatal conductance through hydraulic feedback mechanism **(**Giorio *et al.* 1999). Moreover (West *et al.*1990) showed that, the drought resistance cultivar had a significant higher stomatal resistance plants closed their stomata in response to the slight water stress condition, while the drought sensitive plants kept their stomata open. Shimshi and Ephart (1975), who worked with up to 11 cultivars of spring wheat grown under field conditions, suggested that the porometer method would be useful in wheat breeding programs. The study showed that SC was the best method to use screen plants for drought resistance.

Low soil moisture content decreased the (Pn) in wheat; Aminian *et al.* (2010) studied photosynthesis rate and the relationship with grain yield in wheat under water-stressed and well-watered conditions. Correlation coefficient indicated that photosynthesis rate was most important in affecting yield under the both experiments. The highest mean values of (Pn) for parental lines were Gemm.9 (P_6) and Sahel 1(P_7) followed by P_2 at normal, stress irrigation treatments as well as the combined analysis. Meanwhile, the lowest values were obtained by P_5 at both irrigation treatments and the combined data. Also, the greatest values were recorded by crosses P_5 x $P_{8,}$ P_4 x P_5 and P_4 x P_6 at normal irrigation, P_3 x P_6 and P_5 x P_8 at stress irrigation, P_5 x P_8 and P_4 x P_5 at the combined analysis. Stomatal closure increases the resistance to CO_2 diffusion into the leaf. An inhabitation of chloroplast activity low leaf temperature decreases the capacity to fix CO_2. The stomatal conductance might play an important role in the high Pn under well watered or mid drought stress, but under severe drought stress the high Pn is related more to the maintenance of a higher capacity for mesophyll photosynthesis (Johson *et al.* 1984 and Inoue *et al.* 2004).

The parental variety Yacora (P_8) expressed the highest values of protein percentage and ranked the second of the tested parents for ash percentage and it gave the lowest values for carbohydrate percentage at both irrigation treatments as well as the combined analysis.

Table (3): Mean square estimates of ordinary analysis and combining ability for physiological, chemical analysis and grain yield traits.

S.O.V.	d.f.		Leaf temperature (LT)			Transpiration rate (TR)			Stomatal conductance (SC)			Net photosynthesis rate (Pn)		
	S.	Comb	Control	Drought	Comb.	Control	Drought	Comb.	Control	Drought	Comb.	Control	Drought	Comb.
Irrigation		1			431.52**			24.23**			416553.98**			580.17**
Rep/I	2	4	16.58**	2.31	9.45**	0.28	0.02	0.15	6229.29**	346.67	3287.98**	16.46**	12.86*	14.66**
Genotypes	35	35	5.56**	1.55	4.15**	0.69**	0.27**	0.67**	10664.58**	13811.85**	18427.26**	26.28**	18.91**	36.47**
parent	7	7	0.80	1.54	1.15	0.82**	0.18	0.68**	9661.63**	6509.32**	12818.13**	6.71*	20.20**	21.35**
Cross	27	27	4.10**	1.32	2.60**	0.65**	0.27**	0.63*	11314.90**	15567.59**	20292.26*	32.08**	19.27**	41.55*
Par.vs.cr.	1	1	77.99**	7.60*	67.14**	0.67*	1.09**	1.73**	126.63	17524.79**	7336.04**	6.93*	0.26	4.95
G/I		35			2.95**			0.29**			6049.17**			8.73**
par./I		7			1.20			0.33**			3352.82**			5.55
Cr./I		27			2.83**			0.29**			6590.22**			9.80**
Par.vs.cr.x I		1			18.45**			0.03			10315.37**			2.25
Error	70	140	0.84	1.10	0.97	0.09	0.10	0.10	382.67	902.11	642.40	2.6	3.25	2.92
GCA	7	7	2.29**	0.54	1.49**	0.12**	0.05	0.09*	2182.45**	1727.11**	2761.99**	5.88**	3.06*	5.42**
SCA	28	28	1.74**	0.51	1.36**	0.26**	0.10**	0.26**	3897.96**	5323.16**	6987.53**	9.48**	7.12**	13.84**
GCA x I		7			1.34**			0.09*			1147.57**			3.52**
SCA x I		28			0.90**			0.10**			2233.60**			2.76**
Error	70	140	0.28	0.37	0.32	0.03	0.03	0.03	127.56	300.70	214.13	0.86	1.08	0.97
GCA/SCA			1.32	1.06	1.10	0.49	0.54	0.35	0.56	0.32	0.40	0.62	0.43	0.39
GCAx I/GCA					0.90			1.02			0.42			0.65
SCAx I/SCA					0.66			0.39			0.32			0.20

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

Table (3): Cont.

S.O.V.	d.f.		Protein percentage			Carbohydrate percentage			Ash percentage			Grain yield/plant (g)		
	S.	Comb	Control	Drought	Comb.	Control	Drought	Comb.	Control	Drought	Comb.	Control	Drought	Comb.
Irrigation		1			189.81**			194.20**			2.19**			5914.14**
Rep/I	2	4	0.230	0.21	0.22	0.30	0.13	0.21	0.01	0.01	0.01	4.65	1.35	3.00
Genotypes	35	35	4.832**	5.77**	9.43**	12.77**	9.03**	18.28**	0.07**	0.12**	0.16**	1060.17**	773.86**	1762.56**
parent	7	7	3.223**	5.21**	5.58**	8.70**	13.57**	15.15**	0.15**	0.31**	0.43**	109.52**	69.93**	157.57**
Cross	27	27	4.99**	6.02**	10.28**	14.07**	7.99**	19.34**	0.05**	0.07**	0.10**	1102.80**	814.52**	1833.57**
Par.vs.cr.	1	1	11.79**	3.04**	13.40**	6.23**	5.36**	11.57**	0.01	0.01	0.01	6563.75**	4603.38**	11080.42**
G/I		35			1.18**			3.53**			0.02**			71.46**
par./I		7			2.86**			7.12**			0.03**			21.87**
Cr./I		27			0.73**			2.73**			0.02**			83.75**
Par.vs.cr.x I		1			1.43**			0.02			0.001			86.71**
Error	70	140	0.08	0.14	0.11	0.62	0.35	0.48	0.01	0.01	0.01	2.32	1.79	2.05
GCA	7	7	2.39**	3.86**	5.73**	4.47**	7.08**	10.44**	0.04**	0.08**	0.10**	491.73**	353.49**	819.94**
SCA	28	28	1.42**	1.44**	2.49**	4.21**	1.99**	5.01**	0.02**	0.03**	0.04**	318.81**	234.07**	529.42**
GCA x I		7			0.51**			1.11**			0.01**			25.28**
SCA x I		28			0.36**			1.19**			0.01**			23.46
Error	70	140	0.03	0.05	0.04	0.21	0.12	0.16	0.001	0.001	0.001	0.77	0.60	0.68
GCA/SCA			1.69	2.68	2.30	1.06	3.55	2.09	1.80	2.58	2.48	1.54	1.51	1.55
GCA x I/GCA					0.09			0.11			0.08			0.03
SCA x I/SCA					0.15			0.24			0.18			0.04

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

Table (4): Mean performance of all genotypes in normal and drought as well as combined over them for traits studied.

Traits / Genotypes	Leaf temperature (LT)			Transpiration ate(TR)			Stomatal conductance (SC)		
	Control	Drought	Com.	Control	Drought	Com.	Control	Drought	Com.
Line 1 (P_1)	29.07	29.87	29.47	2.84	2.37	2.61	172.80	239.00	205.90
Line 2 (P_2)	28.50	29.43	28.97	2.38	2.33	2.36	256.60	287.66	272.13
Line 3 (P_3)	28.43	30.20	29.32	2.89	2.08	2.49	198.83	210.64	204.74
Line 4 (P_4)	28.00	29.20	28.60	3.41	2.15	2.78	165.06	309.91	237.49
Line 5 (P_5)	28.00	31.50	29.75	2.02	1.61	1.82	69.88	162.82	116.35
Gemmeiza9(P_6)	27.63	29.73	28.68	2.59	1.88	2.24	216.08	220.84	218.46
Sahel 1 (P_7)	27.43	29.73	28.58	3.42	2.18	2.80	218.43	269.84	244.14
Yacora (P_8)	28.20	29.47	28.83	2.19	2.10	2.15	146.17	238.91	192.54
1x2	28.93	29.07	29.00	3.12	1.76	2.44	136.40	301.49	218.95
1x3	26.97	28.80	27.88	2.81	1.75	2.28	172.01	235.56	203.79
1x4	28.13	28.77	28.45	1.72	1.63	1.68	137.34	174.28	155.81
1x5	27.20	29.07	28.13	2.83	2.01	2.42	205.50	249.97	227.74
1x6	25.67	30.03	27.85	2.99	2.31	2.65	242.84	483.14	362.99
1x7	28.77	30.10	29.43	2.81	1.89	2.35	187.65	198.32	192.98
1x8	26.27	29.33	27.80	2.26	2.12	2.19	220.95	390.43	305.69
2x3	27.53	28.30	27.92	2.14	1.59	1.86	145.79	179.05	162.42
2x4	26.63	29.07	27.85	2.84	2.01	2.43	192.32	272.17	232.24
2x5	25.63	29.93	27.78	2.48	2.15	2.32	152.62	356.16	254.39
2x6	25.57	29.10	27.33	2.10	1.77	1.94	151.25	271.45	211.35
2x7	24.57	29.50	27.03	2.75	1.95	2.35	237.31	265.37	251.34
2x8	25.33	30.17	27.75	2.88	1.44	2.16	155.35	287.23	221.29
3x4	24.70	28.50	26.60	1.49	1.41	1.45	95.56	155.66	125.61
3x5	24.43	28.80	26.62	2.76	2.16	2.46	235.50	390.42	312.96
3x6	25.60	28.67	27.13	3.10	1.67	2.38	252.17	270.94	261.56
3x7	24.57	28.67	26.62	3.19	1.46	2.33	189.69	248.96	219.33
3x8	25.63	29.47	27.55	2.46	1.87	2.16	190.89	256.76	223.83
4x5	26.33	29.00	27.67	2.73	2.28	2.51	171.26	302.21	236.73
4x6	25.77	28.13	26.95	2.89	2.10	2.49	341.31	341.85	341.58
4x7	25.43	30.27	27.85	1.88	1.79	1.83	94.55	240.00	167.28
4x8	25.80	30.73	28.27	2.02	1.65	1.84	82.74	224.76	153.75
5x6	25.40	28.73	27.07	1.99	1.31	1.65	138.19	172.18	155.19
5x7	25.47	30.33	27.90	2.07	1.98	2.03	93.40	268.31	180.86
5x8	26.50	29.10	27.80	2.78	2.38	2.58	269.84	294.09	281.96
6x7	27.43	29.03	28.23	3.42	1.51	2.465	218.43	267.68	243.055
6x8	26.37	28.9	27.635	3.12	1.6	2.36	184.69	276.87	230.78
7x8	26.37	29.47	27.92	3.12	2.1	2.61	184.69	238.91	211.8
mean of parents	28.16	29.89	29.03	2.72	2.09	2.40	180.48	242.45	211.47
mean of crosses	26.11	29.25	27.68	2.53	1.85	2.19	177.88	273.09	225.49
mean of Genotypes	26.57	29.40	27.98	2.57	1.90	2.24	178.46	266.29	222.37
L.S.D 5%	1.49	NS	1.58	0.51	0.52	0.51	31.95	49.05	40.56
L.S.D 1%	1.99	NS	2.07	0.68	0.69	0.66	42.49	65.23	53.19

Table (4): Cont.

Genotypes / Traits	Net photosynthesis (Pn)			Protein percentage			carbohydrate percentage		
	Control	Drought	Com.	Control	Drought	Com.	Control	Drought	Com.
Line 1 (P_1)	15.21	14.11	14.66	8.11	11.09	9.60	68.50	67.47	67.98
Line 2 (P_2)	16.83	15.63	16.23	9.18	10.58	9.88	66.10	65.13	65.62
Line 3 (P_3)	15.08	14.37	14.73	10.12	12.05	11.09	67.93	66.60	67.27
Line 4 (P_4)	15.55	10.50	13.03	9.32	13.60	11.46	66.30	62.40	64.35
Line 5 (P_5)	13.16	7.59	10.38	10.43	12.06	11.24	65.33	66.97	66.15
Gemmeiza9(P_6)	17.53	13.06	15.30	10.13	13.97	12.05	67.83	63.80	65.82
Sahel 1 (P_7)	17.36	14.34	15.85	9.99	10.42	10.20	67.60	62.67	65.13
Yacora (P_8)	14.61	12.57	13.59	11.66	12.62	12.14	63.37	62.50	62.93
1x2	17.11	13.60	15.35	7.99	9.69	8.84	69.40	66.47	67.93
1x3	17.18	12.41	14.80	9.95	11.09	10.52	67.10	66.53	66.82
1x4	13.00	9.74	11.37	7.25	9.04	8.15	73.40	69.00	71.20
1x5	14.56	13.74	14.15	10.64	13.16	11.90	68.00	65.30	66.65
1x6	18.94	13.18	16.06	12.08	13.09	12.59	65.03	63.93	64.48
1x7	16.34	14.83	15.59	10.52	12.74	11.63	67.00	64.20	65.60
1x8	14.02	12.52	13.27	10.88	14.04	12.46	63.60	66.37	64.98
2x3	14.13	13.68	13.91	10.73	11.67	11.20	65.13	63.60	64.37
2x4	16.08	15.73	15.91	11.26	12.40	11.83	64.17	63.07	63.62
2x5	16.32	14.52	15.42	9.43	11.25	10.34	65.77	63.60	64.68
2x6	14.82	10.59	12.70	11.16	12.32	11.74	64.03	62.73	63.38
2x7	17.20	13.22	15.21	9.42	10.86	10.14	66.07	65.07	65.57
2x8	18.17	9.79	13.98	9.93	11.47	10.70	65.80	63.50	64.65
3x4	6.04	5.20	5.62	13.81	16.13	14.97	62.93	60.43	61.68
3x5	13.67	12.74	13.20	10.68	11.48	11.08	65.67	64.37	65.02
3x6	16.55	16.04	16.30	11.86	12.76	12.31	64.57	63.17	63.87
3x7	17.46	11.60	14.53	11.03	12.80	11.92	67.97	63.73	65.85
3x8	15.66	15.52	15.59	9.52	12.56	11.04	68.83	66.27	67.55
4x5	21.94	15.54	18.74	11.24	13.17	12.20	65.10	63.03	64.07
4x6	20.91	14.30	17.61	10.58	12.09	11.34	65.30	63.87	64.58
4x7	13.43	12.49	12.96	12.32	13.74	13.03	63.20	62.67	62.93
4x8	16.60	12.55	14.58	11.20	14.04	12.62	66.20	63.93	65.07
5x6	14.16	9.65	11.91	11.11	13.43	12.27	65.27	62.97	64.12
5x7	19.66	12.75	16.21	9.49	12.07	10.78	66.13	63.43	64.78
5x8	22.93	16.66	19.79	11.12	12.39	11.76	65.17	63.67	64.42
6x7	17.36	10.3	13.83	9.99	11.81	10.9	67.6	63.47	65.535
6x8	17.95	11.66	14.805	11.84	13.78	12.81	67.43	63.6	65.515
7x8	17.95	12.57	15.26	11.84	12.62	12.23	67.43	62.5	64.965
mean of parents	15.67	12.77	14.22	9.87	12.05	10.96	66.62	64.69	65.66
mean of crosses	16.28	12.89	14.58	10.66	12.45	11.56	66.04	64.16	65.10
mean of Genotypes	16.14	12.86	14.50	10.49	12.36	11.42	66.17	64.28	65.22
L.S.D 5%	2.63	2.95	2.74	0.46	0.61	0.53	1.28	0.97	1.11
L.S.D 1%	3.50	3.92	3.59	0.61	0.81	0.69	1.71	1.28	1.46

Table (4): Cont.

Traits / Genotypes	Ash percentage			Grain yield/ plant (g)			Relative to Sahel1		
	Control	Drought	Com.	Control	Drought	Com.	Control	Drought	Com.
Line 1 (P_1)	0.34	0.44	0.39	41.62	34.07	37.85			
Line 2 (P_2)	0.36	0.49	0.43	43.79	28.69	36.24			
Line 3 (P_3)	0.51	0.56	0.54	32.53	25.91	29.22			
Line 4 (P_4)	0.57	0.83	0.70	42.26	38.41	40.34			
Line 5 (P_5)	0.67	0.69	0.68	35.72	28.68	32.20			
Gemmeiza9(P_6)	0.64	1.03	0.84	28.08	23.23	25.66			
Sahel 1 (P_7)	1.03	1.39	1.21	35.14	27.97	31.56			
Yacora (P_8)	0.77	0.94	0.86	45.00	32.43	38.72			
1x2	0.32	0.49	0.41	49.94	44.43	47.19	42.12**	58.85**	49.52**
1x3	0.70	0.73	0.72	56.99	45.49	51.24	62.18**	62.64**	62.36**
1x4	0.38	0.60	0.49	19.14	14.71	16.92	-45.53**	-47.41**	-46.39**
1x5	0.39	0.97	0.68	53.94	45.21	49.58	53.50**	61.64**	57.10**
1x6	0.81	0.97	0.89	43.84	34.84	39.34	24.76**	24.56**	24.65**
1x7	0.79	1.04	0.92	55.22	46.35	50.79	57.14**	65.71**	60.93**
1x8	0.71	1.09	0.90	37.57	22.98	30.28	6.92*	-17.84**	-4.06
2x3	0.67	0.78	0.73	56.70	45.71	51.21	61.35**	63.43**	62.26**
2x4	0.67	0.83	0.75	54.97	50.52	52.74	56.43**	80.62**	67.11**
2x5	0.58	0.68	0.63	64.13	52.92	58.53	82.50**	89.20**	85.46**
2x6	0.71	0.79	0.75	55.92	38.59	47.25	59.13**	37.97**	49.71**
2x7	0.55	0.73	0.64	59.56	47.31	53.44	69.49**	69.15**	69.33**
2x8	0.63	0.85	0.74	50.33	42.60	46.46	43.23**	52.31**	47.21**
3x4	0.83	1.16	0.99	13.37	8.93	11.15	-61.95**	-68.07**	-64.67**
3x5	0.49	0.62	0.56	41.10	32.00	36.55	16.96**	14.41**	15.81**
3x6	0.67	0.75	0.71	56.23	43.68	49.95	60.02**	56.17**	58.27**
3x7	0.55	0.75	0.65	51.00	38.27	44.64	45.13**	36.83**	41.44**
3x8	0.51	0.84	0.67	41.63	35.53	38.58	18.47**	27.03**	22.24**
4x5	0.60	0.81	0.71	30.21	26.14	28.18	-14.03**	-6.54	-10.71**
4x6	0.50	0.79	0.65	49.22	25.34	37.28	40.07**	-9.40*	18.12**
4x7	0.79	0.87	0.83	39.04	24.01	31.52	11.10**	-14.16**	-0.13
4x8	0.51	0.74	0.63	20.47	13.55	17.01	-41.75**	-51.56**	-46.10**
5x6	0.64	0.82	0.73	44.95	36.64	40.80	27.92**	31.00**	29.28**
5x7	0.64	0.66	0.65	55.25	44.98	50.11	57.23**	60.82**	58.78**
5x8	0.55	0.69	0.62	49.37	38.55	43.96	40.50**	37.83**	39.29**
6x7	1.03	0.86	0.945	35.14	46.34	40.74	0.001	65.68**	29.09**
6x8	0.53	1.05	0.79	47.47	33.13	40.3	35.09**	18.45**	27.69**
7x8	0.53	0.94	0.735	47.47	32.43	39.95	35.09**	15.95**	26.58**
mean of parents	0.61	0.80	0.70	38.02	29.92	33.97			
mean of crosses	0.61	0.82	0.72	46.73	36.42	41.58			
mean of Genotypes	0.61	0.81	0.71	44.79	34.98	39.89			
L.S.D 5%	0.11	0.16	0.14	2.23	2.21	2.18			
L.S.D 1%	0.15	0.21	0.18	2.97	2.94	2.86			

Sahel 1 (P_7) recorded the highest mean values for ash percentage at both treatments as well as the combined, while, Gemm.9 (P_6) had the highest values for protein percentage at stress irrigation. The lowest mean values were recorded by (P_1) for ash percentage and protein percentage at both irrigation treatments and the combined analysis, while, it recorded the highest one for carbohydrate percentage.

For protein percentage, the mean values of crosses ranged from 7.25, 9.04 and 8.15 by P_1 x P_4 and 13.81, 16.13 and 14.97 by P_3 x P_4 at normal, stress irrigation as well as the combined analysis. Also, the cross P_1 x P_4 recorded the highest values of carbohydrate percentage (73.40, 69.00 and 71.20). Meanwhile, the cross P_3 x P_4 gave the lowest values for this trait (62.93, 60.43 and 61.68%). Moreover, the cross P_1 x P_2 recorded the lowest values of ash percentage (0.32, 0.49 and 0.41%). While, the cross P_3 x P_4 gave the highest values (1.16 and 0.99) under stress irrigation and the combined analysis and cross P_6 x P_7 at normal irrigation.

It can be noticed from the above results, that there were significant increase of protein, carbohydrate and ash percentage exhibited to water stress. In this respect Kramer (1983) recorded that, carbohydrate and protein metabolism are disturbed under water deficit and this often leads to accumulation of sugar and amino acids.

For grain yield /plant, the parental variety Gemmeiza 9 (P_6) had the lowest mean value at normal, stress irrigation treatments as well as the combined analysis, while the parental variety (Yacora) P_8 recorded the greatest values at stress irrigation treatment and the combined analysis. The cross P_2 x P_5 had the highest mean value at normal, stress irrigation treatments as well as the combined analysis. While, the cross P_3 x P_4 had the lowest mean values and of this trait.

Heterois

Superiority expressed as the percentage deviation of F_1 mean performance from sahel 1at both irrigation treatments as well as the combined analysis are presented in table (4).

Twenty two, twenty one and twenty two hybrids exhibited significant superiority heterotic effects relative to check variety Sahel 1 in normal, stress irrigation treatments and for the combined analysis, respectively. The crosses; P_1 x P_3, P_1 x P_5, P_1 x P_7, P_2 x P_3, P_2 x P_5, P_2 x P_7, P_3 x P_6 and P_5 x P_7 gave the highest heterotic effects in both irrigation treatments and for the combined analysis.

Combining ability

The mean squares associated with general combining ability (GCA) and specific combing ability (SCA) were found to be significant for all drought measurements in both irrigation treatments as well as the combined analysis except GCA and SCA for LT in stress irrigation and GCA for TR in stress condition table(3). It is evident that non-additive type of gene action was more important part of the total genetic variability for TR in stress irrigation. For the other studied drought measurement, both additive and non-additive gene effects were involving in determining the performance of single cross progeny. Also, when GCA/SCA ratio was used, it was found that Pn, TR and SC in both irrigation treatments as well as the combined analysis, exhibited low GCA/SCA ratio of less than unity, indicating the predominance of non-additive gene action in the inheritance of such traits. While, high GCA/SCA ratio, which exceeded than unity was obtained for LT, protein, carbohydrate, ash percentages and grain yield/plant in both treatments and the combined analysis. These results were along the same line of Abul-Naas *et al.* (2000) for the three measurements (i.e) LT, SC and TR. EL Seidy *et al.* (2009) showed that high GCA/SCA variance ratios which exceeded the unity and suggested that selection based on phenotype could be effective to improve and develop wheat genotypes. Muhammad and Ihsan 2009, Moussa and Morad 2009, mentioned that the GCA/SCA ratio exceeded the unity for most characters studied indicating that additive genetic variance was predominantly controlling the inheritance of these traits.

It is fairly evident that the ratios for GCA x I/GCA much higher than ratios of SCA x I/SCA. Such results indicated that additive effects were much more influenced by the environmental conditions than the non- additive genetic ones for these traits. On the other hand, the chemical measurements (protein, carbohydrate and ash percentages) and grain yield/plant the ratio of SCA x I/SCA was much higher than the ratios of GCA x I/GCA was detected. Such results indicated that non additive effects were much more influenced by environmental changes than GCA. El Hosary *et al.* (2009a, b) found that non additive type of gene action was much more influence by the environmental condition than additive genetic ones for some drought measurements.

General combining ability effects

General combining ability effects "$\hat{g}_i$" of each parent for all studied measurements at normal, stress irrigation as well as the combined analysis are presented in table (6). Such results are being used to compare the average performance of each parent with other genotype and facilitate selection of parents for further improvement to drought resistance. High positive values would be interest under all measurements in question except LT and TR where, high negative effects would be useful from the breeder point of view.

The parental line P_1 exhibited significant positive "$\hat{g}_i$" effects for carbohydrate percentage in irrigation treatments as well as the combined analysis and SC under drought condition. However, it gave significant undesirable or insignificant "$\hat{g}_i$" effects for other measurements. The parental line (P_2) expressed significant positive "$\hat{g}_i$" effects for SC and grain yield/plant in both irrigation treatments and the combined analysis and net photosynthesis rate under drought condition. While, it gave significant negative or insignificant "$\hat{g}_i$" effects for other drought treatments. The parental line (P_3) expressed significant positive "$\hat{g}_i$"effects for protein percentage in both irrigation treatments and the combined analysis, stomatal conductance under control and carbohydrate percentage under drought condition and the combined analysis. However, it gave significant undesirable or insignificant "$\hat{g}_i$" effects for other measurements. The parental line (P_4) showed significant positive "$\hat{g}_i$" effects for protein percentage in both irrigation treatments and the combined analysis; however, it gave either significant negative or insignificant "$\hat{g}_i$" effects for other traits. The parental line (P_5) had significant positive "$\hat{g}_i$" effects for grain yield/plant in both irrigation treatments and the combined analysis and TR under normal irrigation, while it expressed insignificant "$\hat{g}_i$" effects for the most other traits. The parental variety Gemm.9 (P_6) expressed significant desirable "$\hat{g}_i$"effects for SC, protein percentage, ash percentage and grain yield/plant in both irrigation treatments and the combined analysis. While, it gave insignificant "$\hat{g}_i$" effects for the most traits. The parental variety Sahel 1 (P_7) seemed to be good general combiner for ash percentage and grain yield/plant in irrigation treatments as well as the combined analysis and Pn in normal irrigation and the combined analysis. While, it gave significant undesirable or in significant "$\hat{g}_i$" effects for other traits. The parental variety Yacora (P_8) expressed significant positive "$\hat{g}_i$" effects for protein percentage in irrigation treatments as well as the combined analysis and ash percentage under drought conditions and the combined analysis. Also, it gave either significant negative or insignificant "$\hat{g}_i$" effects for other traits.

Specific combining ability effects:

Specific combining ability effects "$\hat{S}_{ij}$" of the parental combinations were computed for all the studied measurements under normal, stress irrigation treatments and the combined analysis (Table 7).

The two crosses P_3 x P_5 and P_3x P_7 expressed significant desirable "$\hat{S}_{ij}$" effect for leaf temperature; ten, five and seven crosses, for transpiration rate; eleven, six and nine crosses for stomatal conductance; seven, seven and four hybrids, for Pn; eleven, twelve and thirteen crosses for protein percentage; twelve, twelve and thirteen crosses, for carbohydrate percentage; eight, seven and seven for ash percentage in normal, stress irrigation treatments as well as the combined analysis, respectively.

The most desirable "$\hat{S}_{ij}$" effects were recorded by the cross namely P_3 x P_5 in the combined analysis and P_3 x P_7 under normal irrigation, P_1 x P_4 and P_3 x P_4 under stress irrigation and P_1 x P_4 and P_3 x P_4 in the combined analysis for transpiration rate, P_4 x P_6 and P_5 x P_8 under normal irrigation and P_1 x P_5 and P_4 x P_6 in the combined analysis for stomatal conductance; P_4 x P_5 and P_5 x P_8 under normal, stress irrigation and the combined analysis for Pn; P_3x P_4, P_1 x P_6 and P_1 x P_8 under normal, stress irrigation and the combined analysis for protein percentage; P_1 x P_4 and P_3 x P_8 in normal, stress treatments and the combined analysis for carbohydrate percentage and P_3 x P_4 in both irrigation treatments and the combined analysis and P_1 x $P_{5,}$ P_1 x P_6 and P_1 x P_8 under normal, stress and the combined analysis, respectively for ash percentage. The mentioned combinations might be of interest in breeding programs aimed at producing pure line varieties as most combinations involved at least one good combiner.

Regarding grain yield/plant, sixteen, seventeen and seventeen parental combinations expressed significant positive "$\hat{S}_{ij}$" effects under the normal, stress irrigation and the combined data, respectively. The meantime, the most desirable "$\hat{S}_{ij}$" effects were recorded by the crosses P_1 x P_5, P_2 x P_4, P_2 x P_5, P_4 x P_6, P_5 x$P_{7,}$ P_5 x P_8 and P_6x P_8 in both irrigation treatments as well as the combined data. From such results, it could be concluded that the crosses P_3 x P_4, P_1 x P_5, P_4 x P_5, P_4 x P_6 and P_5 x P_8 were prospective in wheat breeding program since they expressed the highest "$\hat{S}_{ij}$" effects for most studied physiological and chemical traits.

Table (6): Estimate of general combining ability effects " $\hat{g}_i$ " for the eight parents studied at normal, stress irrigation treatments as well as the combined data for the traits studied.

Traits / Parents	Leaf temperature (LT)			Transpiration rate (TR)			Stomatal conductance rate (SC)			Net photosynthesis rate (Pn)		
	Control	**Drought**	**Comb.**	**Control**	**Drought**	**Comb.**	**Control**	**Drought**	**Comb.**	**Control**	**Drought**	**Comb.**
P_1	1.10**	0.03	0.56**	0.11*	0.11	0.11*	4.22	11.46*	7.84	-0.37	0.25	-0.06
P_2	0.21	-0.06	0.08	-0.01	0.02	0.01	7.81*	11.17*	9.49*	0.22	0.66*	0.44
P3	-0.28	-0.30	-0.29	0.06	-0.10	-0.02	7.32*	-23.79**	-8.24	-1.44**	0.02	-0.71*
P_4	-0.03	-0.17	-0.10	-0.07	0.01	-0.03	-16.1**	-6.58	-11.34**	-0.62*	-0.92**	-0.77**
P_5	-0.22	0.34	0.06	-0.15**	0.04	-0.05	-20.0**	-3.76	-11.88**	0.43	-0.50	-0.03
P_6	-0.39	-0.25	-0.32	-0.03	-0.11	-0.07	25.53**	12.92*	19.22**	0.61*	-0.39	0.11
P_7	-0.27	0.23	-0.02	0.19**	0.001	0.09	-9.20**	-9.69	-9.44*	0.93**	0.44	0.69*
P_8	-0.12	0.16	0.02	-0.10	0.03	-0.03	0.41	8.27	4.34	0.24	0.44	0.34
r	0.82*	0.46	0.43	0.66	0.33	0.61	0.63	0.12	0.31	0.34	0.74*	0.37
L.S.D 5% " $\hat{g}_i$ "	0.31	NS	0.34	0.11	NS	0.11	6.68	10.26	8.47	0.55	0.62	0.58
L.S.D1% " $\hat{g}_i$ "	0.42	NS	0.45	0.14	NS	0.14	8.89	13.64	11.27	0.73	0.82	0.77
L.S.D5% ($\hat{g}_i$ - $\hat{g}_i$)	0.47	NS	0.37	0.16	NS	0.12	10.10	7.76	8.93	0.83	0.47	0.65
L.S.D1% ($\hat{g}_i$ - $\hat{g}_i$)	0.63	NS	0.45	0.21	NS	0.14	13.44	7.76	10.6	1.11	0.47	0.79

*** and * * significant at 0.05 and 0.01 levels of probability, respectively.**
r = correlation coefficient between parental means performance and its GCA effects.

Table (6): Cont.

Parents / Traits	Protein percentage			Carbohydrate percentage			Ash percentage			Grain yield/plant (g)		
	Control	**Drought**	**Comb.**	**Control**	**Drought**	**Comb.**	**Control**	**Drought**	**Comb.**	**Control**	**Drought**	**Comb.**
P_1	-0.88**	-0.62**	-0.75**	1.50**	1.83**	1.66**	-0.07**	-0.05**	-0.06**	-3.39**	-1.54**	-2.47**
P_2	-0.61**	-1.04**	-0.83**	-0.30*	-0.02	-0.16	-0.07**	-0.12**	-0.09**	9.90**	9.82**	9.86**
P3	0.35**	0.13*	0.24**	0.25	0.28**	0.27*	-0.01	-0.06**	-0.03*	-6.73**	-6.05**	-6.39**
P_4	0.19**	0.66**	0.42**	-0.26	-0.77**	-0.52**	-0.01	0.02	0.001	-11.18**	-8.86**	-10.02**
P_5	0.02	-0.02	0.001	-0.38**	0.18	-0.10	-0.03*	-0.07**	-0.05**	1.90**	3.96**	2.93**
P_6	0.42**	0.60**	0.51**	-0.47**	-0.71**	-0.59**	0.05**	0.08**	0.07**	5.33**	1.15**	3.24**
P_7	0.09	-0.28**	-0.10	0.17	-0.62**	-0.22	0.11**	0.13**	0.12**	5.51**	3.54**	4.53**
P_8	0.43**	0.58**	0.51**	-0.51**	-0.17	-0.34**	0.02	0.07**	0.05**	-1.35**	-2.02**	-1.68**
r	0.80*	0.89**	0.94**	0.64	0.80*	0.73*	0.91**	0.93**	0.94**	-0.16	-0.47	-0.31
L.S.D 5% " $\hat{g}_i$ "	0.10	0.13	0.11	0.27	0.20	0.23	0.02	0.03	0.03	0.52	0.45	0.48
L.S.D 1% " $\hat{g}_i$ "	0.13	0.17	0.15	0.36	0.27	0.31	0.03	0.04	0.04	0.69	0.60	0.63
L.S.D 5% ($\hat{g}_i$ - $\hat{g}_i$)	0.14	0.10	0.17	0.41	0.15	0.35	0.04	0.03	0.04	0.78	0.69	0.73
L.S.D 1% ($\hat{g}_i$ - $\hat{g}_i$)	0.19	0.10	0.22	0.54	0.15	0.46	0.05	0.03	0.06	1.04	0.91	0.95

*** and * * significant at 0.05 and 0.01 levels of probability, respectively.**
r = correlation coefficient between parental means performance and its GCA effects.

Table (7): Estimate of specific combining ability effects " $\hat{S}_{ij}$ " for the twenty eight crosses studied normal, Stress irrigation treatments as well as the combined data for the traits studied.

Traits / Crosses	Leaf temperature (LT)			transpiration rate (TR)		
	Control	Drought	Combined	Control	Drought	Combined
P1xP2	1.06 *	-0.31	0.38	0.45 * *	-0.27	0.09
P1xP3	-0.42	-0.33	-0.37	0.07	-0.16	-0.04
P1xP4	0.50	-0.49	0.001	-0.88 * *	-0.38 *	-0.63 * *
P1xP5	-0.25	-0.70	-0.48	0.29	-0.04	0.13
P1xP6	-1.61 * *	0.85	-0.38	0.34 *	0.41 *	0.37 *
P1xP7	1.37 * *	0.44	0.90	-0.06	-0.12	-0.09
P1xP8	-1.28 * *	-0.26	-0.77	-0.33 *	0.08	-0.12
P2xP3	1.04 *	-0.74	0.15	-0.49 * *	-0.23	-0.36 *
P2xP4	-0.11	-0.10	-0.11	0.36 *	0.08	0.22
P2xP5	-0.93	0.25	-0.34	0.07	0.19	0.13
P2xP6	-0.83	0.01	-0.41	-0.43 *	-0.05	-0.24
P2xP7	-1.94 * *	-0.07	-1.01	0.001	0.03	0.01
P2xP8	-1.32 * *	0.67	-0.33	0.41 *	-0.52 * *	-0.05
P3xP4	-1.56 * *	-0.43	-0.99	-1.07 * *	-0.39 *	-0.73 * *
P3xP5	-1.64 * *	-0.64	-1.14 *	0.27	0.32	0.30
P3xP6	-0.30	-0.18	-0.24	0.50 * *	-0.02	0.24
P3xP7	-1.45 * *	-0.67	-1.06 *	0.38 *	-0.34 *	0.02
P3xP8	-0.53	0.21	-0.16	-0.07	0.04	-0.02
P4xP5	0.01	-0.57	-0.28	0.38 *	0.34 *	0.36 *
P4xP6	-0.39	-0.84	-0.61	0.42 *	0.30	0.36 *
P4xP7	-0.84	0.81	-0.01	-0.80 * *	-0.12	-0.46 * *
P4xP8	-0.62	1.35	0.37	-0.38 *	-0.29	-0.33 *
P5xP6	-0.57	-0.75	-0.66	-0.41 *	-0.52 * *	-0.46 * *
P5xP7	-0.62	0.36	-0.13	-0.54 * *	0.04	-0.25
P5xP8	0.27	-0.80	-0.26	0.46 * *	0.40 *	0.43 *
P6xP7	0.48	-0.35	0.07	-0.40 *	-0.29	-0.34 *
P6xP8	-0.46	-0.41	-0.43	-0.17	-0.23	-0.20
P7xP8	0.19	-0.26	-0.03	0.46 * *	0.24	0.35 * *
L.S.D 5% (s_{ij})	0.96	NS	1.03	0.33	0.33	0.33
L.S.D 1% (s_{ij})	1.27	NS	1.37	0.44	0.44	0.44
L.S.D 5% (s_{ij}-s_{ik})	1.42	NS	1.53	0.48	0.49	0.49
L.S.D 1% (s_{ij}-s_{ik})	1.88	NS	2.02	0.64	0.66	0.65
L.S.D 5% (s_{ij}-s_{ki})	1.34	NS	1.44	0.46	0.47	0.49
L.S.D 1% (s_{ij}-s_{ki})	1.78	NS	1.91	0.61	0.62	0.62

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

Table (7): Cont.

Traits / Crosses	Stomatal conductance(SC)			Net photosynthesis rate(Pn)		
	Control	**Drought**	**Combined**	**Control**	**Drought**	**Combined**
P1xP2	-54.09 * *	12.58	-20.75	1.12	-0.17	0.47
P1xP3	-17.98	-18.39	-18.19	2.85 * *	-0.71	1.07
P1xP4	-29.25 * *	-96.88 * *	-63.07 * *	-2.15 *	-2.45 *	-2.30 *
P1xP5	42.83 * *	-24.01	9.41	-1.64	1.13	-0.25
P1xP6	34.64 * *	192.47 * *	113.55 * *	2.56 * *	0.46	1.51
P1xP7	14.17	-69.74 * *	-27.79 *	-0.36	1.28	0.46
P1xP8	37.86 * *	104.41 * *	71.13 * *	-1.99 *	-1.03	-1.51
P2xP3	-47.80 * *	-74.61 * *	-61.20 * *	-0.79	0.14	-0.32
P2xP4	22.14 *	1.30	11.72	0.34	3.12 * *	1.73
P2xP5	-13.65	82.46 * *	34.41 *	-0.47	1.49	0.51
P2xP6	-60.54 * *	-18.93	-39.74 * *	-2.15 *	-2.55 * *	-2.35 *
P2xP7	60.24 * *	-2.40	28.92 *	-0.09	-0.75	-0.42
P2xP8	-31.34 * *	1.50	-14.92	1.56	-4.18 * *	-1.31
P3xP4	-74.12 * *	-80.25 * *	-77.19 * *	-8.04 * *	-6.76 * *	-7.40 * *
P3xP5	69.73 * *	151.69 * *	110.71 * *	-1.46	0.36	-0.55
P3xP6	40.87 * *	15.53	28.20 *	1.24	3.56 * *	2.40 * *
P3xP7	13.12	16.16	14.64	1.83 *	-1.73	0.05
P3xP8	4.71	5.99	5.35	0.72	2.20 *	1.46
P4xP5	28.90 * *	46.26 * *	37.58 * *	5.99 * *	4.10 * *	5.04 * *
P4xP6	153.42 * *	69.23 * *	111.32 * *	4.77 * *	2.75 * *	3.76 * *
P4xP7	-58.62 * *	-10.01	-34.31 *	-3.02 * *	0.10	-1.46 *
P4xP8	-80.04 * *	-43.22 * *	-61.63 * *	0.83	0.17	0.50
P5xP6	-45.79 * *	-103.27 * *	-74.53 * *	-3.02 * *	-2.32 * *	-2.67 * *
P5xP7	-55.86 * *	15.47	-20.19	2.16 *	-0.05	1.05
P5xP8	110.97 * *	23.29	67.13 * *	6.12 * *	3.85 * *	4.98 * *
P6xP7	-104.80 * *	-1.84	-53.32 * *	0.10	-2.61 * *	-1.26
P6xP8	9.05	-10.61	-0.78	-3.84 * *	-1.25	-2.54 * *
P7xP8	15.02	6.47	10.74	0.64	2.59 * *	1.61
L.S.D 5% (s_{ij})	20.48	31.45	25.98	1.69	1.89	1.79
L.S.D 1% (s_{ij})	27.24	41.83	34.53	2.24	2.51	2.38
L.S.D 5% (s_{ij}-s_{ik})	30.31	46.53	38.42	2.49	2.80	2.65
L.S.D1% (s_{ij}-s_{ik})	40.31	61.89	51.1	3.32	3.72	3.52
L.S.D 5% (s_{ij}-s_{ki})	28.57	43.87	36.22	2.83	2.48	2.66
L.S.D 1% (s_{ij}-s_{ki})	38.00	58.35	48.18	3.76	3.30	3.53

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

Table (7): Cont.

Traits / Crosses	Protein percentage			Carbohydrate percentage		
	Control	Drought	Combined	Control	Drought	Combined
P1xP2	-1.00 * *	-1.01 * *	-1.01 * *	2.03 * *	0.38	1.21 * *
P1xP3	0.001	-0.78 * *	-0.39 *	-0.82 *	0.15	-0.34
P1xP4	-2.54 * *	-3.35 * *	-2.95 * *	5.99 * *	3.67 * *	4.83 * *
P1xP5	1.02 * *	1.44 * *	1.23 * *	0.71	-0.98 * *	-0.14
P1xP6	2.06 * *	0.76 * *	1.41 * *	-2.16 * *	-1.45 * *	-1.81 * *
P1xP7	0.83 * *	1.28 * *	1.06 * *	-0.84 *	-1.28 * *	-1.06 * *
P1xP8	0.85 * *	1.72 * *	1.28 * *	-3.56 * *	0.44	-1.56 * *
P2xP3	0.51 * *	0.22	0.36 *	-0.99 *	-0.94 * *	-0.97 * *
P2xP4	1.19 * *	0.43 *	0.81 * *	-1.44 * *	-0.42	-0.93 *
P2xP5	-0.47 * *	-0.05	-0.26	0.27	-0.84 * *	-0.28
P2xP6	0.87 * *	0.41 *	0.64 * *	-1.37 * *	-0.81 *	-1.09 * *
P2xP7	-0.54 * *	-0.17	-0.36 *	0.02	1.43 * *	0.72 *
P2xP8	-0.38 *	-0.43 *	-0.40 *	0.44	-0.58	-0.07
P3xP4	2.79 * *	2.98 * *	2.88 * *	-3.23 * *	-3.36 * *	-3.29 * *
P3xP5	-0.17	-0.99 * *	-0.58 * *	-0.38	-0.37	-0.38
P3xP6	0.61 * *	-0.33	0.14	-1.38 * *	-0.68 *	-1.03 * *
P3xP7	0.11	0.59 * *	0.35 *	1.37 * *	-0.21	0.58
P3xP8	-1.74 * *	-0.52 * *	-1.13 * *	2.92 * *	1.88 * *	2.40 * *
P4xP5	0.54 * *	0.17	0.35 *	-0.43	-0.66 *	-0.54
P4xP6	-0.52 * *	-1.52 * *	-1.02 * *	-0.13	1.07 * *	0.47
P4xP7	1.56 * *	1.01 * *	1.28 * *	-2.88 * *	-0.22	-1.55 * *
P4xP8	0.09	0.44 *	0.26	0.80	0.60	0.70
P5xP6	0.19	0.49 *	0.34 *	-0.05	-0.78 *	-0.41
P5xP7	-1.10 * *	0.01	-0.54 * *	0.17	-0.41	-0.12
P5xP8	0.19	-0.53 * *	-0.17	-0.11	-0.62 *	-0.37
P6xP7	-0.36 *	-0.87 * *	-0.61 * *	-1.60 * *	0.52	-0.54
P6xP8	-0.48 * *	0.24	-0.12	1.48 * *	0.21	0.85 *
P7xP8	0.84 * *	0.89 * *	0.86 * *	1.60 * *	0.92 * *	1.26 * *
L.S.D5% (s_{ij})	0.29	0.39	0.34	0.82	0.62	0.71
L.S.D1% (s_{ij})	0.39	0.52	0.44	1.09	0.82	0.94
L.S.D5% (s_{ij}-s_{ik})	0.43	0.58	0.50	1.22	0.92	1.06
L.S.D1% (s_{ij}-s_{ik})	0.57	0.77	0.66	1.62	1.22	1.38
L.S.D5% (s_{ij}-s_{ki})	0.41	0.55	0.47	1.15	0.86	1.00
L.S.D1% (s_{ij}-s_{ki})	0.54	0.73	0.62	1.53	1.15	1.31

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

Table (7): Cont.

Traits / Crosses	Ash percentage			Grain yield/plant (g)		
	Control	**Drought**	**Combined**	**Control**	**Drought**	**Combined**
P1xP2	-0.15 * *	-0.15 * *	-0.15 * *	-9.17 * *	-5.99 * *	-7.58 * *
P1xP3	0.17 * *	0.03	0.10 *	22.52 * *	11.95 * *	17.23 * *
P1xP4	-0.15 * *	-0.17 * *	-0.16 * *	-18.89 * *	-14.36 * *	-16.63 * *
P1xP5	-0.12 * *	0.28 * *	0.08	10.78 * *	10.66 * *	10.72 * *
P1xP6	0.21 * *	0.13 *	0.17 * *	-4.37 * *	3.10 * *	-0.64
P1xP7	0.15 * *	0.15 * *	0.15 * *	10.50 * *	15.21 * *	12.86 * *
P1xP8	0.15 * *	0.26 * *	0.20 * *	-2.96 * *	-10.59 * *	-6.77 * *
P2xP3	0.13 * *	0.14 * *	0.14 * *	16.93 * *	16.13 * *	16.53 * *
P2xP4	0.14 * *	0.12 *	0.13 * *	17.65 * *	22.08 * *	19.86 * *
P2xP5	0.06	0.06	0.06	22.05 * *	21.00 * *	21.53 * *
P2xP6	0.11 * *	0.02	0.06	3.08 * *	3.49 * *	3.28 * *
P2xP7	-0.10 * *	-0.10 *	-0.10 *	7.54 * *	6.81 * *	7.18 * *
P2xP8	0.06	0.08	0.07	-0.83	2.66 * *	0.91
P3xP4	0.23 * *	0.38 * *	0.31 * *	-21.32 * *	-18.30 * *	-19.81 * *
P3xP5	-0.09 *	-0.07	-0.08	-6.67 * *	-8.04 * *	-7.36 * *
P3xP6	0.01	-0.09	-0.04	5.02 * *	6.44 * *	5.73 * *
P3xP7	-0.16 * *	-0.13 *	-0.15 * *	-0.38	-1.37	-0.87
P3xP8	-0.12 * *	0.01	-0.05	-2.89 * *	1.46	-0.72
P4xP5	0.03	0.05	0.04	-13.11 * *	-11.10 * *	-12.10 * *
P4xP6	-0.16 * *	-0.11 *	-0.14 * *	27.46 * *	11.91 * *	19.69 * *
P4xP7	0.08 *	-0.09	0.01	5.09 * *	-0.49	2.30 * *
P4xP8	-0.12 * *	-0.16 * *	-0.14 * *	-20.93 * *	-17.71 * *	-19.32 * *
P5xP6	0.00	0.00	0.00	1.54	4.40 * *	2.97 * *
P5xP7	-0.05	-0.22 * *	-0.13 * *	15.60 * *	15.34 * *	15.47 * *
P5xP8	-0.06	-0.13 *	-0.09	11.20 * *	10.48 * *	10.84 * *
P6xP7	-0.08 *	-0.16 * *	-0.12 * *	15.02 * *	-2.48 * *	6.27 * *
P6xP8	0.06	0.09	0.07 *	22.64 * *	15.54 * *	19.09 * *
P7xP8	-0.22 * *	-0.10 *	-0.16 * *	3.60 * *	9.48 * *	6.54 * *
L.S.D 5% (s_{ij})	0.07	0.10	0.09	1.59	1.39	1.04
L.S.D 1% (s_{ij})	0.10	0.14	0.11	2.11	1.85	1.36
L.S.D 5% (s_{ij}-s_{ik})	0.11	0.15	0.13	2.35	2.06	1.54
L.S.D 1% (s_{ij}-s_{ik})	0.14	0.20	0.17	3.12	2.73	2.02
L.S.D 5% (s_{ij}-s_{ki})	0.10	0.14	0.12	2.21	1.94	0.51
L.S.D 1% (s_{ij}-s_{ki})	0.14	0.19	0.16	2.94	2.58	0.67

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

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تقيم الهجن التبادلية في القمح تحت ظروف الجفاف

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** البنك القومي للجينات والموارد الوراثية

تهدف الدراسة إلي تقييم قمح الخبزفي تجربتين الاولي تحت ظروف الري العادي والثانية تحت ظروف الاجهاد المائي في ثلاث مكررات. كان التباين الراجع للتراكيب الورثية ، الهجن والتفاعل بين الأباء والهجن معنويا لكل من درجة حرارة الورقة، صافي التمثيل الضوئي، معدل النتح، مقاومة الثغور، نسبة البروتين، نسبة الكربوهيدرات و نسبة الرماد ومحصول الحبوب/نبات تحت ظروف الري الطبيعي (الكنترول)، الإجهاد الرطوبي والتحليل المشترك. أظهرت كلا من السلالات الأبوية P_4 وP_6 و P_8 و P_1 وP_7 أعلي قيم لصفات مقاومة الثغور وصافى التمثيل الضوئى ونسبة البروتين% والرماد% و الكربوهيدرات% ومحصول الحبوب للنبات على الترتيب تحت ظروف الإجهاد المائى والتحليل المشترك. كما أظهرت الهجن P_1 x P_6 وP_5 x P_8 وP_3 x P_4 و P_2 x P_5 وP3 x P_4 أعلي قيم لصفات مقاومة الثغور وصافى التمثيل الضوئى ونسبة البروتين% والرماد% و الكربوهيدرات% ومحصول الحبوب للنبات على الترتيب تحت ظروف الإجهاد المائى والتحليل المشترك. كان التباين الراجع للقدرة العامة (GCA) والخاصة علي الإئتلاف (SCA) معنويا في الصفات تحت الدراسة. كانت النسبة بين القدرة العامة/القدرة الخاصة أعلي من الوحدة لصفات: درجة حرارة الورقة، نسبة البرتين، نسبة الكربوهيدرات و نسبة الرماد تحت ظروف الري الطبيعي (الكنترول)، الإجهاد الرطوبي والتحليل المشترك. بينما كانت النسبة بين القدرة العامة/القدرة الخاصة لمعدل النتح و مقاومة الثغور وصافي التمثيل الضوئي أقل من الوحدة تحت ظروف الري الطبيعي (الكنترول)، الإجهاد والتحليل المشترك. كانت النسبة بين القدرة الخاصة وتفاعلها مع معاملات الرى/القدرة الخاصة أعلى من النسبة بين القدرة العامة وتفاعلها مع معاملات الرى/القدرة العامة لنسبة البروتين، نسبة الكربوهيدرات و نسبة الرماد ومحصول الحبوب/نبات. أظهرت كل من السلالات الأبوية P_1، P_2 و قدرة P_5 P_3 عامة على التآلف موجبة و معنوية لصفة المقاومة للثغور و أظهرت كل من، P_6 و P_7 قدرة عامة على التآلف موجبة و معنوية لصفة محصول الحبوب للنبات. أظهر الهجين P_3 x P_4 قدرة خاصة علي التألف معنوية لصفة درجة حرارة الورقة، معدل النتح، صافي التمثيل الضوئي و نسبة الكربوهيدرات و الهجن P_1 x P_5 و P_4 x P_6 لصفة المقاومة للثغور، الهجن P_4 x P_5 و P_5 x P_8 لنسبة البروتين تحت ظروف الري الطبيعي (الكنترول)، الإجهاد والتحليل المشترك.