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DIALLEL CROSS ANALYSIS OF WHEAT (*Triticum aestivum* L.) UNDER STRESS AND NORMAL IRRIGATION TREATMENTS

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ABSTRACT

Combining ability analysis was practiced in F_2 of 8 x 8 diallel set for grain yield and four of its attributes in bread wheat under two irrigation treatments (stress irrigation and normal irrigation).

The variances associated with general (GCA) and specific combining ability (SCA) were significant for all traits recorded in both irrigation treatments as well as the combined analysis, indicating that additive and additive x additive types of gene action were more important then non-additive genetic effects for these traits.

Sham 6 (P_4) was the best combiner for no. of kernels/spike under irrigation and the combined analysis; 1000-kernel weight in normal irrigation. The parent P_6 (Sk 8) gave significantly positive $\widehat{g}_i$ effects for grain yield in stress irrigation and in the combined analysis. The parent SK 69 (P_8) was the best combiner for grain yield in both irrigation and the combined analysis.

Six F_2 hybrids expressed significantly positive s_{ij} effects for grain yield in both irrigations as well as the combined analysis P_1 x P_5, P_2 x P_3, P_2 x P_7, P_3 x P_4, P_4 x P_8 and P_6 x P_8.

Application of the drought stress susceptibility index (DSI) over both irrigation treatments (stress and normal irrigations) indicated that P_2, P_4, P_5 and P_6, as well as 16 crosses had low susceptibility index of stress irrigation. The best hybrids were P_1 x P_2, P_1 x P_7, P_2 x P_5, P_3 x P_7 and P_6 x P_8.

The variance associated with general and specific combining ability was highly significant for all traits of stress susceptibility index.

The parents P_2, P_6 and P_8 gave significant negative values for grain yield and most studied traits. The parent P_4 showed a significant negative value for no. of spikes/plant and 1000-kernel weight of DSI.

The crosses P_1 x P_2, P_2 x P_4, P_3 x P_4, P_3 x P_6, P_3 x P_8, P_6 x P_8 and P_7 x P_6 exhibited significantly negative S_{ij} for grain yield of drought susceptibility index.

Key words: ***Wheat, Irrigation, Drought, Stress, General and Specific Combining Ability.***

INTRODUCTION

Wheat, the most important cereal crop in Egypt, covered one million hectares with a total annual production of 6.3 million tons in 1999 (Gomaa 1999). This amount satisfies around 55% of the fast growing population.

Drought is a major stress factor which limits crop production in most areas of the world. Wheat production under rain fed or minimum irrigation conditions became an objective in Egypt as well as many areas world wide due to increasing limitations of water supply. Breeding wheat cultivars within proved drought tolerance is challenged by inadequate screening and tolerance quantification procedures. Using yield components as a quantification and selection criterion should be superior to using yield under drought. Sadiq *et al* (1994) found high grain yield proved to be the best indicator of drought tolerance. Yadav and Mishra (1993) found positive associations were recorded between grain yield/plant and number of tillers/plant, number of spikelets/spike and 1000-grain weight. Many investigators reported significant differences among wheat cultivars in their response to the environmental conditions and, hence, their grain yield (Darwish 1998 and Afiah 2002).

In some self-pollinated species, producing enough F_1 grains is a time consuming and laborious procedure. But, F_2 generation grains can be obtained easily and in a relatively larger quantities. In such species, it is easier to collect data from the F_2 generation of a diallel cross. Therefore, F_2 diallel cross technique have been used to obtain considerable information on the genetic parameters and/or to gain a better understanding of the nature of gene action involved in controlling quantitative characters by many investigators. Abdalla *et al* (1999) reported that F_1 and F_2 diallel cross analysis in faba bean had similar efficiency. Owing to the likely multiplicity of factors and factor interactions contributing to drought resistance in the field, plant breeders selecting for drought resistance are mostly guided by grain yield and its stability under dry conditions. This is necessarily a slow and difficult process. Also, high yield under dry conditions (y_d) could arise as a result of drought escape or high yield potential (yield in the absence of drought Y_p) as well as drought resistance mechanisms. Separation of these influences upon yield under drought could in itself facilitates breeding and selection.

Selection for both low drought susceptibility index value with high mean performance of any trait under stress environment would be a useful criterion to exploit more drought resistant genotypes.

It is hoped that the present study helps wheat breeders for producing new genotypes of high yielding ability under stress, and normal irrigations.

Besides, the relative importance of general and specific combining ability for yield and its attributes as well as the susceptibility index of all traits were investigated.

MATERIALS AND METHODS

The genetic materials used in this investigation as parents included eight bread wheat cultivars and/or lines (*Triticum aestivum* L.), representing a wide range of diversity for several agronomic characters and drought resistance. The names, pedigree and origin of these cultivars and/or lines are presented in Table 1. All possible cross combinations excluding reciprocals, were made between the eight parental genotypes through study (Darwish 1998).

Table 1. Names, pedigree, sources and origins of the parental cultivars and/or lines.

No.	Entry name/cross	Pedigree	Source	Origin
1	PFAU/SERI//BOW	CM 85295-0/0/Y-2M-OY-Om-1Y.OM.	WOL92	Mexico
2	KVZ/7 C//Jun "S"	CM 78457-03AP-300 AP-4AP-300 L-3AP-300-OAF	WOL92	Mexico / Syria
3	PAT10/ALD "S"//PAT1300/2/PVN "S"/4/URES/5/PVAU "S"	CM78688-29TOPM-5y-OH-OSY-1M-OY	WOL92	Mexico
4	Sham 6 (Improved check)	-	-	Syria
5	Kea "S"/4/4/KVZ/3/cc/Inia //ch/ Elgau//SN64	ICW 84-0300.08AP-300L-2AP-OL	WOL92	Syria
6	Sakha 8	Indus 66 x Norteno "S"-IK348	1979	Egypt
7	Giza 157	G.155 (pitic 62^4 x L.R. 64^4) x T2 pp-knott II	-	Egypt
8	Skha 69	Inia-RL 4220 x 7C/yr "S". CM 1540-25-65.oS.	-	Egypt

In 1998-1999 season, the eight parents and their F_2 cross combinations were sown at the Faculty of Agriculture, Minufiya University, Shebin El-Kom. Two adjacent experiments were conducted. The first experiment (stress experiments) was irrigated one time after planting irrigation (i.e, two irrigations were given through the whole season).

Meanwhile, the second experiment (non-stress or normal experiment) was irrigated four times after planting irrigation. Each experiment was designed in a Randomized Complete Block Design with three replications. The F_2's were represented by four rows while parents by two rows. Each row containing 48 plants spaced about 7.5 cm. with 20 cm. a part between rows. The amounts of total rainfall during 1998-1999 season were recorded in Table 2.

Table 2. Monthly average of total rainfall during (1998-1999) at Shibin El-Kom.

Months	Nov. 99	Dec. 99	Jan. 2000	Feb. 2000	Mar. 2000	Apr. 2000	May 2000
Rainfall (ml)	-	-	3	5	-	-	-

During harvest, data were recorded for random samples of thirty guarded, plants in each replicate for grain yield/plant and four yield attributes i.e. plant height, number of spikes/plant, number of kernels/spike and 1000-grain weight. The drought susceptibility index (S) was used to characterize the relative stress resistance of all genotypes. The susceptibility indices were calculated independently using original data for yield and yield components using a generalized formula (Fischer and Maurer 1978) as follows:

$$S = (1-Yd/Yp)/D$$

Where:

S = An index of drought susceptibility.

Yd = Performance drought stress, experiment of a genotype.

Yp = Performance from normal irrigated experiment of a genotype.

D = Drought intensity = 1-(mean Yd of all genotypes/mean Yp of all genotypes).

The data obtained for drought susceptibility index values for each trait were analyzed on individual plant mean basis. An ordinary analysis of variance, and the combined analysis was performed between the two experiments (stress and normal irrigation) according to Snedecor and Cochran (1980). It was carried out whenever homogeneity of error was detected. For comparison between means, L.S.D. test was used. General and specific combining ability estimates (GCA and SCA) were obtained by employing Griffing's diallel cross analysis (1956) designated as method 2 model 1.

RESULTS AND DISCUSSION

The analysis of variance for each of the two treatments of irrigation (stress and normal irrigations) as well as the combined analysis for all studied traits are presented in Table (3). Results indicated that irrigation mean squares were highly significant for the studied traits in both treatments, indicating all over differences between the stress and normal irrigation treatments. Mean squares for genotypes, parental variety, F_2 hybrids and parents vs. crosses were highly significant for all the studied traits in both irrigation treatments as well as the combined analysis indicating wide diversity between the parents used in the present study for these traits except mean squares due to parent x irrigation for no. of kernels/spike and parents vs. crosses for no. of spikes/plant and no. of kernels/spike. Such results indicated that the tested genotypes varied from each other, and ranked differently in the two different experiments.

The mean performances of the eight parents and twenty eight F_2 hybrids of wheat at stress and normal irrigation as well as the combined analysis data are presented in Table (4).

Table 3. Mean squares from analysis of variance, for main effects and for general and specific combining ability of all studied traits.

S.O.V.	D.F		Plant height			No. of spikes/plant			No. of kernels per spike			Grain yield/plant			100 kernel weight		
	S	C	I	II	C	I	II	C	I	II	C	I	II	C	I	II	C
Irrigation	-	1			3128**			2165**			80.42**			5945**			3720**
Replication	2	4	3.95	3.59	3.77	1.06	4.0	2.53	3.75	6.30	5.03	3.02	7.6	5.31	14.7	1.75	8.23
Genotype	35	35	224.2**	261.4**	446**	11.3**	20.9**	26.3**	107.7**	128.5**	210.5**	66.1**	76.5**	76.6**	84.3**	67.7**	127.6**
Parent	7	7	257.6**	76.6**	284.7**	12.13**	13.69**	18.57**	78.3**	46.0**	119.2**	41.4**	22.85**	37.77**	18.28**	9.43	24.94**
Crosses (F_1S)	27	27	97.5**	99.4**	164.7**	7.29**	20.56**	22.08**	105.2**	134.2**	207.6**	74.11**	87.56**	140.8**	63.6**	61.85**	95.7**
P.V.S.	1	1	3414**	5932**	9173**	113.4**	81.6**	193.6**	383.1**	552**	926.6**	22**	153**	114.8**	1105**	634**	1706**
Irrigation x Genotype	-	35			39.6**			5.95**			25.7**			34.2**			29.8**
I x Parent	-	7			49.4**			7.26**			5.08			26.5**			2.77
I x (F_1S)		27			32**			9.48**			31.7**			21.2**			29.7**
I.P.V.S		1			173**	3.687	13.51**	1.35			8.5			60.2**			222**
G.C.A.		7	126.3**	79.1**	196.6**	13.19**	29.46**	6.03**	164.79**	158.86**	282.2**	58.93**	23.81**	37.754**	43.67**	17.73**	47.14**
S.C.A.		28	248.7**	307.1**	508.3**			31.31**	93.45**	120.85**	192.5**	248.3**	89.65**	86.26**	84.83**	80.2**	14.77**
G.C.A. x I		7			8.70**			11.16**			41.44**			35.13**			14.27**
S.C.A. x I		28			445**			11.35**			21.79**			251.7**			17.35**
Errors	70	140	2.84	2.48	2.66	1.04	0.53	0.785	3.92	3.08	3.5	2.286	3.44	2.86	1.91	2.0	1.96
GCA/SCA			0.507	0.26	3.386	0.28	0.459	0.20	1.76	1.31	1.465	0.237	0.265	0.44	0.52	0.22	0.32

I = Normal irrigation, II = one irrigation (stress), C = the combined analysis

S = Separate

C = Combined

Table 4. The genotypes mean performance for all studied traits in both irrigation treatments.

Genotypes	Plant height			No. of spikes/plant			No. of kernels per spike			Grain yield/plant, gm			100 kernel weight, gm		
	I	II	C	I	II	C	I	II	C	I	II	C	I	II	C
P_1	93.7	108.6	101.2	12.0	21.3	16.65	60.6	72.3	66.5	27.8	41.3	35.6	51.5	43.5	47.5
P_2	103.0	114.0	108.5	15.0	21.3	18.15	61.6	74.0	67.8	30.2	37.4	33.8	50.7	44.1	47.4
P_3	107.0	2118.6	112.8	12.3	19.3	15.8	58.6	69.0	63.8	26.0	35.4	30.7	50.5	41.0	45.8
P_4	108.3	116.0	112.2	16.0	20.3	18.15	68.6	79.0	73.8	33.4	40.3	36.9	47.0	41.1	44.0
P_5	80.7	103.3	92.0	12.7	23.0	17.85	65.0	76.0	70.5	27.6	35.7	31.7	50.6	43.5	47.0
P_6	102.6	107.0	104.8	15.3	19.6	17.45	51.6	66.3	58.9	31.5	38.3	34.9	50.1	44.3	47.2
P_7	105.6	114.0	109.8	10.0	16.0	13.0	60.3	73.3	66.8	25.3	39.9	32.6	44.3	39.4	41.85
P_8	105.0	112.0	108.8	13.0	18.3	15.65	65.0	73.6	69.3	29.4	43.4	36.4	49.5	43.2	46.4
1 x 2	75.0	92.7	83.9	17.6	24.0	20.8	69.3	82.6	75.95	30.4	35.5	32.9	59.4	51.7	55.6
1 x 3	90.0	94.3	92.1	15.0	20.5	17.8	78.0	85.0	81.5	30.4	38.7	34.5	53.7	43.3	48.5
1 x 4	92.0	94.0	93.0	18.0	23.4	20.7	72.0	78.6	75.3	27.7	41.9	34.8	61.4	51.7	56.6
1 x 5	87.0	88.7	87.8	15.2	25.4	20.3	75.0	80.6	77.8	38.3	48.5	43.4	60.1	49.0	54.6
1 x 6	93.0	103.3	98.2	15.3	20.6	17.95	73.0	89.3	81.15	36.5	40.3	38.4	59.3	50.0	54.7
1 x 7	85.6	90.3	87.9	17.6	21.9	19.75	70.0	76.3	73.2	27.4	48.7	38.05	64.5	52.3	58.4
1 x 8	84.0	86.7	85.4	13.7	18.9	16.3	65.0	71.0	80.6	25.3	34.4	27.8	61.3	51.7	56.5
2 x 3	81.7	86.7	84.2	19.3	25.1	22.2	67.0	83.0	75.0	36.2	48.5	43.4	64.8	51.00	57.9
2 x 4	80.7	92.7	173.4	15.1	19.6	17.35	66.6	88.0	77.3	26.2	34.4	30.3	55.4	53.3	54.4
2 x 5	85.3	85.7	85.5	13.4	19.3	16.35	72.3	83.0	77.7	33.6	38.4	35.9	52.1	40.3	46.2
2 x 6	92.3	94.0	93.2	15.5	23.2	19.35	66.0	78.3	72.2	35.5	42.9	39.2	60.0	49.0	54.5
2 x 7	86.0	90.7	88.4	14.4	18.3	16.35	63.6	82.0	72.8	35.1	48.2	41.6	53.6	43.7	48.7
2 x 8	85.0	92.7	88.9	16.7	22.7	19.7	61.6	80.6	71.1	34.5	38.	36.7	61.6	40.3	50.9
3 x 4	88.6	106.3	97.5	16.1	21.2	18.64	63.6	75.6	69.6	34.5	46.0	40.3	53.0	49.0	51.0
3 x 5	87.0	90.3	88.7	14.6	24.9	19.75	59.6	69.6	69.6	28.7	45.5	34.6	60.1	56.7	58.4
3 x 6	94.0	95.7	94.9	14.03	23.9	18.96	55.0	62.3	58.65	24.4	40.8	32.6	47.3	44.3	45.8
3 x 7	84.3	95.0	89.7	18.8	26.5	22.65	53.6	64.0	58.8	27.6	32.3	25.45	58.7	51.0	54.8
3 x 8	87.3	91.0	89.2	14.2	18.2	16.18	72.6	82.0	77.3	22.7	28.2	25.5	52.7	47.3	50.2
4 x 5	86.6	92.0	89.3	13.9	18.6	16.4	70.3	82.0	76.15	21.03	38.6	29.8	55.3	47.7	51.5
4 x 6	78.0	91.3	84.7	14.6	18.9	16.75	63.3	74.0	68.65	27.7	36.4	31.9	58.3	48.3	53.3
4 x 7	89.0	93.3	91.2	16.5	22.1	19.3	68.0	82.6	75.3	25.7	41.0	33.4	62.0	56.00	59.0
4 x 8	80.3	90.3	85.3	15.6	25.6	20.06	56.6	72.6	64.6	33.6	48.1	40.9	53.7	43.3	48.5
5 x 6	80.7	94.7	87.7	15.8	22.3	19.05	65.3	73.0	69.2	32.4	44.7	38.6	59.7	48.00	53.85
5 x 7	92.3	98.3	95.3	16.3	25.4	20.85	67.3	82.0	74.7	28.06	44.3	36.2	55.3	49.3	52.3
5 x 8	95.0	100.0	97.5	16.1	24.2	20.45	64.6	84.0	74.3	27.9	45.8	36.9	46.6	43.0	44.8
6 x 7	88.0	93.3	90.7	14.6	19.07	16.84	65.6	84.6	75.1	29.03	38.7	33.87	57.6	40.3	48.95
6 x 8	102.7	111.7	107.2	15.2	19.2	17.2	61.0	71.6	66.3	39.7	44.3	92.6	52.6	48.7	50.7
7 x 8	82.6	93.0	87.8	17.2	23.13	20.17	60.7	76.0	68.4	37.0	45.03	41.0	57.3	53.3	55.3
L.S.D. 5%	2.75	2.57	2.66	1.765	1.188	1.926	3.23	2.865	3.05	2.469	3.03	2.749	2.256	2.309	2.283
L.S.D. 1%	3.66	3.42	3.54	2.21	1.581	1.89	4.30	3.1	4.06	3.28	4.03	3.65	3.00	3.07	3.04

I = Normal irrigation, II = one irrigation (stress), C = the combined analysis

The mean squares for combining ability GCA, SCA ratio for the studied traits in both irrigation treatments and the combined analysis are presented in Table (3). The mean squares associated with general and specific combining ability were significant for all studied traits. The results showed that, with the exception of kernels/spike in both irrigation treatments as well as the combined analysis, high GCA/SCA ratio, largely exceeding the unity were obtained for all studied traits, indicating that the largest part of the total genetic variability associated with those traits was of the additive type of gene action. For the exceptional cases, however, non additive type of gene action seem to be more prevalent. These results are in general agreement with those previously reported by Chowdhry *et al* (1996).

The mean squares of interaction between irrigation treatments and both types of combining ability were significant for all traits indicating that the magnitude of all types of gene action varied from irrigation treatment to another. It is fairly evident that ratios for SCA x irrigation/SCA was much higher than ratios of GCA x irrigation/GCA for plant height and grain yield plant. Such results indicated than non additive gene effects were more influenced by the irrigation treatments than the additive genetic ones. Specific combining ability was studied by several investigators to be more sensitive to environmental changes than GCA (Gilbert 1958).

Kheiralla (1994) and Darwish (1998) found highly significant differences among genotypes under water stress treatments and their interaction for all the studied traits (yield and yield components).

Estimates of GCA effects ($\hat{g}_i$) for individual parents for each trait at stress and normal irrigation as well as the combined analysis are presented in Table (5).

Highly significant positive values would be of interest for all traits studied except plant height in question from the breeding point of view.

The parental line (1) expressed significantly positive $\hat{g}_i$ effects for 1000-kernel weight in both irrigation treatments as well as the combined analysis, no. of kernels/spike in normal irrigation and the combined analysis, and grain yield/plant in normal irrigation. However, it gave significantly negative $\hat{g}_i$ effects for plant height in both irrigation treatments and the combined analysis.

The parental line (2) expressed, significantly, positive $\hat{g}_i$ effects for 1000-kernel weight no. of spike/plant and grain yield in stress irrigation and the combined analysis. However, it gave significantly negative $\hat{g}_i$ effects

Table 5. Estimates of general combining ability effects for all studied traits.

Parents	Plant height			No. of spikes/plant			No. of kernels per spike			Grain yield/plant			100 kernel weight		
	I	II	C	I	II	C	I	II	C	I	II	C	I	II	C
P_1	-1.808**	-1.325**	-1.5665**	-0.0466	-0.3583	-0.2088	3.916**	-1.3666*	1.2747**	-1.733*	3.033**	0.65	24.583**	13.283**	18.933**
P_2	-2.008**	-1.7583**	-1.8831**	32.853**	0.09166	1.1972**	0.5166	3.1**	1.808**	18.766**	-6.166**	6.3**	10.116**	-5.7833**	2.1663**
P_3	1.4916**	1.6083**	1.5499**	-0.02	0.5083*	0.2441	-1.7833**	-3.5**	-2.654**	-165.83**	-16.9**	-16.866**	-6.916**	1.2833**	-2.8163**
P_4	-0.0083	1.1467*	0.5666	0.5866	-0.3783	0.0541	1.3166*	1.70**	1.508**	-6.433**	-0.666	-3.5495**	-4.95**	8.0839**	1.5666**
P_5	-2.875**	-2.425**	-2.65**	-0.5466	1.225**	0.3392	1.983**	1.166*	1.5745**	-7.867**	9.533**	0.833	-7.683**	-2.45**	-5.0665**
P_6	2.9916**	1.7416**	2.366**	-0.12	-0.738**	-0.429	-3.183**	-2.866**	-3.0245**	20.70**	-2.966**	8.867**	-1.35**	-6.116**	-3.733**
P_7	0.725	0.14166	0.4333	-0.133	-0.545*	-0.339	-1.5166*	-0.033	-0.7748	-12.866**	10.433**	-1.2165*	-04166*	1.35**	0.4662
P_8	1.4916**	0.875	1.183*	-0.14	-0.5216*	-0.3308	-1.25*	-0.9333	-1.0915	6.266**	3.70**	4.983**	-13.383**	-9.45**	-11.4165
L.S.D. g_i 5%	0.996	0.932	0.964	0.605	0.430	0.516	1.171	1.038	1.10	0.894	1.097	0.965	0.817	0.836	0.826
L.S.d. g_i 1%	1.361	1.239	1.30	0.802	0.578	0687	1.557	1.38	1.468	1.189	1.45	1.32	1.087	1.113	1.1
L.S.d. (g_i-g_j) 5%	1.507	1.408	1.45	0.912	0.651	0.782	1.77	1.569	1.67	1.352	1.659	1.505	1.236	1.265	1.25
L.S.d. (g_i-g_j) 1%	2.00	1.873	1.94	1.213	0.866	1.04	2.35	2.66	2.520	1.7898	2.0006	2.002	1.644	1.682	1.663

for plant height in both irrigation treatments as well as the combined analysis.

The parental line (3) expressed significantly positive $\hat{g}_i$ effects for no. of spike/plant and 1000-kernel weight in normal irrigation. The parental variety Sham 6 (4) seemed to be the best gene combiner for no. of kernels/spike in both irrigation treatments as well as the combined analysis, 1000-kernel weight in normal irrigation and the combined analysis.

The parental line (P_5) expressed significantly positive $\hat{g}_i$ effects for no. of kernels/spike in both irrigation treatments and the combined analysis, no. of spikes/plant in grain yield in normal irrigation.

The parental variety SK 8 (P_6) expressed significantly positive $\hat{g}_i$ effects for grain yield under stress. irrigation and the combined analysis. The parental variety Giza 157 (P_7) expressed significantly positive $\hat{g}_i$ effects for grain yield and 1000-kernels weight in normal irrigation.

The parental variety Sk 69 (P_8) seemed to be the best combiner for grain yield in both irrigation treatment and the combined analysis.

Specific combining ability effects of the parental combinations computed for all traits in both treatments of irrigation as well as the combined analysis are presented in Table 6.

For plant height, fifteen, twenty one and seventeen crosses had significantly negative (Sij) effects in stress, normal irrigation treatments as well as the combined analysis, respectively. The best combinations were P_2 x P_3, P_4 x P_6 and P_3 x P_8 for number of spikes/plant. Eight, fourteen and eight crosses had significantly positive (Sij) effects in stress, and normal irrigation treatments as well as the combined analysis, respectively. The best combinations were P_1 x P_2, P_1 x P_4, P_2 x P_3, P_3 x P_7, P_5 x P_7, P_5 x P_8 and P_7 x P_8 (Table 7).

For number of kernels/spike, eight crosses had significantly positive (S_{ij}) effects for each of stress, and normal irrigation treatments as well as the combined analysis. The best combinations were P_1 x P_3, P_1 x P_6, P_2 x P_3, P_3 x P_8, P9 x P_7 and P_6 x P_2.

Table 6. Estimates of specific combining ability effects for all traits in both irrigation treatments as well as the combined analysis.

Genotypes	Plant height			No. of spikes/plant			No. of kernels per spike			Grain yield/plant			100 kernel weight		
	I	II	C	I	II	C	I	II	C	I	II	C	I	II	C
P1 x P2	-11.41**	-2.09	-6.75**	1.982*	2.01**	1.99**	-0.08	1.013	0.466	-1.696	-5.01**	-3.35*	0.58	3.886**	2.23*
P1 x P3	-0.086	-3.78**	-1.94	-0.145	-1.91**	-1.3	10.886**	9.946**	10.41**	1.93	-.73	0.598	-3.38**	-4.44**	-3.91**
P1 x P4	3.587*	-3.66**	-0.036	2.348**	1.91**	2.13**	1.786	-1.586	0.10	-1.809	0.81	-0.449	4.086**	2.48*	3.28**
P1 x P5	1.453	-5.426**	-1.986	0.548	2.24**	1.39*	4.12*	0.946	2.53	8.90**	6.4**	7.65**	3.06**	0.866*	1.96
P1 x P6	1.587	1.522	1.55	0.222	-0.53	-0.154	7.62**	13.646**	10.63**	4.21**	-0.56	1.83	1.626	2.233*	1.92
P1 x P7	-3.48*	-6.33**	-4.905*	2.268**	0.61	1.439*	2.62	-2.186	0.217	-1.499	6.532**	2.52	6.76**	3.82**	5.29**
P1 x P8	-5.91**	-10.73**	-8.32**	-1.291	-.2.48**	-1.88*	-2.65	-6.62**	-4.64**	-5.54**	-7.09**	-6.31**	4.796**	4.23**	4.51**
P2 x P3	-8.046**	-11.3**	-9.54**	3.622**	2.923**	3.272**	3.28*	6.213**	4.75**	5.647**	9.95**	7.79**	9.16**	4.43**	6.79**
P2 x P4	-7..55**	-4.56**	-6.06**	-1.118	-1.656**	-1.39*	-0.146	6.013**	2.93	-5.392**	-5.72**	-5.56**	-0.433	6.07**	2.81
P2 x P5	-5.88**	-7.99**	-6.94**	-1.751*	-3.526**	-2.64**	4.85**	1.546	3.19**	2.184*	-2.76	-0.288	-10.16	-5.87**	-8.01**
P2 x P6	1.12	-3.83**	-1.36	-0.111	2.27**	1.08	3.686*	0.913	2.29	1.227	2.926	2.09	3.77**	3.16**	3.46**
P2 x P7	-2.946**	-5.56**	-4.25**	-1.164*	-2.79**	-1.977**	-0.028	-1.746	-0.882	4.15**	6.95**	5.55**	-2.72	-2.97**	-2.82*
P2 x P8	-4.71**	-4.29**	-4.5**	1.075	1.55**	1.313	-2.58	1.313	-0.63	1.73	-1.84	-0.05	6.543**	-5.173**	0.68
P3 x P4	-3.05**	5.74**	1.35	0.388	-.507	-0.059	-0.846-	0.28	-.028	6.46**	6.90**	6.68**	-1.13**	1.013	-0.058
P3 x P5	-1.846	-6.69**	-4.24**	-0.045	1.656**	0.805	5.513**	-5.18**	-5.35**	0.772	5.35**	3.06*	6.176**	9.73**	7.95**
P3 x P6	-0.713	-5.53**	-3.12*	-1.038	2.586**	0.721	-5.013**	-8.48**	-6.75**	-6.37**	1.92	-2.2	-7.223	-2.23*	-4.73**
P3 x P7	-8.113**	-4.59**	-6.35**	3.775**	4.99**	4.38**	-8.01**	-9.65**	-8.83**	0.177	-7.94**	-3.88**	4.05**	4.58**	4.31**
P3 x P8	-5.88**	-9.33**	-7.61**	-0.885	-3.296**	-2.09**	10.72**	9.22**	9.97**	-0.602**	-11.36**	-8.96**	-0.653	1.1	0.22
P4 x P5	-0.346	-4.56**	-2.453	-1.284	-3.79**	-2.54**	2.053	1.95	2.00	-7.896**	-3.17*	-5.53**	1.25	0.053	0.65
P4 x P6	-15.21**	-9.38**	12.3**	0.978	-1.56**	1.27	0.22	2.02	-0.9	-4.38**	-4.6**	-4.22**	0.3238	1.086	0.702
P4 x P7	-1.95	-5.79**	-3.87**	0.968	-1.48*	1.22	3.22*	3.893**	3.52**	-2.763**	-0.83	-1.796	7.18**	8.00**	7.59**
P4 x P8	-11.38**	-9.53*	-10.45**	0.042	5.023**	2.53**	-0.838	-5.28	-3.9**	3.324**	6.976**	5.1**	0.15	-3.58**	-1.71
P5 x P6	-1.68	-2.49*	-2.08	1.2555	0.027	0.641	1.553	-2.486	-0.47	0.724**	3.10*	1.94	5.22**	1.806	3.51**
P5 x P7	4.253**	2.77*	3.51**	1.802*	3.143**	2.473**	1.886	3.68**	2.78**	-0.219	1.45	0.61	0.793	3.14**	1.96
P5 x P8	6.153**	3.706**	4.9**	2.408**	1.95**	2.18**	-1.0496	6.56**	2.75	-2.233	3.59**	0.678	-6.576**	-2.86	-4.71**
P6 x P7	-5.946**	-6.39**	-6.17**	0.109	1.193	-0.542	5.386**	10.38**	7.88**	-2.104	-2.93*	2.52	2.49**	-6.24**	-1.87
P6 x P8	7.95**	11.21**	9.58**	0.248	-1.083	-0.418	0.453	-1.72	-0.63	6.646**	3.406*	5.3**	-1.21	3.173**	0.98
P7 x P8	-9.78**	-1.76	-5.77**	2.262**	2.950**	2.61**	-0.141	-0.22	-0.18	7.30**	2.766	5.03**	3.363**	7.993**	5.678**
L.S.D. (Sii) 5%	2.653	2.482	2.567	1.608	1.147	1.38	3.123	2.768	2.94	2.384	2.925	2.654	2.179	2.23	2.20
1%	3.526	3.30	3.41	2.14	1.525	1.83	4.15	3.68	3.91	2.172	3.89	3.03	2.899	2.966	2.93
L.S.D. 5%	3.69	3.45	3.57	2.234	1.594	1.91	4.33	3.84	4.08	3.31	4.06	32.68	3.03	3.09	3.06
(S^ij-S^ik) 1%	4.91	4.588	4.75	2.97	2.12	2.54	5.76\	5.11	5.44	4.40	5.04	4.70	4.03	4.12	4.07
L.S.D. 5%	4.52	4.225	4.37	2.736	1.97	2.35	2.73	1.953	2.34	5.312	4.709	5.01	4.054	3.79	3.92
(S^ij-S^kl) 1%	6.01	5.62	5.82	3.64	2.62	3.13	3.638	2.598	3.118	7.065	6.26	6.66	5.39	5.05	5.22

*, **significant 0.05 and 0.01 level, respectively.

Table 7. Mean squares from analysis of variance, general and specific combining of susceptibility index for all studied traits.

S.O.V.	D.F.	Plant height	No. of spikes plant	No. of kernels/spike	Grains yield/plant	1000-kernels weight
Replication	2	0.010	0.009	0.002	0.020	0.088
Genotypes	35	1.217**	0.180**	0.278**	0.484**	0.975**
Parents	7	1.600**	0.282**	0.132**	0.437**	0.111**
Crosses (FS)	27	1.083**	0.140**	0.325**	0.512**	1.235**
P.V.S.	1	2.100**	0.510**	0.018	0.059	0.002
G.C.A.	7	0.326**	0.286**	0.503**	0.650**	0.472**
S.C.A	28	1.438**	0.155**	0.221**	0.442**	1.100**
Error	70	0.026	0.029	0.027	0.025	0.034

For 1000-kernels weight, fifteen, fifteen and eleven crosses had significantly positive (S_{ij}) effects in stress, and normal irrigation treatments as well as the combined analysis, respectively. The best combination were P_1 x P_4, P_1 x P_7, P_1 x P_8, P_2 x P_3, P_2 x P_6, P_3 x P_5, P_3 x P_7, P_4 x P_7 and P_7 x P_8. Regarding grain yield/plant nine, ten and seven crosses had significantly positive (S_{ij}) effects in stress, normal irrigation treatments as well as the combined analysis, respectively. The best combination were P_1 x P_5, P_2 x P, P_2 x P_7, P_3 x P_4, P_4 x P_8 and P_6 x P_7.

Two of the previous crosses (P_4 x P_8 and P_6 x P_8) had two good combining parents and the other four crosses involved only one good combiner. Such combinations would show desirable transgressive segregates, providing that additive genetic system present in the good combiner as well as the complementary other epistatic effects present in these crosses, act in the same direction to reduce undesirable plant characteristics and maximize the character in question.

Genetic analysis of the susceptibility index

Mean squares of genotypes and its components for drought stress susceptibility index (DSI) were significant for all studied traits except mean squares due to parents vs. crosses for no. of kernels/spike, grain yield/plant and 1000-kernel weight.

The variance associated with GCA and SCA for susceptibly index were significant in all traits. To get an idea about the predicted performance of a single cross progeny in each trait, the relative magnitude of general to specific combining ability mean squares may be helpful. High ratio, which exceeded the unity, was obtained for DSI in number of spikes/plant, no. of kernels/spike and grain yield/plant, indicating that largest part of the total genetic variability associated with those of DSI in the three traits was a result of additive and additive by additive types of gene action. However, for plant height and 1000-kernel weight, low ratios, which were less than unity were detected for DSI, revealing that large part of the total genetic variability was associated with these traits due to the non additive type gene action.

The mean performances for DSI of all genotypes calculated for all studied traits are presented in Table 8.

The previous index was used to estimate the relative stress injury because it was counted for variation in yield potential stress intensity. Low stress susceptibility (LSS) < 1 is synonymous with higher stress resistance (Fischer and Maurer, 1978), Farshadfar *et al*, 1995 and Darwish 1998.

Application of DSI over both, irrigation levels (stress and normal) indicated that P_2, P_4, P_7, P_8 and eighteen hybrids had resistance to the stress irrigation condition for plant height, respectively. The best crosses were P_1 x P_4, P_1 x P_5, P_2 x P_6, P_3 x P_5, P_3 x P_6 and P_3 x P_8 in the same order.

Regarding DSI for no. of spikes per plant, P_4, P_6 and P_8 and twenty hybrids had resistance of stress irrigation respectively. The best crosses were P_1 x P_7 and P_6 x P_8 in the same order.

Three parents P_4, P_5 and P_8 and fourteen crosses had the desirable DSI for no. of kernels per spike respectively. The best crosses were P_1 x P_3, P_1 x P_4, P_1 x P_5, P_1 x P_7, P_1 x P_8, P_2 x P_5, P_3 x P_8 and P_5 x P_6, in the same order. Regarding grain yield/plant , the four parents P_2, P_4 (Sham 6), P_5, and (P_6) SK 8 and sixteen crosses had low susceptibility of stress irrigation, respectively. Also, the best hybrids for resistance to irrigation stress were P_1 x P_2, P_1 x P_7, P_2 x P_5, P_3 x P_7 and P_6 x P_8 in the same order.

Estimates of GCA effects $\hat{g}_i$ for individual parents per each trait of (DSI) are presented in Table (9). Highly significant negative values would be of interest for all measurements of drought susceptibility indices in question from the breeders point of view.

Table 8. Genotypes mean performance of susceptibility index calculated for all studied traits.

Genotypes	Plant height	No. of spikes plant	No. of kernels per plant	Grain yield per plant	1000-kernels weight
P_1	1.78	1.49	1.53	1.25	1.207
P_2	0.800	1.01	1.18	0.723	1.00
P_3	1.26	1.21	0.95	1.03	1.493
P_4	0.846	0.727	0.83	0.59	1.073
P_5	2.82	1.53	0.92	0.876	1.08
P_6	0.518	0.747	1.4	0.56	1.017
P_7	0.936	1.28	1.12	1.42	.846
P_8	0.800	0.947	0.743	1.25	0.99
1 x 2	2.45	0.896	1.016	0.54	0.864
1 x 3	0.590	0.91	0.526	0.89	1.407
1 x 4	0.27	0.786	0.53	1.31	1.10
1 x 5	0.24	1.37	0.443	0.823	1.32
1 x 6	1.29	0.883	1.126	0.367	1.083
1 x 7	0.66	0.67	0.526	1.70	1.35
1 x 8	0.396	0.896	0.536	1.03	1.09
2 x 3	0.743	0.78	1.213	0.983	1.58
2 x 4	1.66	0.78	1.53	0.93	0.229
2 x 5	0.346	1.00	0.806	0.48	1.686
2 x 6	0.227	1.08	1.00	0.67	1.31
2 x 7	0.642	0.87	1.41	1.05	1.33
2 x 8	1.07	0.80	1.49	0.43	3.09
3 x 4	2.14	0.813	0.996	0.593	0.483
3 x 5	0.473	1.41	0.906	1.436	0.353
3 x 6	0.22	1.41	0.743	1.52	0.391
3 x 7	1.45	1.00	1.023	0.551	0.869
3 x 8	0.52	0.853	0.713	0.747	0.667
4 x 5	0.746	0.863	0.896	1.766	0.930
4 x 6	1.87	0.80	0.91	0.966	1.204
4 x 7	0.597	0.836	1.12	1.457	0.626
4 x 8	1.426	1.42	1.39	1.18	1.38
5 x 6	0.75	0.98	0.663	1.07	1.417
5 x 7	0.786	1.27	1.13	1.42	0.703
5 x 8	0.64	0.96	1.473	1.513	0.481
6 x 7	0.73	0.896	1.416	0.963	2.505
6 x 8	1.04	0.733	0.936	0.403	0.483
7 x 8	1.43	0.880	1.276	0.686	0.435
L.S.D. 5%	0.263	0.278	0.268	0.258	0.301
L.S.S. 1%	0.350	0.369	0.357	0.343	0.40

Table 9. Estimates of general combining ability effects of susceptibility index calculated for all studied traits.

Parent		Plant height	No. of spikes pler plant	No. of kernels per spike	Grain yield per plant	1000-kernel weight
P_1		0.5525**	0.41**	-2.195**	0.4045**-	0.8575**
P_2		0.71525**-	-0.7533**	1.895**	2.17716**	2.323**
P_3		0.2414**	0.62**	-0.915**	0.06616	-1.0308**
P_4		1.5016**	-1.06**	0.0916	0.40783**	-1.66916**
P_5		0.7219**	1.923**	-0.07716	1.536**	-071816**
P_6		-1.7304**	-0.706*	0.0592	-1.9645**	0.6558**
P_7		-0.74342**	0.01	1.2116**	1.9578**	-0.25616**
P_8		-0.78475**	-0.4437*	-0.03166	-0.2296**	-0.16283**
)$\hat{g}_i$ L.S.D. (	5%	0.0959	0.1007	0.097	0.0935	0.109
	1%	0.127	0.1339	0.129	0.124	0.145
L.S.D. ($\hat{g}_i - \hat{g}_j$)	5%	0.144	0.152	0.146	0.141	0.0165
	1%	0.192	0.202	0.195	0.187	0.219

*, **significant 0.05 and 0.01 level, respectively.

The parent (P_1) showed significantly negative $\hat{g}_i$ effect of DSI for no. of kernel per spike. While, the parental line (P_2) seemed to be the best combiner for DSI in no. of spikes/plant and grain yield. The parental line (P_3) showed significantly negative $\hat{g}_i$ effect of DSI for plant height, no. of spikes/plant and 1000-kernel weight. However, the parental variety Sham 6 (P_4) showed significant DSI for no. of spikes/plant and 1000-kernels weight. The parental line (P_5) showed significantly negative DSI for 1000-kernel weight. The parental Sakha 8 (P_6) showed significant negative effects for no. of spikes and grain yield.

The parental variety Giza 157 (P_7) expressed significantly negative $\hat{g}_i$ effects for drought susceptibility indices with respect to 1000-kernel weight. The parental cultivar Sakha 69 (P_8) gave significantly negative $\hat{g}_i$ effects for four traits studied except no. of kernels/spike.

It could be indicated that parents P_2, P_6, and P_8 could be considered as good general combiners for grain yield and most of its components. Also, the parental cultivars Sham 6 (P_4) was the best general combiner for drought susceptibility index in number of spikes per plant and 1000-kernel weight.

Specific combining ability effects of the parental combinations for drought susceptibility index of all studied traits are presented in Table (10).

For plant height, fourteen crosses expressed significantly negative Sij effects. The best crosses were P_1x P $_4$, P_1 x P_5, P_2 x P_5, P_2 x P_6 and P_7xP_8.

The cross (P_1 x P_7) exhibited significantly negative S_{ij} effects for DSI of no. of spikes/plant. For number of kennels/spike, seven crosses expressed significantly negative S_{ij} effects. The best crosses were P1 x P_8, P1 x P_5 and P1 x P_7.

Seven crosses exhibited significant S_{ij} effects for DSI of 1000-kernel weight. The best crosses were P_2 x P_4, P_3 x P_6, P_6 x P_8 and P_7 x P_8.

Table 10. Estimates of specific combining ability effects (Sij) for drought susceptibility index calculated for all studied traits.

Genotypes		Plant height	No. of spikes plant	No. of kernels per plant	Grain yield per plant	1000-kernels weight
		SI				
P1 x P2		1.34**	-0.067	0.049	-0.415**	-0.539**
P1 x P3		-0.43**	-0.191	-0.577**	0.139	0.338*
P1 x P4		-0.926**-	-0.146	-0.403**	0.512**	0.096
P1 x P5		0.875**	0.135	-0.792**	0.108	0.221
P1 x P6		0.419**	-0.085	0.154	-1.267	-0.154
P1 x P7		-0.313*	-0.370**	-0.517**	0.786**	0.205
P1 x P8		-0.571**	-0.098	-0.462**	0.238	-0.066
P2 x P3		-0.295*	-0.204	0.225	-0.128	0.365*
P2 x P4		0.447**	-0.036	0.709**	-0.280*	-0.921**
P2 x P5		-0.78**	-0.115	-0.312	-0.643**	0.441**
P2 x P6		-0.662**	0.228	0.145	-0.599**	-0.073
P2 x P7		-0.342**	-0.050	0.483**	-0.273	0.038
P2 x P8		0.086	-0.078	0.608**	-0.774**	1791**
P3 x P4		1.023**	-0.140	0.039	-0.336	-0.333
P3 x P5		1.101**	0.161	-0.349**	0.594**	-0.557
P3 x P6		-0.573**	0.418**	-0.249	0.585**	-0.99**
P3 x P7		0.554**	-.068	-0.041	-0.48**	-0.0079
P3 x P8		-0.368**	-0.162	-0.305*	-0.243	-0.298*
P4 x P5		-0.467**	-0.22	-0.191	0.823**	0.0835
P4 x P6		0.905**	-0.021	0.085	-0.119	0.2198
P4 x P7		-0.471**	-0.056	0.020	0.315*	-0.2663
P4 x P8		0.364**	-0.042	0.539**	0.089	0.487**
P5 x P6		-0.013	-0.211	-0.04	0.07	0.337*
P5 x P7		-0.203	0.012	-0.064	0.353**	-.285
P5 x P8		-0.345**	-0.186	0.323*	0.046	-0.047
P6 x P7		-0.0044	-0.031	0.485**	-0.235	1.38**
P6 x P8		0.300*	-0.150	0.050	-0.743**	-0.0653**
P7 x P8		0.587**	-0.074	0.318*	-0.514**	-0.068**
L.S.D. (S_{ij})	5%	0.254	0.0268	0.2592	0.249	0.291
	1%	0.338	0.356	0.345	0.332	0.386
L.S.D. (S_{ij}-S_{ik})	5%	0.353	0.343	0.360	0.346	0.484
	1%	0.469	0.496	0.478	0.461	0.537
L.S.D. (S_{ij}-S_{kl})	5%	0.433	0.457	0.441	0.424	0.496
	1%	0.575	0.607	0.586	0.564	0.658

*, **significant 0.05 and 0.01 level, respectively.

Regarding grain yield, the crosses P1 x P_2, P_2 x P_4, P_3 x P_4, P_3 x P_6, P_3 x P_8, P_6 x P_8 and P_7 x P_8 exhibited significantly negative S_{ij}.

Stress resistance genotypes, as defined by DSI values, need not have a high yield potential since drought susceptibility index provides a measure of resistance based on minimization of yield loss under stress rather than on stress yield per se. Genotypes identified as stress resistant using DSI, should possesses resistance mechanisms, which may need to be incorporated into germplasm with higher yield potential for development of high yielding stress resistant cultivars.

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تحليل الهجن التبادلية فى قمح الخبز تحت معاملتى الرى الطبيعى والاجهاد المائى

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يهدف هذا البحث الى دراسة القدرة العامة والخاصة على التآلف فى الجيل الثانى من الهجن التبادليــة بين ٨ اصناف وسلالات متباينة وراثيا من قمح الخبز فى تجربتين: التجربة الاولى رويت أربع ريات (رى طبيعى) بالإضافة لرية الزراعة والتجربة الثانية رويت ريه واحدة (الإجهاد المائى) بالإضافة لرية الزراعة وذلك لصفات ،محصول الحبوب للنبات واربعة من الصفات المساهمة فيه ويمكن تلخيص أهم النتائج كما يلى:

١-كــان التباين الراجع لكل من القدرة العامة والخاصة على التآلف معنويا لكافة الصفات المسجلة فى كلا معاملتى الرى وكذلك التحليل المشترك ، مما يوضح أهمية كل من الفعل الجينى المضيف وغير المضيف التى تحكم وراثة هذه الصفات.

٢-كان الصنف شامل (٦) أحسن الآباء فى القدرة العامة على التآلف لصفات عدد الحبوب فى المنبلة فى كلا معاملتى الرى وكذلك التحليل المشترك وصفة وزن ١٠٠٠ حبة فى الرى الطبيعى. كما أبدى الصنف سخا ٨ تآلفــا جيدا ومعنويا لصفة محصول الحبوب فى الاجهاد المائى وكذلك التحليل المشترك. وكذلك أعطى الصنف سخا ٦٩ تآلفا معنويا وموجبا لصفة محصول الحبوب فى كلا التجربتين وكذلك التحليل المشترك.

٣-كانت الهجن (P_1 x P_5) ، (P_2 x P_3) ، (P_2 x P_7) ، (P_3 x P_4) ، (P_4 x P_8) ، (P_6 x P_8) هم افضل هجن تحت الدراسة فى كل من معاملتى الرى والتحليل المشترك.

٤-بحســاب دلــيل الحساســية للاجهاد المائى كانت ١٦ تركيبة وراثية اكثر تحملا لنقص الماء لمحصول الحبوب ومعظم الصفات المساهمة فيه وكانت احسن هذه الهجن (P_6 x P_8) ، (P_3 x P_7) ، (P_1 x P_2) ، (P_1 x P_7) ، (P_2 x P_5).

٥-كــان التباين الراجع لكل من القدرة العامة والخاصة على التآلف معنوية لكل الصفات المدروسة لمعاملة الحساسية للجفاف.

أوضـــح التحليل الوراثى لبيانات دليل الحساسية للاجهاد المائى ان الآباء P_2, P_6, P_8 افضل الآباء لصفات محصـــول الحبوب ومعظم الصفات المدروسة ، كما كان الاب P_4 افضل الآباء لصفات السنابل للنبات ووزن الالــف حــبة كما اشتركت هذه الآباء فى سبعة هجن ابدت قدرة خاصة ومناسبة على التآلف والتى تبشر بحدوث انعزالات فائقة الحدود فى الاتجاه الموجب للمحصول ، ويمكن الانتخاب لها فى الاجيال التالية تحت ظروف الاجهاد المائى.

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