IMPROVING WHEAT PRODUCTION UNDER DROUGHT CONDITIONS BY USING DIALLEL CROSSING SYSTEM

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ABSTRACT

Five drought measurements, i.e. stomatal resistance (SR), transpiration rate (TR), leaf temperature (LT), relative water content (RWC) and Potassium content (K^+) were estimated for seven parental varieties and their hybrid under 40% and 60% depletion of the available soil moisture. Irrigation mean squares were highly significant for all the studied traits, except for TR and RWC, mean values of stress condition for all drought measurements were higher than those of normal irrigation. Mean squares for genotypes, parents, crosses and parent vs. crosses were significant for all traits in both environments as well as the combined analysis, except parents' mean square for LT in stress condition, parent vs. crosses for SR in the combined analysis and TR, LT and RWC in stress condition

The variety ICARDA 3 expressed significant positive $\hat{g}_i$ effects for SR, RWC and K^+ in the normal irrigation as well as the combined analysis. Also, it seemed to be the best combiner for LT in both irrigation as well as the combined analysis. The parent variety Sakha 93 seemed to be the best general combiner for TR in the stress irrigation and the combined analysis. It could be considered as an excellent parent in breeding programs towards releasing varieties characterized by low TR.

The most desirable Sij effects were recorded by the crosses Sham 6 x L 606, ICARDA 3 x Giza 168 and Sham 6 x Gemmiza 7 for SR, Gemmiza 7 x L 606, Giza 168 x Sakha 93 and Sham 6 x ICARDA 3 for TR, Sakha 93 x L 606, ICARDA 3 x Gemmiza 7 and Sham 6 x Giza 168 for RWC in both irrigation treatments as well as the combined analysis and Yacora Rojo x L606 under stress irrigation treatment for LT and Sakha 93 x L 606 and Gemmiza 7 x L606 for K^+ under stress and the combined data.

Key words: Wheat, drought stress, heterosis, combining ability, diallel crosses

INTRODUCTION

Increasing grain yield of cereal crops is considered one of the more important national goals in Egypt to face the needs of increment of Egyptian people. Wheat production in Egypt increased from 2.08 million ton in 1982/83 to 7.18 million ton in 2003/04 season, (Statistical Year's Book, 2004, ARC, Giza). This increase was achieved by both increasing wheat area from 554,400 to 1 085 618 hectares and the continuous rise in grain yield ha^{-1} because of cultivating high yielding genotypes from 3.595 to 6.61-ton ha^{-1} and improved cultural practices at newly reclaimed areas. It has become necessary to develop wheat lines adapted to drought region.

Today, the world's agriculture is seriously affected by drought. In particular, drought is the number one environmental limitation to many crops. It was predicted that drought is becoming the largest constraint to productions of some water-consuming crops such as wheat in the new century. In general, screening and discovering drought tolerant gene resources are urgently needed for creating productive breeding materials with improved drought tolerance. Diallel cross technique is the good tool for identification of hybrid combinations that have the potentiality of producing maximum improvement and identifying superior lines among the progenies in early segregating generations.

Griffing (1956) noted that parental and F_1 data have distinct advantage over data from segregating generations in studying quantitative genetic systems because, being unaffected by genetic segregation and linkage, the former data require relatively few individuals for estimation genetic parameters. Hence, more parents and wider range of germplasm can be included. Diallel analysis for estimating certain genetic parameters in terms of gene models have been developed and extensively used by plant breeders

Combining ability is one of the powerful tools in identifying the best combiners, which may be hybridized either to exploit heterosis or to accumulate fixable genes. Heterosis in wheat has not been exploited yet.

The main objectives of the present investigation are to assess the variations amongst a few wheat genotypes and available crosses for several drought tolerance characters, to estimate the magnitude of heterosis, general combining ability and specific combining ability to improve wheat under drought conditions and to determine suitable measurements for drought resistance in wheat genotypes.

MATERIAL AND METHODS

diallel cross set involving the seven parents was made in winter of 2002/03 in a wire green-house under normal conditions at Desert Research Center (DRC), Matarya, Cairo, Egypt, to produce the F_1-generation. In 2003/04 growing season, two experiments were conducted in the headquarters of DRC, each experiment include the seven parents and their twenty one F_1 hybrids, which were sown in a randomized complete block design (RCBD) with three replications. The first and the second experiments irrigated when the field capacity was 60% and 40% depletion of the available soil moisture respectively.

At flowering stage between 11 a.m. and 2 p.m. hour on peduncle leaf from each genotype using portable steadily state prometer (Li-COR model-1600) were used to measure:, Leaf temperature (LT), Stomatal resistance (SR), Transpiration rate (TR), and Relative water content (R.W.C.). Also, Potassium content (K^+) was estimated in the acid digest that was prepared by using a mixture of 1:5 percloric acid ($HClC_4$) and sulfuric acid (H_2So_4) respectively.

Heterosis for each trait computed as parents vs. hybrids sum of squares was obtained by partitioning the genotypes sum squares to its components. Procedure genotypes were subdivided to parents, crosses, and parents vs. crosses. Heterosis was also determined according to Paschal and Wilcox (1975) for individual crosses as the percentage deviation of F_1 mean performance from either the mid-parent value (MP) or the better parent mean (BP) for each experiment as well as the combined analysis. General and specific combining ability estimates were obtained by employing Griffing's (1956) diallel cross analysis designated as a model-1 method-2.

Table (1): Name and pedigree of the seven wheat genotypes under study.

Parent	Source	Pedigree and or selection history
Yacora Rojo (P_1)	CIMMYT	Ciano 67/Sonora 6411 klien Rendidor/3/1L815626Y-2M-1Y-0M-302M
Sham-6 (P_2)	Syria	CM39992-8M-7Y-OM-OAPMex/syr/orgin
ICARDA-3 (P_3)	Syria	CM59456-3AP-1AP-2AP- 1AP-0AP
Giza-168 (P_4)	Egypt	MRL/BUC//SERI CM 93046-8M-0Y-0M-2Y-0B-$0G_z$
Sakha-93 (p_5)	Egypt	S 92 / TR 810328 S8871-1S-2S-1S-0S
Gemmiza-7 (P_6)	Egypt	CMH 74A- 630/Sx//Seri 82/3/Agent/C GM 4611 2Gm-3Gm-16 Gm- 0Gm
Line-606 (P_7)	Egypt	Atlas 66/Nap Hall // (NE70117) Skores Pelka35/3/2* RCB-61 Su606-13Su-2Su-5Su-0Su.

*Newly bread line released through Desert Research Center, Crop Breeding Program

RESULTS AND DISCUSSION

Results in Table (2) indicated that irrigation mean squares were highly significant for all the studied traits, indicating overall differences between normal and stress condition. Except for TR and RWC, mean values of stress condition for all drought measurements were higher than those of normal irrigation, indicating that selection for stress tolerance should give a positive yield response under stress. In addition, 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 the same genes, making indirect selection unattractive, did not control low-productivity environments.

Mean squares for genotypes, parents, crosses and parent vs. crosses were significant for all traits in both environments as well as the combined analysis, except parents mean square for LT in stress condition, parent vs. crosses for SR in the combined analysis and TR, LT and RWC in stress conditions, indicating wide diversity between the parental used in the present study for these traits. Genotypes × irrigation, parent × irrigation, F_1 × irrigation and parent vs. crosses × irrigation mean squares were significant for all traits except parent × irrigation for LT, crosses × irrigation for SR and parent vs. crosses × irrigation for LT and K^+ content. Such results indicated that the tested genotypes varied from each other and ranked differently from normal to stress irrigation treatments.

Stomatal resistance (SR)

In addition, mean values of normal environment for yield and its components were higher than those of stress condition.

Data presented in (Table 3) clearly show that during occurrence of water stress, SR increased considerably. The highest mean values of SR under stress condition were recorded with ICARDA 3 × Giza 168 (5.80), followed by cross Sham 6 × line 606 (5.73) and then by Giza 168 (5.4). While, the crosses Sham 6 × ICARDA 3 (3.3), Gemmiza 7 × line 606 (3.26) recorded lowest SR values. Moreover, the other genotypes recorded moderate SR values. Similar results were found by El-Gamal (2001) who 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 fed back mechanism Giorio *et al*., (1999). Moreover, West *et al*., (1990) showed that, the drought resistance cultivar had a significant higher stomatal resistance than the drought sensitive cultivar. The drought resistant plants closed their stomata in response to the slight water stress condition, while the drought sensitive plants kept their stomata open. However, Shimishi and Ephart (1975) suggested that the prometer method would be useful in wheat breeding programs. The study showed that stomatal resistance was the best method to use to screen plant for drought resistance.

Transpiration rate (TR) and leaf temperature (LT):

Results in (Table 3) showed that water treatments had significant effect on transpiration rate and leaf temperature overall genotypes where the water stress decreased TR by 50.63% and increased LT by 4.92%. The rise of leaf temperature under water stress conditions may be due to the decrease in transpiration rate as compared with normal irrigation. Ehrler *et. al.* (1978) and El-Gamal (2001), they added that stomatal closure results increased LT. if other relevant factors, like wind speed and vapor pressure remain relatively constant.

The mean performance of the seven parents and twenty-one hybrids of wheat at stress and normal irrigation in (Table 3) showed that the parental Sakha 93 had the lowest mean values for TR followed by Yacora Rojo, Sham 6 and line 606 and the highest mean values observed by ICARDA 3 and Giza 168. In addition, the lowest values were obtained from crosses Giza 168×Sakha 93, ICARDA 3 × line 606, Sham 6 × ICARDA 3 and Gemmiza 7 × line 606 in stress conditions. While, the crosses Yacora Rojo × Giza 168, Yacora Rojo × line 606, Sham 6 × Gemmiza 7,ICARDA 3 × Gemmiza 7 and Giza 168 × line 606 had the greatest values. The cross Giza 168 × Gemmiza 7 and ICARDA 3 had the lowest LT values in stress condition. Zhongjin and Neumann (1998) reported that drought environments lead to inhibition of leaf growth by water stress, which can be considered an adaptive response. Thus, it limits leaf area production and eventually per plant rates of transpiration. Reduced transpiration may then prolong plant survival by extending the period of availability of essential soil water reserves. Misra and Gangwar (1990) and West *et al.* (1990) showed that, transpiration rate is the important criteria to be used for screening a large number of germplasm for drought resistance.

Relative water content (RWC)

Data in Table (3) indicate that, generally there was a gradual decrease in RWC with increasing water stress condition in root media of parents and their crosses. The minimum reduction was in Yacora Rojo, Sham 6, ICARDA 3, Yacora Rojo × Sham 6, Yacora Rojo × ICARDA 3, Sham 6 × Giz168 Sham 6 × line 606, ICARDA 3 × line 606), Giza 168 × Sakha 93 and Gemmiza 7 × line 606. Meanwhile the maximum reduction was in Giza 168, ICARDA 3 × Sakha 93, ICARDA 3 × Gemmiza 7 and Giza 168 × Gemmiza 7.

Potassium content (K^+):

It is found the obtained results (Table 3) that, water stress increased gradually the concentration of K^+ in leaves. The increment in K^+ of wheat plants recorded with water stress treatment reached about 24.51 % for all genotypes, 26.62 for parents and 32.45 for crosses. These results are in a good line with those reported by Jones *et al.* (1980) who showed that K^+ was the major cation contributing to osmotic adjustment in wheat. Morgan (1992) reported that lines exhibiting high osmotic adjustment did so largely (78%) through K^+ accumulation

Table (3): The genotypes mean performance for drought measurements studied on F_1 generation.

Genotypes	Stomatal resistance at flowering stage (SRDF)			Transpiration rate at flowering stage (TRDF)			Leaf temperature at flowering stage (LTDF)		
	NS	S	C	NS	S	C	NS	S	C
Yacora Rojo (P_1)	2.24	3.70	2.97	6.50	5.11	5.80	24.00	24.70	24.35
Sham 6 (P2)	3.02	4.02	3.52	7.97	3.71	5.84	23.70	25.00	24.35
ICARDA 3 (P3)	2.99	4.36	3.67	10.78	5.77	8.27	23.27	24.20	23.73
Giza 168 (P4)	4.31	5.40	4.85	8.57	7.57	8.07	23.07	24.50	23.78
Sakha 93 (P5)	1.91	4.89	3.40	8.42	0.42	4.42	23.70	24.40	24.05
Gemmiza 7 (P6)	2.15	4.50	3.32	7.75	5.17	6.46	24.30	24.90	24.60
Line 606 (P7)	1.61	5.40	3.50	7.32	4.36	5.84	23.20	24.90	24.05
$P_1 \times P_2$	2.47	4.08	3.27	9.59	2.74	6.16	22.83	24.40	23.62
$P_1 \times P_3$	3.21	4.19	3.70	8.92	5.64	7.28	23.10	24.27	23.68
$P_1 \times P_4$	3.37	4.22	3.79	8.54	6.58	7.56	23.60	24.97	24.28
$P_1 \times P_5$	3.00	3.49	3.24	9.06	4.16	6.61	23.80	24.50	24.15
$P_1 \times P_6$	2.71	4.44	3.57	7.62	3.99	5.81	23.00	24.30	23.65
$P_1 \times P_7$	2.94	4.45	3.69	9.91	6.32	8.12	23.70	24.07	23.88
$P_2 \times P_3$	2.75	3.30	3.02	8.17	1.74	4.95	23.30	24.30	23.80
$P_2 \times P_4$	3.10	3.85	3.48	8.99	3.31	6.15	23.57	24.50	24.03
$P_2 \times P_5$	2.57	4.25	3.41	9.60	4.21	6.90	24.00	24.40	24.20
$P_2 \times P_6$	3.87	4.93	4.40	9.68	6.92	8.30	23.20	24.50	23.85
$P_2 \times P_7$	4.16	5.73	4.94	11.12	5.75	8.43	24.25	24.60	24.43
$P_3 \times P_4$	4.84	5.80	5.32	9.44	4.74	7.09	22.70	24.30	23.50
$P_3 \times P_5$	2.57	3.61	3.09	8.66	3.71	6.19	23.15	24.20	23.68
$P_3 \times P_6$	3.05	4.66	3.85	9.80	6.81	8.30	23.10	24.67	23.88
$P_3 \times P_7$	2.71	3.74	3.23	8.63	0.91	4.77	22.65	24.67	23.66
$P_4 \times P_5$	3.39	3.68	3.54	8.26	0.56	4.41	22.75	24.20	23.48
$P_4 \times P_6$	2.40	3.50	2.95	10.51	4.79	7.65	23.00	24.00	23.50
$P_4 \times P_7$	2.26	3.60	2.93	9.81	6.36	8.09	23.35	24.80	24.08

Genotypes	Stomatal resistance at flowering stage (SRDF)			Transpiration rate at flowering stage (TRDF)			Leaf temperature at flowering stage (LTDF)		
	NS	S	C	NS	S	C	NS	S	C
$P_5 \times P_6$	2.92	3.98	3.45	10.91	4.94	7.93	23.30	24.90	24.10
$P_5 \times P_7$	2.36	3.63	3.00	7.68	5.54	6.61	23.25	24.80	24.03
$P_6 \times P_7$	2.31	3.26	2.78	7.32	1.19	4.26	23.67	24.80	24.23
X of parents	2.603	4.610	3.606	8.186	4.588	6.387	23.605	24.657	24.131
X of crosses	2.997	4.112	3.554	9.152	4.329	6.740	23.298	24.483	23.890
X of genotypes	2.898	4.236	3.567	8.911	4.394	6.652	23.375	24.526	23.951
L.S.D. 0.05 %	0.70	0.91	0.57	1.01	1.55	0.91	0.61	0.57	0.41
L.S.D. 0.01 %	0.94	1.21	0.76	1.34	2.06	1.21	0.81	0.76	0.55

S = Stress condition NS = Normal irrigation C = Combined

Table (3): cont.

Genotypes	Relative water content (RWC)			K^+ content m/g		
	NS	S	C	NS	S	C
Yacora Rojo (P_1)	23.58	21.40	22.49	34.60	45.16	39.88
Sham 6 (P_2)	16.98	15.19	16.08	33.49	50.54	42.01
ICARDA 3 (P_3)	17.86	15.15	16.51	42.93	50.18	46.55
Giza-168 (P_4)	22.80	15.13	18.97	41.82	45.14	43.48
Sakha 93 (P_5)	14.04	11.80	12.92	32.21	43.49	37.85
Gemmiza 7 (P_6)	13.82	11.97	12.90	36.24	45.72	40.98
Line 606 (P_7)	13.53	9.39	11.46	33.49	42.38	37.93
$P_1 \times P_2$	19.27	14.17	16.72	34.59	46.28	40.43
$P_1 \times P_3$	19.84	14.60	17.22	35.16	46.28	40.72
$P_1 \times P_4$	22.28	16.14	19.21	40.70	44.90	42.80
$P_1 \times P_5$	22.37	15.17	18.77	37.87	47.95	42.91
$P_1 \times P_6$	15.05	12.53	13.79	34.05	51.77	42.91
$P_1 \times P_7$	26.97	13.94	20.46	37.36	49.62	43.49
$P_2 \times P_3$	21.49	13.68	17.59	42.38	50.74	46.56
$P_2 \times P_4$	19.72	16.39	18.06	41.37	50.45	45.91
$P_2 \times P_5$	14.03	12.52	13.28	48.03	48.61	48.32
$P_2 \times P_6$	15.60	12.79	14.20	42.36	48.24	45.30

Genotypes	Relative water content (RWC)			K$^+$ content m/g		
	NS	S	C	NS	S	C
$P_2 \times P_7$	15.76	13.45	14.61	44.05	47.05	45.55
$P_3 \times P_4$	18.97	10.67	14.82	46.84	49.62	48.23
$P_3 \times P_5$	24.50	14.87	19.69	43.48	48.47	45.97
$P_3 \times P_6$	31.12	14.36	22.74	33.90	48.51	41.20
$P_3 \times P_7$	19.07	14.63	16.85	35.17	44.05	39.61
$P_4 \times P_5$	13.23	12.07	12.65	39.59	47.39	43.49
$P_4 \times P_6$	21.98	9.51	15.75	33.18	46.83	40.01
$P_4 \times P_7$	11.44	10.90	11.17	33.46	41.82	37.64
$P_5 \times P_6$	17.71	14.57	16.14	41.82	46.83	44.32
$P_5 \times P_7$	25.22	17.27	21.25	35.13	54.39	44.76
$P_6 \times P_7$	15.57	13.51	14.54	36.80	52.41	44.60
Mean of parents	17.515	14.291	15.903	36.396	46.086	41.241
Mean of crosses	19.581	13.703	16.642	38.917	48.199	43.558
Mean of enotypes	19.064	13.850	16.457	38.287	47.671	42.979
L.S.D.$_{0.05\%}$	2.25	1.91	1.46	3.41	5.88	3.37
L.S.D.$_{0.01\%}$	2.99	2.55	1.94	4.54	7.82	4.46

NS = Normal irrigation   S = Stress condition   C = combine

Heterosis:

Mean squares for parent vs. crosses as an indication to average heterosis overall crosses were significant for all drought measurements in both irrigation treatments as well as the combined analysis, except SR in the combined analysis, TR, LT and RWC in stress condition (Table 2). The F_1 mean performances were significantly higher than parental means for most traits (Table 3).

Heterosis expressed as the percentage deviation of F_1 mean performance from either mid-parent or better-parent average values for all the studied measurements at both irrigation treatments as well as the combined analysis are presented in (Table 4). With regard to SR, six, two and three hybrids expressed significant positive heterotic effects relative to mid-parent value at normal, stress irrigation as well as the combined analysis, respectively. In addition, four, zero and two crosses expressed significant positive heterotic effects relative to better-parent value in the same order. The two crosses Sham 6 × Gemmiza 7 and Sham 6 × line 606 gave the most desirable heterotic effects in both irrigation treatments and the combined analysis for this trait. For TR, two, eight and six exhibited significant negative heterotic effects relative to mid-parent value in normal, stress irrigation treatments as well as the combined analysis, respectively. On the other hand, zero, three and three from the previous crosses expressed significant negative heterotic effects relative to better-parent value in the same order. The most desirable heterotic effects for TR was recorded by crosses Gemmiza 7 (P_6) × line 606 (P_7), ICARDA 3 (P_3) × line 606 (P_7) and Sham 6 (P_2) × ICARDA 3 (P_3). On the basis of the above discussed data, the decrease in the TR can be considered a survival mechanism in dry conditions. To optimize yield, the plant must keep its stomata open during stress, so that it receives better water and nutrient absorption from the soil. In this case, such genotypes can be considered drought resistant, it is suggested that transpiration rate and diffusive resistance could be used for screening wheat cultivars for drought resistance.

For leaf temperature (LT), nine, three and six hybrids exhibited significant negative heterotic effects relative to mid-parent value in normal, stress irrigation treatments as well as the combined analysis, respectively. While, two, one and three crosses from the previous hybrids expressed significant negative heterotic effects relative to better-parent in the same order. The most desirable negative heterotic effects were recorded in cross Yacora Rojo (P_1) × line 606 (P_7) in stress environment.

With respect to relative water content (RWC), nine, four and eight crosses surpassed the mid-parent value in normal, stress irrigation treatments as well as the combined analysis, respectively. While, six, two and five crosses exhibited significant positive heterotic effects relative to better-parent value in the same order. The most desirable heterotic effect was recorded in crosses Sakha 93 (P_5) × Gemmiza 7 (P_6) and Sakha 93 (P_5) × line 606 (P_7) in stress environment.

For Potassium (K^+) content, ten, four and eleven crosses exhibited significant positive heterotic effects relative to mid-parent value in normal, stress irrigation treatments as well as the combined analysis, respectively. Also, five, three and five crosses from the previous crosses expressed significant positive heterotic effects relative to better-parent in the same order. The most desirable heterotic effect was recorded by the three crosses Sakha 93 (P_5) × Gemmiza 7 (P_6) followed by the cross Sakha93 (P_5) × line606 (P_7) and then by the cross Yacora Rojo (P_1) × Gemmiza 7 (P_6) in stress condition.

Clarke and McCaing (1982) found differences in excised leaf water loss rate between cultivars.

For LT, nine, three and six hybrids exhibited significant negative heterotic effects relative to mid-parent value in normal, stress irrigation treatments as well as the combined analysis, respectively. While, two, one and three crosses from the previous hybrids expressed significant negative heterotic effects relative to better parent in the same order. The most desirable negative heterotic effects were recorded in cross Yacora Rojo × line 606 in stress environment.

Table (4): Percentage of heterosis in the F_1 generation over both mid-parent (MP) and better-parent (BP) for drought measurements studied.

Crosses	Stomatal resistance at flowering stage (SRDF)						Transpiration rate at flowering stage (TRDF)					
	NS		S		C		NS		S		C	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
$P_1 \times P_2$	-6.084	-18.212	5.699	1.493	0.770	-7.102	32.550**	47.538**	-37.868*	-26.146	5.842	6.207
$P_1 \times P_3$	22.753	7.358	3.970	-3.899	11.446	0.817	3.241	37.231**	3.676	10.372	3.483	25.517**
$P_1 \times P_4$	2.901	-21.810*	-7.253	-21.852*	-3.069	-21.856**	13.338*	31.385**	3.785	28.767	9.012	30.345**
$P_1 \times P_5$	44.578**	33.929*	-18.743*	-28.630**	1.727	-4.706	21.448**	39.385**	50.452*	890.476**	29.354**	49.548**
$P_1 \times P_6$	23.462	20.982	8.293	-1.333	13.514	7.530	6.947	17.231*	-22.374	-21.918	-5.220	0.172
$P_1 \times P_7$	52.727**	31.250	-2.198	-17.593*	14.065	5.429	43.415**	52.462**	33.474*	44.954*	39.519**	40.000**
$P_2 \times P_3$	-8.486	-8.940	-21.241*	-24.312*	-15.994*	-17.711*	-12.853**	2.509	-63.291**	-53.100*	-29.837**	-15.240
$P_2 \times P_4$	-15.416	-28.074**	-18.259*	-28.704**	-16.846**	-28.247**	8.706	12.798*	-41.312**	-10.782	-11.574*	5.308
$P_2 \times P_5$	4.260	-14.901	-4.602	-13.088	-1.445	-3.125	17.145**	20.452**	103.874**	902.381**	34.503**	56.109**
$P_2 \times P_6$	49.710**	28.146*	15.728	9.556	28.655**	25.000**	23.155**	24.903**	55.856**	86.523**	34.959**	42.123**
$P_2 \times P_7$	79.698**	37.748**	21.656*	6.111	40.741**	40.341**	45.455**	51.913**	42.503*	54.987*	44.349**	44.349**
$P_3 \times P_4$	32.603**	12.297	18.852*	7.407	24.883**	9.691	-2.429	10.152	-28.936**	-17.851	-13.219**	-12.144*
$P_3 \times P_5$	4.898	-14.047	-21.946*	-26.176**	-12.588	-15.804*	-9.792*	2.850	19.871	783.333**	-2.443	40.045**
$P_3 \times P_6$	18.677	2.007	5.192	3.556	10.157	4.905	5.774	26.452**	24.497	31.721*	12.695*	28.483***
$P_3 \times P_7$	17.826	-9.365	-23.361**	-30.741**	-9.902	-11.989	-4.641	17.896*	-82.034**	-79.128**	-	-18.322*
$P_4 \times P_5$	9.003	-21.346*	-28.474**	-31.852**	-14.182*	-	-2.766	-1.900	-85.982**	33.333	-	-0.226
$P_4 \times P_6$	-	-	-29.293**	-35.185**	-	-	28.799**	35.613**	-24.804*	-7.350	5.299	18.421*
$P_4 \times P_7$	-23.649*	-47.564**	-33.333**	-33.333**	-29.820**	-39.588**	23.474**	34.016**	6.622	45.872*	16.319**	38.527**
$P_5 \times P_6$	43.842**	35.814*	-15.229	-18.609*	2.679	1.471	34.941**	40.774**	76.744**	1076.190**	45.772**	79.412**
$P_5 \times P_7$	34.091	23.560	-29.446**	-32.778**	-13.043	-14.286	-2.414	4.918	131.799**	1219.048**	28.850**	49.548**
$P_6 \times P_7$	22.872	7.442	-34.141**	-39.630**	-18.475*	-20.571*	-2.853	-0.046	-75.026**	-72.706**	-30.732**	-27.055**

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

P_1= Yacora Rojo P_2= Sham-6 P_3= ICARDA-3 P_4= Giza-168 P_5= Sakha-93 P_6= Gemmiza-7 P_7= Line-606

Table (4): cont.

Crosses	Leaf temperature at flowering stage (LTDF)						Relative water content (RWC)					
	NS		S		C		NS		S		C	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
$P_1 \times P_2$	- 4.277**	- 3.671**	-1.811	-1.215	- 2.998**	- 2.998**	-4.980	-18.278**	-22.547**	-33.785**	-13.300**	-25.656**
$P_1 \times P_3$	-2.264*	-0.731	-0.736	0.289	-1.498*	-0.211	-4.247*	-15.861**	-20.109**	-31.776**	-11.692**	-23.433**
$P_1 \times P_4$	0.276	2.297	1.504	1.918	0.893	2.103*	-3.924	-5.513	-11.634*	-24.579**	-7.332*	-14.584**
$P_1 \times P_5$	-0.210	0.422	-0.204	0.410	-0.207	0.416	18.926**	-5.131	-8.614	-29.112**	6.015	-16.541**
$P_1 \times P_6$	-	-	-2.016*	-1.619	-	-	-19.519**	-36.175**	-24.903**	-41.449**	-22.068**	-38.684**
$P_1 \times P_7$	0.424	2.155	- 2.944**	- 2.551*	-1.322	-0.707	45.352**	14.377**	-9.451	-34.860**	20.530**	-9.026**
$P_2 \times P_3$	-0.788	0.129	-1.220	0.413	-0.998	0.295	23.364**	20.325**	-9.822	-9.941	7.947*	6.541
$P_2 \times P_4$	0.791	2.167	-1.010	0.000	-0.145	1.051	-0.855	-13.509**	8.113	7.900	3.053	-4.797
$P_2 \times P_5$	1.266	1.266	-1.215	0.000	0.000	0.624	-9.542	-17.373*	-7.225	-17.577**	-8.414	-17.413**
$P_2 \times P_6$	- 3.333**	-2.110	-1.804	-1.606	- 2.554**	-2.053*	1.299	-8.127	-5.817	-15.800*	-2.001	-11.692*
$P_2 \times P_7$	3.412**	4.526**	-1.403	-1.205	0.950	1.580	3.310	-7.185	9.439	-11.455	6.100	-9.142*
$P_3 \times P_4$	-2.028	-1.604	-0.205	0.413	-1.073	-0.969	-6.690	-16.798**	-29.524**	-29.571**	-16.460**	-21.877**
$P_3 \times P_5$	-1.426	-0.516	-0.412	0.000	-0.879	-0.211	53.605**	37.178**	10.353	-1.848	33.809**	19.261**
$P_3 \times P_6$	-2.880*	-0.731	0.489	1.942	-1.179	0.632	96.465**	74.244**	5.900	-5.215	54.641**	37.735**
$P_3 \times P_7$	-2.518*	-2.371	0.489	1.942	-0.963	-0.295	21.504**	6.775	19.234**	-3.432	20.486**	2.059
$P_4 \times P_5$	-2.715*	-1.387	-1.022	-0.820	-1.819*	-1.262	-28.176**	-41.974**	-10.360	-20.225**	-20.665**	-33.316**
$P_4 \times P_6$	-2.892*	-0.303	- 2.834**	-2.041	- 2.852**	-1.177	20.044**	-3.596	-29.815**	-37.145**	-1.161	-16.974**
$P_4 \times P_7$	0.929	1.214	0.405	1.224	0.690	1.262	-37.022**	-49.825**	-11.093	-27.958**	-26.586**	-41.118**
$P_5 \times P_6$	-2.917*	-1.688	1.014	2.049	-0.925	0.208	27.136**	26.140**	22.592**	21.721**	25.019**	24.923**
$P_5 \times P_7$	-0.853	0.216	0.609	1.639	-0.083	-0.083	82.952**	79.630**	63.001**	46.356**	74.323**	64.474**
$P_6 \times P_7$	-0.337	2.026	-0.402	-0.402	-0.391	0.748	13.857	12.663	26.498**	12.865	19.376**	12.713*

*and ** indicates significant at 0.05 and 0.01 levels of probability, respectively. NS = Normal irrigation, S= Stress condition, C= Combined.
P_1 = Yacora Rojo P_2 = Sham-6 P_3 = ICARDA-3 P_4 = Giza-168 P_5 = Sakha-93 P_6 = Gemmiza-7 P_7 = Line-606

Table (4): cont.

Crosses	K^+ content m/g					
	NS		S		C	
	MP	BP	MP	BP	MP	BP
$P_1 \times P_2$	1.601	-0.029	-3.281	-8.429	-1.258	-3.761
$P_1 \times P_3$	-9.300*	-18.099**	-2.916	-7.772	-5.773	-12.524**
$P_1 \times P_4$	6.517	-2.678	-0.554	-0.576	2.687	-1.564
$P_1 \times P_5$	13.366**	9.451	8.178	6.178	10.408**	7.598
$P_1 \times P_6$	-3.868	-6.043	13.930*	13.233*	6.134	4.710
$P_1 \times P_7$	9.737*	7.977	13.365*	9.876	11.785**	9.052*
$P_2 \times P_3$	10.913**	-1.281	0.755	0.396	5.149	0.021
$P_2 \times P_4$	9.866*	-1.076	5.456	-0.178	7.404*	5.589
$P_2 \times P_5$	46.210**	43.416**	3.393	-3.819	21.012**	15.020**
$P_2 \times P_6$	21.497**	16.887**	0.229	-4.551	9.170*	7.831
$P_2 \times P_7$	31.532**	31.532**	1.270	-6.905	13.960**	8.427*
$P_3 \times P_4$	10.537**	9.108*	4.112	-1.116	7.142*	3.609
$P_3 \times P_5$	15.731**	1.281	3.491	-3.408	8.934*	-1.246
$P_3 \times P_6$	-14.362**	-21.034**	1.168	-3.328	-5.861	-11.493**
$P_3 \times P_7$	-7.956*	-18.076**	-4.818	-12.216*	-6.226	-14.909**
$P_4 \times P_5$	6.957	-5.332	6.939	4.984	6.947	0.023
$P_4 \times P_6$	-14.988**	-20.660**	3.082	2.428	-5.257	-7.981*
$P_4 \times P_7$	-11.141**	-19.990**	-4.433	-7.355	-7.530*	-13.431**
$P_5 \times P_6$	22.191**	15.397**	4.988	2.428	12.445**	8.150
$P_5 \times P_7$	6.941	4.897	26.680**	25.063**	18.131**	18.007**
$P_6 \times P_7$	5.550	1.545	18.978**	14.633*	13.040**	8.834*

*and ** indicates significant at 0.05 and 0.01 levels of probability, respectively. NS = Normal irrigation, S= Stress condition C= Combined. P_1 = Yacora Rojo, P_2 = Sham-6, P_3 = ICARDA-3, P_4 = Giza-168, P_5 = Sakha-93, P_6 = Gemmiza-7 and P_7 = Line-606

With respect to RWC, nine, four and eight crosses surpassed the mid-parent value in normal, stress irrigation treatments as well as the combined analysis, respectively. While, six, two and five crosses exhibited significant positive heterotic effects relative to better-parent value in the same order. The most desirable heterotic effect was recorded in crosses Sakha 93 × Gemmiza-7 and Sakha 93 × line 606 in stress environment.

For Potassium content (K^+), ten, four and eleven crosses exhibited significant positive heterotic effects relative to mid-parent value in normal, stress irrigation treatments as well as the combined analysis, respectively. Also, five, three and five crosses from the previous crosses expressed significant positive heterotic effects relative to better-parent in the same order. The most desirable heterotic effect was recorded by the three crosses most desirable heterotic effect was recorded by the three crosses Sakha 93 × Gemmiza 7 followed by the cross Sakha 93 × line 606 and then by the cross Yacora Rojo × Gemmiza-7 in stress condition. Clarke and McCaing (1982) found differences in excised leaf water loss rate between cultivars.

In all drought measurements, the values of heterosis were mostly differed from irrigation treatment to another. This finding coincided with that reached above where significant genotypes by environment and its components was significant (Table 2).

Combining ability:

The mean squares associated with general combining ability (GCA) were significant for all drought measurements in both irrigation treatments as well as the combined analysis except SR, LT and K^+ content in stress irrigation. While, mean squares due to SCA were significant for all drought measurements under study (Table 5). It is evident that non-additive type of gene action was the more important part of the total genetic variability for SR, LT and K^+ content under stress irrigation. For the other studied drought measurements, 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, SR in stress irrigation as well as the combined analysis, TR in both irrigation treatments as well as the combined analysis, RWC in normal irrigation and K^+ content in the stress conditions exhibited low GCA/SCA ratios of less than unity, indicating the predominance of non-additive gene action in the inheritance of such traits. While, the magnitudes of additive and non-additive types of gene action were similar for RWC, TR and SR in the normal, stress irrigation treatments as well as the combined analysis, respectively. On the other hand, high GCA/SCA ratio, which exceeded than the unity was obtained for other cases. Such results indicate that additive and additive by additive gene action were more important than non-additive gene effects controlling in these cases. These results were along the same line of El-Marakby *et al.*, (1993), and Darwish (1998), who found equal importance of additive and non-additive effects for most traits,. Also, EL-Hennawy (1996), El-Marakby *et al.*, (1993a), Darwish (1998), El-Borhamy (2000) and El-Gamal (2001), revealed that high ratios of GCA/SCA mean squares were obtained for almost all characters, indicating there dominant role of additive gene action in the inheritance of these characters.

With the exception of SR and TR, it is fairly evident that ratios for SCA × E/SCA was much higher than ratios of GCA × E/GCA for other drought measurements. Such results indicated that non-additive effects were much more influenced by the environmental conditions than the additive genetic ones specific combining ability was stated by Gilbert, (1958) to be more sensitive to environmental changes than GCA, . El-Gamal (2001) found that the mean squares of interaction between irrigation and both types of combining ability were significant for LT, RWC and SR.

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 variety with other genotypes and facilitate selection of varieties for further improvement to drought resistance.

The parent variety Yacora Rojo seemed to be good general combiner for RWC in both irrigation treatments as well as the combined analysis. Also, it gave desirable $\hat{g}_i$ effect for TR in normal irrigation. The parent variety Sham 6 expressed significant desirable $\hat{g}_i$ effects for SR and K^+ content and LT in the normal irrigation and the combined analysis and TR in stress irrigation. Also, it seems to be good combiner for K^+ content, while, it gave either significant undesirable or insignificant $\hat{g}_i$ effects for other cases. The parent variety ICARDA 3 expressed significant positive $\hat{g}_i$ effects for SR, RWC, and K^+ content in the normal irrigation as well as the combined analysis. Also, it seemed to be the best combiner for LT in both irrigations as well as the combined analysis The parent variety Giza-168 seemed to be a good combiner for SR in the normal treatment and the combined analysis. Also, it expressed significant desirable $\hat{g}_i$ effects for LT in normal irrigation as well as the combined analysis and K^+ content in normal irrigation treatment. Also, it almost expressed moderate values for the most of other measurements. The parent variety Sakha-93 seemed to be the best general.

Combiner for TR in the stress irrigation and the combined analysis. It could be considered as an excellent parent in breeding programs towards releasing varieties characterized by low TR. While, it almost expressed moderate $\hat{g}_i$ values for the most other measurements. The parent variety Gemmiza 7 expressed undesirable either significant or insignificant $\hat{g}_i$ effects for all measurements in both irrigation treatments and the combined analysis The parent line 606 expressed significant negative $\hat{g}_i$ effects for TR in normal irrigation as well as the combined analysis. While, it gave undesirable significant or insignificant for other measurements.

Significant positive correlation coefficient values between parental performance and its ($\hat{g}_i$) effects were obtained for TR in normal, stress irrigation treatments and the combined analysis, RWC in stress irrigation and the combined analysis, LT in the combined analysis and SR in normal irrigation and the combined analysis (Table 6). This finding indicates that parental genotypes gave good indexes of intrinsic performance or $\hat{g}_i$ effects. Therefore, selection among the tested parental population for initiation any proposed breeding program could be practiced either on mean performance or $\hat{g}_i$ effects basis with similar efficiency.

For other cases, insignificant correlation coefficient values were detected between the two variables. Such results might add another that both types of genetic variance are important for these traits and coincides with the findings reached above (Table 5).

Specific combining ability effects:

Specific combining ability effects of the parental combinations were computed for all the studied measurements in the F1 under normal, stress irrigation treatments and the combined analysis over them (Table7).

Six, three and four crosses for SR, six, seven and six crosses for TR, five, two and five crosses for LT, eight, six and seven crosses for RWC and eight, three and six hybrids K^+ content expressed significant desirable S_{ij} effects in normal, stress irrigation treatments as well as the combined analysis, respectively. The most desirable S_{ij} effects were recorded by crosses namely Sham 6 × line 606, ICARDA3 × Giza 168 and Sham 6 × Gemmiza 7 for SR, by crosses Gemmiza 7 × line 606, Giza 168 × Sakha 93 and Sham 6 × ICARDA 3 for TR, Sakha 93 × line 606, ICARDA 3 × Gemmiza 7 and Sham 6 × Giza 168 for RWC in both irrigation treatment as well as the combined analysis, Giza 168 × Gemmiza 7 under stress irrigation and the combined analysis and Yacora Rojo × line 606 under strrrigation treatments for LT and Sakha 93 × Line 606 and Gemmiza 7 × line 606 under stress irrigation treatment as well as the combined analysis for K^+. The mentioned combinations might be of interest in breeding programs amid at producing pure line varieties as most combinations involved at least one good combiner.

Table (5): Observed mean squares of general and specific combining ability for F_1 crosses in diallel analysis for drought measurements studied

S.O.V.	d.f.		Stomatal resistance at flowering stage (SRDF)			Transpiration rate at flowering stage (TRDF)			Leaf temperature at flowering stage (LTDF)			Relative water content (RWC)			K^+ content m/g		
	Single	Comb.	NS	S	C	NS	S	C	NS	S	C	NS	S	C	NS	S	C
G.C.A.	6	6	0.93**	0.17	0.73**	0.87**	3.89**	2.12**	0.27**	0.09	0.28**	21.43**	10.02**	26.10**	25.27**	6.70	21.09**
S.C.A.	21	21	0.42**	0.61**	0.80**	1.53**	4.03**	3.89**	0.18**	0.08*	0.16**	22.76**	4.93**	18.70**	19.39**	9.95*	17.73**
G.C.A. x I		6			0.37**			2.63**			0.08			5.35**			10.88**
S.C.A. x I		21			0.23**			1.67**			0.10**			8.99**			11.61**
Error	54	108	0.06	0.10	0.08	0.13	0.30	0.21	0.05	0.04	0.04	0.63	0.46	0.55	1.45	4.32	2.89
G.C.A./S.C.A.			2.23	0.27	0.91	0.57	0.96	0.55	1.47	1.17	1.77	0.94	2.03	1.40	1.30	0.67	1.19
G.C.A. x I/G.C.A.					0.51			1.24			0.28			0.20			0.52
S.C.A. x I/S.C.A.					0.29			0.43			0.64			0.48			0.66

* and ** indicates significant at 0.05 and 0.01 levels of probability, respectively. NS = Normal irrigation S= Stress condition C= Combined.
G.C.A. and S.C.A. indicates general and specific combining ability

Table (6): Estimates of general combining ability effects for all parents in the drought measurements studied on F_1 generation.

Parental Variety or Line	Stomatal resistance at flowering stage (SRDF)			Transpiration rate at flowering stage (TRDF)			Leaf temperature at flowering stage r (LTDF)			Relative water content (RWC)			K^+ content m/g		
	NS	S	C	NS	S	C	NS	S	C	NS	S	C	NS	S	C
Yacora Roj (P_1)	-0.113	-0.182	-0.148**	-0.518**	0.500**	-0.009	0.115	-0.034	0.040	2.270**	2.060**	2.165**	-1.930**	-0.473	-1.201**
Sham-6 (P_2)	0.196*	0.032	0.114**	0.199	-0.341*	-0.071	0.172*	0.054	0.113**	-1.410**	0.288	-0.561**	1.495**	1.230	1.362**
ICARDA-3 (P_3)	0.213**	0.013	0.113**	0.431**	-0.007	0.212**	-0.274**	-0.157	-0.215**	2.023**	0.258	1.141**	1.832**	0.738	1.285**
Giza-168 (P_4)	0.530**	0.172	0.351**	0.155	0.704**	0.430**	-0.211**	-0.049	-0.130**	0.079	-0.539*	-0.230*	1.385**	-1.120	0.132
Sakha-93 (P_5)	-0.284**	-0.164	-0.224**	-0.031	-1.244**	-0.637**	0.072	-0.046	0.013	-0.820**	-0.080	-0.450**	0.449	-0.083	0.183
Gemmiza-7 (P_6)	-0.181*	-0.015	-0.098*	0.006	0.426*	0.216**	0.096	0.084	0.090**	-0.872**	-1.064**	-0.968**	-1.301**	0.517	-0.392
Line-606 (P_7)	-0.360**	0.145	-0.108**	-0.242*	-0.039	-0.140*	0.030	0.147	0.088**	-1.270**	-0.924**	-1.097**	-1.929**	-0.809	-1.369**
L.S.D	0.154	-----	0.076	0.219	0.337	0.123	0.132	-----	0.055	0.491	0.418	0.196	0.744	-----	0.452
L.S.D	0.204	-----	0.101	0.292	0.449	0.163	0.176	-----	0.074	0.654	0.556	0.261	0.990	-----	0.600
L.S.D	0.235	-----	0.135	0.335	0.515	0.216	0.202	-----	0.098	0.751	0.638	0.347	1.137	-----	0.797
L.S.D (0.01 %) gi-gj	0.312	-----	0.179	0.446	0.685	0.287	0.269	-----	0.130	0.998	0.849	0.460	1.512	-----	1.058
r	0.987**	0.651	0.861*	0.886**	0.932**	0.893**	0.705	0.902**	0.833*	0.686	0.900**	0.828*	0.524	0.803*	0.683

*and**indicates significant at 0.05 and 0.01 levels of probability, respectively. NS = Normal irrigation, S = Stress conditions C = Combined = correlation coefficient between mean and general combining ability effects.

Table (7): Estimates of specific combining ability effects for drought measurements studied on F_1 generation.

Crosses	Stomatal resistance at flowering (SRDF)			Transpiration rate at flowering (TRDF)			Leaf temperature at flowering (LTDF)		
	NS	S	C	NS	S	C	NS	S	C
$P_1 \times P_2$	-0.51*	-0.01	-0.26	1.00**	-1.82**	-0.41	-0.83**	-0.15	-0.49**
$P_1 \times P_3$	0.21	0.12	0.16	0.09	0.75	0.42	-0.12	-0.07	-0.09
$P_1 \times P_4$	0.05	-0.01	0.02	-0.01	0.98*	0.49	0.32	0.52**	0.42**
$P_1 \times P_5$	0.50*	-0.40	0.05	0.70*	0.51	0.60*	0.24	0.05	0.15
$P_1 \times P_6$	0.11	0.40	0.25	-0.78*	-1.33**	-1.05**	-0.59**	-0.28	-0.43**
$P_1 \times P_7$	0.52*	0.25	0.38*	1.76**	1.47**	1.61**	0.18	-0.57**	-0.20
$P_2 \times P_3$	-0.56*	-0.98**	-0.77**	-1.37**	-2.31**	-1.84**	0.03	-0.12	-0.05
$P_2 \times P_4$	-0.53*	-0.59*	-0.56**	-0.28	-1.45**	-0.86**	0.23	-0.03	0.10
$P_2 \times P_5$	-0.24	0.14	-0.05	0.52	1.40**	0.96**	0.38	-0.14	0.12
$P_2 \times P_6$	0.96**	0.68*	0.82**	0.56	2.44**	1.50**	-0.44*	-0.16	-0.30**
$P_2 \times P_7$	1.42**	1.31**	1.37**	2.25**	1.73**	1.99**	0.67**	-0.13	0.27*
$P_3 \times P_4$	1.19**	1.38**	1.29**	-0.06	-0.35	-0.20	-0.19	-0.02	-0.11
$P_3 \times P_5$	-0.26	-0.47	-0.37*	-0.65*	0.57	-0.04	-0.02	-0.12	-0.07
$P_3 \times P_6$	0.12	0.42	0.27	0.45	1.99**	1.22**	-0.10	0.21	0.06
$P_3 \times P_7$	-0.04	-0.65*	-0.35*	-0.47	-3.43**	-1.95**	-0.48*	0.15	-0.17
$P_4 \times P_5$	0.25	-0.56	-0.16	-0.77*	-3.30**	-2.04**	-0.49*	-0.23	-0.36**
$P_4 \times P_6$	-0.85**	-0.90**	-0.87**	1.43**	-0.73	0.35	-0.26	-0.56**	-0.41**
$P_4 \times P_7$	-0.81**	-0.96**	-0.88**	0.98**	1.30**	1.14**	0.16	0.18	0.17
$P_5 \times P_6$	0.49*	-0.08	0.21	2.02**	1.36**	1.69**	-0.24	0.34	0.05
$P_5 \times P_7$	0.11	-0.59*	-0.24	-0.96**	2.43**	0.73**	-0.23	0.17	-0.03
$P_6 \times P_7$	-0.05	-1.11**	-0.58**	-1.35**	-3.59**	-2.47**	0.17	0.04	0.10
L.S.D. 0.05 % (Sij)	0.45	0.58	0.31	0.64	0.98	0.50	0.39	0.36	0.22
L.S.D. 0.01% (Sij)	0.59	0.77	0.41	0.85	1.30	0.66	0.51	0.48	0.30
L.S.D. 0.05 % (Sij-Sik)	0.66	0.86	0.54	0.95	1.46	0.87	0.57	0.54	0.39
L.S.D. 0.01% (Sij-Sik)	0.88	1.14	0.71	1.26	1.94	1.15	0.76	0.72	0.52
L.S.D. 0.05% (Sij-Skl)	0.62	0.80	0.19	0.89	1.36	0.31	0.54	0.51	0.14
L.S.D.	0.83	1.06	0.25	1.18	1.81	0.41	0.71	0.67	0.18

Crosses	Stomatal resistance at flowering (SRDF)			Transpiration rate at flowering (TRDF)			Leaf temperature at flowering (LTDF)		
	NS	S	C	NS	S	C	NS	S	C
0.01% (Sij-Skl)									

* and ** significant at 0.05 and 0.01 levels of probability, respectively.
NS = Normal irrigation S = Stress condition C = Combined

Table (7): cont.

Crosses	Relative water content (RWC)			K^+ content m/g		
	NS	S	C	NS	S	C
$P_1 \times P_2$	-0.65	-2.03**	-1.34**	-3.26**	-2.15	-2.71**
$P_1 \times P_3$	-3.52**	-1.57*	-2.55**	-3.03**	-1.66	-2.35*
$P_1 \times P_4$	0.87	0.77	0.82*	2.96**	-1.18	0.89
$P_1 \times P_5$	1.86*	-0.66	0.60	1.07	0.83	0.95
$P_1 \times P_6$	-5.41**	-2.32**	-3.87**	-1.01	4.06*	1.52
$P_1 \times P_7$	6.91**	-1.05	2.93**	2.93**	3.23	3.08**
$P_2 \times P_3$	1.82*	-0.71	0.55	0.76	1.10	0.93
$P_2 \times P_4$	1.99**	2.79**	2.39**	0.20	2.67	1.43
$P_2 \times P_5$	-2.81**	-1.53*	-2.17**	7.80**	-0.21	3.80**
$P_2 \times P_6$	-1.18	-0.28	-0.73	3.88**	-1.18	1.35
$P_2 \times P_7$	-0.62	0.24	-0.19	6.19**	-1.04	2.57**
$P_3 \times P_4$	-2.20**	-2.90**	-2.55**	5.33**	2.33	3.83**
$P_3 \times P_5$	4.23**	0.84	2.54**	2.91**	0.14	1.53
$P_3 \times P_6$	10.91**	1.32*	6.11**	-4.92**	-0.42	-2.67**
$P_3 \times P_7$	-0.75	1.45*	0.35	-3.02**	-3.55	-3.29**
$P_4 \times P_5$	-5.10**	-1.16	-3.13**	-0.53	0.92	0.19
$P_4 \times P_6$	3.71**	-2.73**	0.49	-5.19**	-0.24	-2.71**
$P_4 \times P_7$	-6.43**	-1.49*	-3.96**	-4.29**	-3.92*	-4.11**
$P_5 \times P_6$	0.33	1.86**	1.10**	4.38**	-1.27	1.55
$P_5 \times P_7$	8.25**	4.42**	6.33**	-1.68	7.61**	2.97**
$P_6 \times P_7$	-1.36	1.65**	0.15	1.74	5.03**	3.39**
L.S.D. 0.05 % Sij	1.43	1.21	0.79	2.16	3.73	1.83
L.S.D. 0.01 % Sij	1.90	1.62	1.05	2.88	4.96	2.42
L.S.D. 0.05 % (Sij-Sik)	2.12	1.80	1.39	3.22	5.54	3.19
L.S.D. 0.01 % (Sij-Sik)	2.82	2.40	1.84	4.28	7.37	4.23
L.S.D. 0.05 % (Sij-Skl)	1.99	1.69	0.49	3.01	5.19	1.13
L.S.D. 0.01 % (Sij-Skl)	2.64	2.25	0.65	4.00	6.90	1.50

* and ** significant at 0.05 % and 0.01% levels of probability, respectively
NS = Normal irrigation S = Stress condition C = Combined

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الملخص العربي

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تحسين إنتاجية القمح تحت ظروف الجفاف باستخدام نظام التهجين الدائري

أجري هذا البحث بهدف دراسة إمكانية التربية لتحمل ظروف الإجهاد المائى باستخدام بعض الدلائل الفسيولوجية المرتبطة بتحمل النباتات للجفاف وتفاعلهم مع البيئة وكذلك دراسة قوة الهجين والقدرة علي التآلف لهذه الصفات. وقد استخدم لهذا الغرض سبعة تراكيب وراثية ذات أصول وراثية متباعدة هي (إيكاردا-٣، شام-٦ ، ياكورا، جيزة 168 ، سخا-93 ، جميزة-7 ، سلالة-606). وقد أجرى هذا البحث خلال ثلاثة مواسم هى: 2003/2002، 2003/ 2004، 2004 / 2005 حيث تم عمل جميع الهجن الممكنة بين الآباء السبعة دون العكسية بنظام Half diallel crosses في صوبة التهجينات بمركز بحوث الصحراء بالقاهرة تحت ظروف الري بالمياه العادية. وتم تسجيل القياسات التالية المرتبطة بتحمل الجفاف: ١- مقاومة الثغر 2 - معدل النتح ٣- درجة حرارة الورقة ٤- المحتوى المائي للورقة ٥- محتوى البوتاسيوم بالأوراق

وقد اظهرت النتائج مايلى:-

* كان التباين الراجع لمعاملتي الري عالي المعنوية لكافة قياسات الجفاف. وكانت قيم متوسطات معاملة الإجهاد لكافة قياسات الجفاف أعلى من تلك التي تحت ظروف الري العادي فيما عدا صفات معدل النتح والمحتوى المائي بالأوراق كانت أعلى في البيئة العادية.أيضا كان التباين الراجع للتراكيب الوراثية والآباء والهجن والآباء مقابل الهجن معنويا لكافة قياسات الجفاف في كلا من البيئتين وكذلك التحليل المشترك بينهما فيما عدا التباين الراجع للآباء لصفة درجة حرارة الورقة تحت ظروف الإجهاد، والتباين الراجع للآباء مقابل الهجن لصفة مقاومة الثغر في التحليل المشترك، ومعدل النتح ودرجة حرارة الورقة والمحتوى المائي للورقة تحت ظروف الإجهاد.

* كان التباين الراجع للتفاعل بين التراكيب الوراثية والآباء والهجن والآباء مقابل الهجن ومعاملتي الري معنويا لكافة قياسات الجفاف ما عدا التباين الراجع إلى التفاعل بين الآباء ومعاملتي الري لصفة درجة حرارة الورقة، والتباين الراجع إلى التفاعل بين الهجن ومعاملتي الري لصفة مقاومة الثغر، والتباين الراجع إلى التفاعل بين الآباء مقابل الهجن ومعاملتي الري لصفتي درجة حرارة الورقة ومحتوى البوتاسيوم بالأوراق. كانت أحسن الآباء قدرة على التآلف هي إيكاردا-3 (P_3) وذلك لصفات مقاومة الثغر و المحتوى المائي للورقة ومحتوى البوتاسيوم تحت ظروف الري العادي وأيضا التحليل المشترك بينهما، ودرجة حرارة الورقة في كلا من معاملتي الري وأيضا التحليل المشترك بينهما. كما كان الأب سخا-93 (P_5) أحسن الآباء في صفة معدل النتح تحت ظروف الإجهاد وكذا التحليل المشترك ويمكن اعتباره أحسن الآباء في برامج التربية الموجه لانتاج صنف ذو معدل نتح منخفض. * أظهرت الهجن ($P_2 \times P_7$)، ($P_3 \times P_4$)، ($P_2 \times P_6$) لصفة مقاومة الثغر و ($P_6 \times P_7$)، ($P_4 \times P_5$)، ($P_2 \times P_3$) لصفة معدل النتح. ($P_5 \times P_7$)، ($P_3 \times P_6$)، ($P_2 \times P_4$) لصفة المحتوى المائي للورقة في كلا من معاملتي الري وأيضا التحليل المشترك بينهما تأثيرات معنوية مرغوبة للقدرة الخاصة على التآلف .