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EFFECT OF INDUSTRIAL POLLUTION ON DIFFERENT WHEAT GENOTYPES BY USING DIALLEL CROSS

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ABSTRACT

The aim of this study was aimed to assess the variations amongst a half diallel cross using six varieties for pollution characters, estimating combining ability and heterosis. This investigation was carried out at two locations i.e., the first, at Zarzora Farm, El-Behira Governorate (normal condition) and the second at Kafr El-Zaiyat area El-Gharbia Governorate, Egypt (pollution condition) during the two seasons 2008/09 and 2009/10. Six diverse wheat varieties (*Triticum aestivum, L.*) and 15 F_1's were planted in two experiments. The ratios of GCA/SCA were greater than unity under the two environments and the combined analysis for all traits, except total chlorophyll and 1000-grain weight under stress and the combined analysis, plant height under normal and the combined analysis, flag leaf angle, NO. of spikes per plant and grain yield per plant under the two environments and their combined. These results suggested predominant role of additive type of gene action for these traits and the potential for obtaining further improvements of these traits by using pedigree selection program. The best parental combinations were ; Ug2 X Sahel1, Ug2 x Gem.9 and Ug3 x Sahel 1 for most studied traits**.** The crosses; Ug2 X Sahel1, Ug2 x Gem.9 and Sids 1 x Sahel 1 expressed parental heterosis for most traits which indicates that these crosses could be used in breeding program for pollution tolerance.

Keywords: *Triticum aestivum* vulgare, Hetrosis, GCA, SCA, stress, pollution, tolerance, wheat.

INTRODUCTION

During the last few decades, the contamination of Egyptian soils with heavy metals has been a steadily increasing problem due to industrial development. In Egypt, there are many industrial aggregates adjacent to different agricultural soils such as Kafer El-Zaiyat, (city) belong to El-Gharbia Governorate. Soil quality and productivity at this area has been dramatically reduced. Middle Delta region of Egypt (El-Gharbia Governorate) contains many industrial factories which are the main source of soil pollution either from atmospheric emissions or through discharge points drainage water. Heavy metal contamination of soil in this region is typically quantified and regulated on the basis of total content, regardless of solubility. However, the relative differences in the contents of heavy metal ions between plant species and cultivars are genetically controlled and can be due to various factors, inducing type of soils and their properties, metal availability, surface area of roots, root exudates and the rate of evapotranspiration (Kapata-Pendias and pendias, 1992). Colver and wheat plants grown in soils adjacent to factories, at Kafr El-Zaiyat area, were affected by heavy metals emission from industrial complex (Rania *et al*., 2010). The aim of this study was to assess the variations amongst a half diallel cross using six varieties for pollution tolerant.

MATERIALS AND METHODS

This investigation was carried out at two locations i.e., the first, at Zarzora Farm, El-Behira Governorate (normal condition) and the second in the middle Nile Delta, at Kafr El-Zaiyat area El-Gharbia Governorate, Egypt (pollution condition). The second location was contaminated by heavy metals resulted from the industrial activities either from atmospheric emissions or throw discharge point of drainage water. During the two successive seasons, 2008/09 and 2009/10, six wheat varieties and /or lines (*Triticum aestivum, L.*) i.e; Sham 6 (P_1), Ug2 (P_2), Sids 1 (P_3), Ug3 (P_4), Gem.9 (P_5) and Sahel 1 (P_6) and representing a wide range of diversity for several agronomic characters and pollution tolerance measurements were selected for this study.

In 2008/09 growing season, grains from each of the parental varieties and/or lines were sown at a various sowing dates in order to overcome the differences in time of heading. During this season, all possible parental combinations without reciprocals were made among six parents giving a total of fifteen crosses.

In 2009/10 season, the six parents and their fifteen possible F_1 crosses were sown on 15^{th} November in each locations. The experiment was designed in a randomized complete block design with three replications. Each plot consisted of two rows; 1.5 meters long with 30 cm between rows and plants within row were 15 cm. apart allowing a total of 20 plants per plot. The dry method of sowing (Afir) was used in this concern. The other cultural practices of growing wheat were practiced.

The following characters were recorded at 50 % heading stage for ten guarded plants chosen randomly per plot in each replicate: Relative water content (RWC %), measured as described by Barrs and Weatherley(1962). Total soluble solids; values of the total soluble solids of the cell sap were obtained from the pressed sap of the (fourth upper leaf) of tested plants using the Abbe Refrectometer, total chlorophyll: Minolta SPAD-502 meter.

Flag leaf angle (FLa): it was determined by using the protractor, Flag leaf area (cm^2), plant height (cm) ; as well as yield and some of its components; number of spikes/plant (NS/P), number of grains/spike, 1000-kernel weight (g) and grain yield /plant (g).

Statistical analysis:

The data of both experiments were subjected to proper statisical analysis of variance according to Snedecor and Cochran (1967). The combined analysis across the two experiments (stress and normal condition) were performed according to Cochran and Cox (1957). For comparason between means, Duncan's multiple range test was used, as proposed by Duncan (1955). General (GCA) and specific (SCA) combining ability estimates were obtained by employing Griffing (1956), diallel cross analysis designated as method 2 model 1. The amount of heterosis was expressed as the percentage deviation of F_1 mean performance from the mid-parent,

$$= \frac{\overline{F}_1 - M\overline{P}}{M\overline{P}} X100$$

Appropriate L.S.D. values were calculated to test the significance of the heterotic effects according to the following formulae:

L.S.D. for mid-parental heterosis ($(\bar{F}_1 - M\bar{P}) = t(\sqrt{3MSe/2r}$), MSe: is the mean squares of the experimental error and r is the number of replication.

RESULTS AND DISCUSSION

Analysis of variances: Mean squares of different wheat genotypes for all studied characters in each environment and their combined data are presented in Tables (1 and 2). Statistical analysis revealed significant of pollution treatments (locations) for all studied characters, indicating that the two pollution regimes behaved differently for these characters.

In addition, mean squares due to genotypes were highly significant for all traits, providing evidence for presence of large amount of genetic variability, which considered adequate for further biometrical assessment. Highly significant differences among the parents for all traits were found at both conditions and their combined, except grain yield per plant under normal condition and relative water content under stress condition.

Meanwhile, highly significant differences of crosses mean squares were detected for all characters, reflecting the diversity of the parents for these studied characters, and that these diversity could be transmitted to the progenies. Also, mean squares of parents vs. crosses showed significant differences for all traits, except flag leaf angle under normal condition, total chlorophyll under stress condition, relative water content under combined analysis and NO/ of grains per spike under normal and stress as well as the combined analysis, indicating the presence of hybrid vigor of the studied wheat genotypes .

For all traits, mean squares of genotypes x environments interactions were highly significant, except for NO. of grains per spike and grain yield per plant, indicating that genotypes responded differently to pollution regime for these traits and reflecting the possibility of selecting the most tolerant genotypes. Mean squares of parents x environments, crosses x environment and parent vs. crosses x environment were highly significant for most traits, revealing that the performance of parents and/or most crosses were changed from environment to another.

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Mean performances of the eight parents and their F_1 at stress and normal conditions as well as their combined data are presented for all the studied characters in Tables (3 and 4). The results showed that, the highest values for total soluble solids were recorded by Sham 6, Sahel 1 under two conditions and their combined. Also hybrids, Ug2 X Sahel1, Sids 1 x Sahel 1, Sham 6 x Gem.9, Sham 6 x Sids1and Ug2 x Sids 1 observed the highest values at the two conditions and their combined. For total chlorophyll**,** the highest values belonged to Ug2, Gem.9, Ug3 and Sids 1 at the two conditions and their combined analysis. Also crosses, Ug2 X Sahel1, sham 6 x Sahel 1, Sids 1 x Sahel 1 and Ug3 x Sahel 1 gave the highest values at the two conditions and their combined analysis. Yong *et al.* (2010) revealed that decrease in photosynthesis was accompanied by significant declines in chlorophyll contents and growth parameters. In respect to relative water content, the highest values were detected for Sham 6 and Sids1at the two conditions and their combined analysis normal and for Ug2, Sahel 1 and Gem. 9 under stress condition. With regard to flag leaf area, the highest values were recorded by Sids 1, Sham 6 and Gem. 9 under two conditions and their combined. Also hybrids, Sids 1 x Ug3 and Ug2 X Sahel1 observed the highest values at the two conditions and their combined.

Table (3): The genotype mean performance for total soluble solids, total chlorophyll and relative water content in both environments as well as the combined data.

Genotypes	Total soluble solids			Total Chlorophyl			Relative water content		
	N	S	Comb	N	S	Comb	N	S	Comb
Sham 6	11.17	6.33	8.75	40.77	48.97	44.87	85.95	82.37	84.16
Ug2	8.17	8.93	8.55	51.17	51.17	51.17	64.55	81.84	73.19
Sids 1	4.67	9.50	7.08	38.47	53.47	45.97	82.80	79.73	81.26
Ug3	6.13	12.20	9.17	51.40	43.23	47.32	61.35	76.72	69.04
Gem 9	8.20	9.07	8.63	39.47	56.00	47.73	75.15	80.16	77.66
Sahel 1	8.83	11.17	10.00	38.43	46.03	42.23	67.94	81.20	74.57
Sham 6 x Ug2	7.00	10.63	8.82	41.97	49.00	45.48	85.39	82.46	83.93
Sham 6 x sids1	11.37	10.00	10.68	41.90	50.37	46.13	83.26	75.74	79.50
Sham 6 x Ug3	7.00	7.77	7.38	46.87	48.80	47.83	81.00	55.29	68.14
Sham 6 x Gem 9	12.17	10.00	11.08	41.03	51.60	46.32	67.29	73.49	70.39
Sham 6 x Sahel 1	9.13	8.57	8.85	46.53	55.13	50.83	76.54	81.34	78.94
Ug2 x Sids 1	10.23	11.00	10.62	48.37	49.40	48.88	75.79	79.71	77.75
Ug2 x Ug3	7.57	11.23	9.40	41.07	49.17	45.12	61.26	82.13	71.69
Ug2 x Gem 9	6.13	8.57	7.35	41.80	49.70	45.75	78.58	83.10	80.84
Ug2 X Sahel1	11.37	12.13	11.75	53.10	50.93	52.02	67.26	81.37	74.31
Sids 1 x Ug3	9.17	10.30	9.73	44.73	47.80	46.27	62.13	80.48	71.31
Sids 1 x Gem 9	10.13	10.23	10.18	44.27	46.23	45.25	82.31	83.40	82.85
Sids 1 x Sahel 1	11.17	12.10	11.63	46.97	54.67	50.82	92.02	75.83	83.93
Ug3 x Gem 9	8.37	9.33	8.85	46.83	47.73	47.28	53.85	76.69	65.27
Ug3 x Sahel 1	7.00	11.23	9.12	42.83	56.83	49.83	69.29	67.22	68.25
Gem 9 x Sahel 1	7.70	9.40	8.55	42.87	47.27	45.07	84.97	84.59	84.78
Mean	8.70	9.99	9.34	44.33	50.17	47.25	74.22	78.33	76.27
L.S.D. 5 %	0.52	0.55	0.53	3.61	3.90	3.67	3.75	4.26	3.92
L.S.D. 1 %	0.70	0.73	0.70	4.83	5.14	4.85	5.02	5.61	5.18

N= normal, S= stress and Comb= Combined.

Table (4): The genotype mean performance for flag leaf area, flag leaf angle and plant height in both environments as well ast he combined data.

Genotypes	Flag leaf area			Flag leaf angle			Plant height (cm)		
	N	S	Comb	N	S	Comb	N	S	Comb
sham 6	59.66	52.75	56.20	32.67	26.00	29.33	103.42	98.93	101.18
Ug2	49.78	45.97	47.87	22.50	35.67	29.08	100.67	87.89	94.28
Sids 1	63.53	62.27	62.90	23.00	26.00	24.50	101.64	98.90	100.27
Ug3	40.44	30.74	35.59	20.00	28.50	24.25	99.19	96.98	98.09
Gem 9	52.24	48.79	50.51	25.00	32.00	28.50	97.42	96.11	96.76
Sahel 1	49.07	45.32	47.20	18.50	22.00	20.25	98.86	95.88	97.37
Sham 6 x Ug2	44.45	39.47	41.96	22.33	33.50	27.92	94.58	89.97	92.28
Sham 6 x sids1	62.36	51.83	57.10	21.33	17.00	19.17	104.38	100.33	102.36
Sham 6 x Ug3	35.79	25.37	30.58	20.50	32.50	26.50	105.98	101.23	103.61
Sham 6 x Gem 9	56.98	48.81	52.89	12.50	11.67	12.08	104.83	99.77	102.30
Sham 6 x Sahel 1	52.91	36.32	44.62	39.50	27.50	33.50	106.17	104.47	105.32
Ug2 x Sids 1	51.24	45.10	48.17	19.33	30.00	24.67	103.78	97.53	100.65
Ug2 x Ug3	42.04	39.99	41.01	20.00	17.67	18.83	102.25	97.07	99.66
Ug2 x Gem 9	51.55	41.65	46.60	30.50	21.00	25.75	107.39	104.86	106.12
Ug2 X Sahel1	54.62	50.46	52.54	24.50	25.50	25.00	106.80	101.04	103.92
Sids 1 x Ug3	65.18	57.02	61.10	28.50	26.50	27.50	106.08	103.71	104.90
Sids 1 x Gem 9	45.14	36.52	40.83	41.50	31.00	36.25	103.47	100.93	102.20
Sids 1 x Sahel 1	45.56	35.68	40.62	28.00	19.00	23.50	108.75	108.35	108.55
Ug3 x Gem 9	42.10	35.58	38.84	23.00	26.50	24.75	102.50	96.57	99.54
Ug3 x Sahel 1	57.58	47.80	52.69	20.00	24.00	22.00	105.61	103.49	104.55
Gem 9 x Sahel 1	50.73	40.37	45.55	22.50	25.00	23.75	104.78	102.32	103.55
Mean	51.09	43.70	47.40	24.56	25.64	25.10	103.26	99.35	101.31
L.S.D. 5 %	3.70	0.00	2.58	5.46	3.71	4.57	2.56	2.05	2.27
L.S.D. 1 %	4.95	0.00	3.41	7.31	4.89	6.05	3.43	2.70	3.00

N= normal , S= stress and Comb= Combined.

For Flage leaf angle, the lowest values belonged to Sahel 1, Ug3 and Sids 1 at the two conditions and their combined analysis. Also crosses, sham 6 x sids1, Ug2 x Ug3, Ug3 x Sahel 1, Sids 1 x Sahel 1 and Gem. 9 x Sahel 1 gave the lowest values at the two conditions and their combined analysis. Talanova *et al*. (2001) showed that, treatment with increasing doses of heavy-metal ions results not only in growth retardation, but also in a disturbance of water relations. This disturbance is caused by a decrease either in the hydraulic conductivity of roots, in the water-holding capacity of leaves, or in the formation of lateral roots and root hairs. For plant height were recorded by Sham 6, Sids 1 and Ug2 under two conditions and their combined. Also hybrids, Sids 1 x Sahel 1, Ug2 x Gem.9 and Sids1 x Ug3 observed the highest values at the two conditions and their combined. Wang *et al*. (2007) recorded that, ambient air pollution has been shown to reduce the growth and economic yield of awide range of major rice crop species. Yong *et al.* (2010) showed that plant height decreased significantly compared to control due to the presence of Cd and/or O3.

Yield and yield components:

It is clear from the data in Table (5) that pollution condition decreased the mean number of no. of spike per plant, for the parents and hybrids.

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The highest NO. of spikes per plant belonged to Gem.9, Ug3 and Sham 6 at the two conditions and their combined while, Sahel 1 revealed lowest number of spikes per plant at the two conditions and their combined. Also crosses; Ug2 x Gem.9, Ug2 X Sahel1, sham 6 x Gem.9 and Ug3 x Sahel 1 showed the highest values at the two conditions and their combined. While, Ug2 x Ug3 and sham 6 x Ug3 showed the lowest values at the two conditions and their combined.

With regard to number of grains per spike**,** the parents Gem.9 and Ug2 showed the highest values at the two conditions and their combined. Also crosses; Ug2 X Sahel1, sham 6 x Ug2 and sham 6 x Sahel 1 showed the highest values at the two conditions and their combined.

Results showed that the mean values of 1000 -grain weight for the parents and hybrids under normal condition were higher than that under pollution condition. With regard to the parents, the heaviest 1000- grain weight were obtained from Gem.9, sham 6, Sids1 and Ug2 under the two conditions and their combined. While, the grains of Ug3 at the two conditions and their combined were the lightest. The heaviest 1000-grain weight of wheat hybrids were obtained from Ug3 x Gem.9, Sids 1 x Ug3, Ug2 x Gem.9 and Sids 1 x Gem.9 under the two conditions and their combined. While, the lowest 1000- grain weight of wheat crosses were relative to Sham 6 x Sids1 and Sids 1 x Sahel 1 at the two conditions and their combined.

As a result of pollution condition, the average of grain yield per plant for parents and their hybrids was decreased. The highest grain yield per plant were showed by Gem.9 and Ug2 under the two conditions and their combined , While, the lowest grain yield per plant was obtained by Sahel 1 at the two conditions and their combined. The hybrids, Ug2 x Gem.9, Ug2 X Sahel1 and Ug2 x Sids 1 yielded more than the other crosses under the two conditions and their combined. While, Sids 1 x Gem.9 and Gem.9 x Sahel 1 gave the lowest values under normal and stress condition as well as the combined analysis. These results were agreement with Akram *et al.* (2008) in Faba bean.

Combining ability analysis: Combining ability implies the capacity of parent to produce good progenies when crossed with the other parent.

Analysis of variance for combining ability as out lined by Griffing (1956) method 2 model 1in each environment as well as their combined for all the studied traits are presented in Tables (6 and 7). The results indicate that mean squares of general combining ability (GCA) and specific combining ability (SCA) were significant for all the studied traits under the two environments and their combined indicating the presence of both additive and non additive types of gene effects in the genetic system controlling of these traits.

The ratios of GCA/SCA were greater than unity under the two environments and the combined analysis for all traits, except total chlorophyll and 1000- grain weight under stress and the combined analysis, plant height under normal and the combined analysis, flag leaf angle, NO. of spikes per plant and grain yield per plant under the two environments and their combined.

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These results suggested predominant role of additive type of gene action for these traits and the potential for obtaining further improvements of these traits by using pedigree selection program. These results were coincident with those reported by Abd El-Aty and El-borhamy (2007).

The mean squares of interaction between environment and each of GCA and SCA were significant for all the studied traits, except GCA x Env, SCA x Env for NO. of spikes per plant, NO. of grains per spike and grain yield per plant revealing that the magnitudes of different type of gene action were varied from one environment to another.

General combining ability effects: Estimates of GCA ĝ(i) effects of all wheat parental genotypes for each trait in both locations and the combined data are presented in Tables (8 and 9). Such effects are being used to compare the average performance of each parent with the other and facilitate selection of parents for further improvement to pollution tolerance.

GCA (ĝi) in this study was found to be significantly differed from zero in all traits. High positive values would be highly appreciated under all the studied traits, except flag leaf angle where high negative effects would be useful from the breeder's point of view. It could be concluded that the parent sahel 1 was the best combiner for flag leaf angle indicating that this variety considered as a good tolerant combiner for pollution.

Table (8): Estimates of general combining ability effects of parents for total soluble solids, total chlorophyll , relative water content, flag leaf area, flag leaf angle and plant height in both environments as well as the combined data.

Parent	Total soluble solids			Total Chlorophyl			Relative water content		
	N	S	Comb.	N	S	Comb.	N	S	Comb.
Sham 6	1.01**	-1.28**	-0.13**	-1.31**	0.21	-0.55**	5.73**	-1.90**	1.91**
Ug2	-0.28**	0.19**	-0.05	2.29**	- 0.08	1.11**	-2.77**	3.02**	0.12
Sids 1	0.06	0.34**	0.20**	-0.89*	0.53	-0.18	5.19**	0.79	2.99**
Ug3	-1.19**	0.55**	-0.32**	1.86**	-1.80**	0.03	-8.66**	-4.13**	-6.40**
Gem 9	0.00	-0.53**	-0.26**	-1.82**	0.42	-0.70**	- 0.28	1.66**	0.69**
Sahel 1	0.39**	0.73**	0.56**	-0.14	0.72	0.29	0.80	0.56	0.68**
LSD gi 5%	0.12	0.12	0.06	0.82	0.88	0.40	0.86	0.96	0.43
LSD gi 1%	0.16	0.17	0.08	1.10	1.17	0.53	1.15	1.28	0.57
LSD gi-gj 5%	0.19	0.19	0.09	1.28	1.36	0.65	1.33	1.48	0.69
LSD gi-gj 1%	0.25	0.26	0.12	1.71	1.82	0.86	1.77	1.98	0.92

Parent	Flag leaf area			Flag leaf angle			Plant height		
	N	S	Comb.	N	S	Comb.	N	S	Comb.
Sham 6	1.77**	0.46**	1.11**	1.20	-0.67	0.27	- 0.01	-0.23	-0.12
Ug2	-1.77**	0.54**	-1.16**	-1.28*	2.44**	0.58*	-0.84**	-3.65	-2.24**
Sids 1	4.86**	0.167	2.51**	1.60*	-0.50	0.55*	0.86**	1.65**	1.26**
Ug3	-4.26**	-0.79**	-2.52**	-2.49**	0.58	-0.95**	- 0.25	0.07	-0.09
Gem 9	-0.83	-0.38*	-0.23	1.01	-0.04	0.49	-0.63*	0.15	-0.24
Sahel 1	0.24	-0.33*	0.28	-0.05	-1.81**	-0.93**	0.87**	2.00**	1.43**
LSD gi 5%	0.84	0.31	0.30	1.25	0.83	0.50	0.59	0.46	0.25
LSD gi 1%	1.13	0.42	0.37	1.67	1.12	0.66	0.78	0.62	0.33
LSD gi-gj 5%	1.31	0.48	0.40	1.93	1.29	0.81	0.91	0.71	0.40
LSD gi-gj 1%	1.75	0.64	0.64	2.58	1.73	1.07	1.21	0.96	0.53

N= normal , S= stress and Comb= Combined.

Table (9): Estimates of general combining ability effects of parents for no. of spikes/plant , no of grains/spike, 1000-grain weight and grain yield/plant in both environments as well as the combined data.

Parent	No of spikes/plant			No of grains/spike		
	N	S	Comb.	N	S	Comb.
Sham 6	- 0.56	-0.43*	-0.50**	-1.44*	0.73	-0.36
Ug2	0.62	-0.10	0.26	5.34**	4.56**	4.95**
Sids 1	-0.67	-0.51*	-0.59**	-3.56**	-4.93**	-4.25**
Ug3	-0.78	-1.05**	-0.91**	-3.22**	-4.71**	-3.96**
Gem 9	1.64**	1.86**	1.75**	1.24*	2.03**	1.64**
Sahel 1	-0.25	0.22	0.02-	1.64**	2.32**	1.98**
LSD gi 5%	0.92	0.41	0.34	1.16	0.93	1.04
LSD gi 1%	1.24	0.55	0.45	1.55	1.24	1.4
LSD gi-gj 5%	1.43	0.63	0.55	1.8	1.44	1.6
LSD gi-gj 1%	1.92	0.85	0.72	2.4	1.93	2.16

Parent	1000 grain wieght			Grain yield/plant		
	N	**S**	**Comb.**	**N**	**S**	**Comb.**
Sham 6	-0.28	-2.70**	-1.49**	-2.75**	-2.62**	-2.68**
Ug2	-0.19	0.24	0.02	4.64**	3.68**	4.16**
Sids 1	- 0.13	0.43	0.15	-1.85*	0.07	- 0.40
Ug3	0.62	0.57	0.60**	-1.76	-2.34**	-2.05**
Gem 9	1.90**	2.87**	2.39**	0.78	0.52	0.60
Sahel 1	- 1.91**	-1.42**	-1.67**	- 0.06	0.69	0.41
LSD gi 5%	0.70	0.63	0.31	1.43	1.33	1.38
LSD gi 1%	0.93	0.84	0.41	1.91	1.78	1.84
LSD gi-gj 5%	1.08	0.97	0.51	2.21	2.06	2.13
LSD gi-gj 1%	1.44	1.30	0.67	2.95	2.75	2.85

N= normal , S= stress and Comb= Combined.

With respect to the traits, which the positive direction are interested, one parent Sids1 for plant height, Gem.9 NO. of spikes per plant, NO. of grains per spike, 1000- grain weight and grain yield per plant. Therefore, the two parents Sids1 and Gem.9 could be considered as excellent parents in breeding programs aimed to release parents to pollution tolerance.

Specific combining ability effects (Sij)**:**

SCA (Sij) of the parental combinations computed for seven traits in combined analysis are presented in Tables (10, 11 and 12).

Under the two environments and the combined analysis, significant positive SCA effects were found in the crosses; Sham 6 x Gem.9 followed by, Ug2 X Sahel 1; Sids 1 x Sahel 1, Sham 6 x Sids1, Ug2 x Sids 1, Sids 1 x Gem.9 and Ug2 x Ug3 for Total soluble solids, Sham 6 x Sahel 1 and Sids 1 x Sahel 1 for total chlorophyll, Gem.9 x Sahel 1 and sham 6 x Ug2 for relative water content, Sids 1 x Ug3, Ug3 x Sahel 1, Ug2 X Sahel1, Sham 6 x Gem.9 and Sham 6 x Sids1 for Flag leaf area. Significant negative SCA effects were detected in two parental combinations Sham 6 x Gem.9 and Sham 6 x Sids1 for flag leaf angle. Highly significant positive SCA effects were found in the crosses; Ug2 x Gem.9, Sids 1 x Sahel 1, Ug2 X Sahel1, sham 6 x Sahel 1, sham 6 x Ug3 and Sids 1 x Ug3 for plant height, two crosses Ug2 x Gem.9 and Ug3 x Sahel 1 for NO of spike/plant . One parental combination; Ug2 X Sahel 1 for NO of grains per spike.

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11

12

Five crosses; Sids 1 x Ug3, Ug3 x Sahel 1, Ug3 x Gem.9, Ug2 x Gem.9 and Ug2 x Sids 1 for 1000- grain weight, Ug2 x Gem.9, Ug2 X Sahel 1, Ug2 x Sids 1, Ug3 x Sahel 1 and Sids 1 x Sahel 1 for grain yield. Generally, the best parental combinations were ; Ug2 X Sahel1, Ug2 x Gem.9 and Ug3 x Sahel 1 for most studied traits. These crosses could be successfully need for breeding to pollution tolerant in wheat. The results obtained herein concerning general and specific combining ability effects indicated that the excellent hybrid combinations were obtained from the three possible combinations between the parents of high and low general combining ability effects *i.e.* high x high , high x low and low x low. Consequently, it could be concluded that general combining ability effects of the parental lines were generally unrelated to the specific combining ability effects of their respective crosses.

Hetrosis

Hetrosis relative to mid-parent in normal and stress conditions as well as the combined analysis are presented in Tables (13 and 14).

Its evident from Tables (14 and 15) that negative highly significant heterotic values relative to mid parent were observed in two crosses (Sham 6 x Gem.9 and sham 6 x sids1) in normal and stress condition as well as the combined analysis for flag leaf angle ranging from -1.09% to -59.77%.

It could be observed from the data that highly significant heterotic values in positive direction were found for other remained pollution measurements overall environments.

Results revealed that six crosses exhibited highly significant heterosis as deviation from mid-parent for total soluble solids. Such estimates ranged from 25.65% to 65.43%, 10.23% to 29.87% and 26.86% to 36.20% in both pollution conditions as well as the combined analysis, respectively, two crosses; Sham 6 x Sahel 1 and Sids 1 x Sahel 1 gave highly significant heterosis as deviation from mid-parent for total chlorophyll ranged from 9.88% to 22.15%.

Three crosses; Ug3 x Sahel 1, Sids 1 x Ug3 and Ug2 X Sahel1 showed highly significant positive heterosis over the mid-parent for the flag leaf area, ranged from 10.52% to 28.66%, 10.55% to 25.68%, and 10.53% to 27.29%, at normal and stress condition as well as the combined analysis, respectively.

For plant height, eleven crosses; expressed highly significant mid-parental heterosis ranged from 2.60% to 8.48%, 2.30% to 13.98% and 3.37% to 11.10% under normal, stress conditions and their combined data, respectively. Two crosses; Ug2 X Sahel1 and Ug2 x Gem.9 had highly significant heterosis deviated than corresponding mid-parents for NO. of spike per plant.

Only one cross, Ug2 X Sahel1 showed highly significant positive heterosis over the mid-parent for the NO. of grains per spike**,** at normal and stress condition as well as the combined analysis.

Seven crosses expressed highly significant mid-parental heterosis for 1000- grain weight ranged from 8.32% to 24.38%, 10.42% to 41.24% and 10.92% to 29.44% under normal, stress conditions and their combined data, respectively.

13

14

For grain yield, five crosses expressed highly significant mid-parental heterosis ranged from 36.78% to 49.22%, 35.46% to 61.61% and 40.93% to 54.50% under normal, stress conditions and their combined data, respectively.

However, it could be concluded from the above results that the crosses; Ug2 X Sahel1, Ug2 x Gem.9 and Sids 1 x Sahel 1 expressed parental heterosis for most traits which indicates that these crosses could be used in breeding program for pollution tolerance.

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تأثير تلوث الهواء الصناعى على التراكيب الوراثية المختلفة من القمح باستخدام الهجن التبادلية

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أقيمت تجربتان الاولى بمزرعة محطة بحوث ززوورة بمحافظة البحيرة (بيئة طبيعية) ، والثانية بمركز كفر الزيات، محافظة الغربية (بيئة تحت تأثير التلوث) .

الهدف من هذه البحث هو تقييم أداء التراكيب الوراثية المختلفة من القمح الربيعى ، وتقدير القدرة على الائتلاف ، و قوة الهجين تحت تأثير التلوث الصناعى .

تم زراعة ستة اصناف من القمح فى الموسم 2009/2008 فى عروات مختلفة ، واجرى التهجين بينها طبقا لجريفنج 1956 الموديل الثابت الطريقة الثانية. وفى الموسم 2010/2009 تم زراعة الاباء الستة وهجنها الخمسة عشرة

ويمكن تلخيص أهم النتائج كما يلى:

١ - اشارت النتائج أن التباين الراجع لكل من البيئتين عالى المعنوية لكل الصفات المدروسة مما يدل على الاختلاف بين البيئة المعرضة للتلوث (كفر الزيات) والبيئة الخالية منه (ايتاى البارود).

٢ -اوضحت النتائج ان التباين الراجع للاباء مقابل الهجن على أن متوسط قوة الهجين لكل الهجن كان معنويا او عالى المعنوية لكل الصفات فى التجربتين وكذلك التحليل المشترك ؛ فيما عدا محصول الحبوب تحت ظروف عدم التلوث ؛ وصفة عدد الحبوب /سنبلة تحت كلا البيئتين والتحليل المشترك مما يدل على ان متوسط قوة الهجين كان مرتفعا لكل الصفات عنه لتلك الصفات المستثناه.

٣ - أظهرت النتائج أن النسبة بين التباين الراجع للقدرة العامة الى التباين الراجع للقدرة الخاصة على الائتلاف اكبر من الواحد الصحيح لخمسة صفات هى: عدد الحبوب/سنبلة ، المحتوى المائى للورقة ، ومساحة ورقة العلم فى كلا التجربتين والتحليل المشترك ولصفة المواد الصلبة الكلية تحت ظروف التجربتين مما يدل على ان جزء كبير من الاختلافات الوراثية لهذه الصفات يرجع الى الفعل الجينى المضيف والمضيف X المضيف ؛ بينما باقى الصفات فقد كان الفعل الجينى الغير مضيف اكثر اهمية من الفعل الجينى المضيف.

7- كان أفضل الأباء قدرة عامة على الائتلاف هو الصنف سخا جميزة 9 لخمسة صفات هى عدد السنابل/نبات ، ووزن الالف حبة فى كلا التجربتين والتحليل المشترك. بينما كان الأباء سدس1 ، شام6 ، ويوجى2 ذو قدرة عامة عالية على الائتلاف لصفتين هما ارتفاع النبات و مساحة ورقة العلم ، عدد الحبوب/سنبلة و محصول الحبوب على التوالى فى كلا التجربتين والتحليل المشترك. ويمكن ادخال هذه الأباء فى برامج التربية التى تهدف لاستنباط اصناف مقاومة للتلوث.

٨ - اوضحت النتائج ان أفضل الهجن تحت ظروف التلوث وعدم التلوث و التحليل المشترك هى: (يوجى2 x جميزة9) حيث اظهر هذا الهجين قيما عالية للقدرة الخاصة على الائتلاف لصفات هى عدد السنابل/نبات و ارتفاع النبات. والهجين (يوجى 2 x ساحل 1) لصفات و ارتفاع النبات وعدد الحبوب/سنبلة. والهجين (سدس1 x ساحل1) لصفات ارتفاع النبات و المواد الصلبة الكلية و محتوى الكلوروفيل الكلى. والهجين (يوجى 3 x ساحل1) لصفات وهى عدد السنابل/نبات و ارتفاع النبات ومحصول الحبوب ووزن الالف حبة ومساحة ورقة العلم .

قام بتحكيم البحث

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Table (1): Observed mean squares from the analysis of variance for total soluble solids, total chlorophyll, relative water content, flag leaf area, flag leaf angle and plant height in both environment treatments as well as the combined data.

S.O.V.	df		Total soluble solids			Total Chlorophyll			Relative water content		
	S	Comb.	N	D	Comb.	N	D	Comb.	N	D	Comb.
Env.		1			52.20**			1,074.79**			530.64**
Rep x Env.	2	4	0.17	0.46*	0.31*	3.38	4.44	3.91	37.31**	5.63	21.47**
Genotypes (G)	20	20	12.64**	6.80**	10.40**	54.58**	36.75**	38.34**	320.66**	132.37**	228.82**
Parents (P)	5	5	15.16**	12.36**	5.46**	117.39**	67.05**	54.13**	300.72**	12.38	183.55**
Crosses (F1)	14	14	11.38**	4.94**	11.41**	34.10**	28.32**	33.69**	347.81**	177.41**	260.84**
P vs F1	1	1	17.67**	5.16**	20.96**	27.36*	3.19	24.61*	40.40**	101.80**	6.97
GxEnv.		20			9.05**			52.99**			224.21**
PxEnv.		5			22.06**			130.31**			129.55**
F1xEnv.		14			4.91**			28.74**			264.38**
p vsF1 x Env.		1			1.87**			5.94			135.22**
Error	40	80	0.10	0.11	0.11	4.78	5.41	5.09	5.17	6.46	5.81

S.O.V.	df		Flag leaf area			Flag leaf angle			Plant height		
	S	Comb.	N	D	Comb.	N	D	Comb.	N	D	Comb.
Env.		1			1,719.53**			37.24*			482.84**
Rep x Env.	2	4	0.40	3.73	2.07	5.78	4.75	5.26	0.41	0.39	0.40
Genotypes (G)	20	20	191.17**	237.21**	408.5**	143.37**	108.96**	161.74**	37.77**	68.50**	96.01**
Parents (P)	5	5	202.63**	321.12**	510.30**	74.82**	70.95**	78.29**	13.92**	50.09**	37.21**
Crosses (F1)	14	14	197.40**	196.34**	376.10**	176.49**	117.02**	200.26**	32.06**	57.06**	84.27**
P vs F1	1	1	46.62**	389.85**	353.04**	22.48	186.20**	39.64*	236.93**	320.64**	554.41**
GxEnv.		20			19.88**			90.59**			10.25**
PxEnv.		5			13.45*			67.48**			26.79**
F1xEnv.		14			17.64**			93.24**			4.85**
p vsF1 x Env.		1			83.42**			169.03**			3.16
Error	40	80	5.03	4.34	4.69	10.95	4.90	7.93	2.42	1.50	1.96

***and ** significant at 0.05 and 0.01 respectively**

Table (2): Observed mean squares from the analysis of variance for No of spikes/plant , No of grains/spike, 1000-grain weight and grain yield/plant in both environment treatments as well as the combined data.

S.O.V.	df		No of spikes/plant			No fo grains/spike		
	S	Comb.	N	D	Comb.	N	D	Comb.
Env.		1			131.18**			1,823.01**
Rep x Env.	2	4	9.16	1.65	5.41	22.54	6.02	14.28
Genotypes (G)	20	20	25.63**	32.47**	55.25**	189.03**	234.18**	406.46**
Parents (P)	5	5	13.98	21.94**	34.97**	262.16**	276.37**	530.34**
Crosses (F1)	14	14	29.07**	37.05**	62.47**	175.89**	235.63**	391.21**
P vs F1	1	1	35.60*	20.97**	55.60**	7.27	2.92	0.49
GxEnv.		20			2.84			16.75**
PxEnv.		5			0.95			8.19
F1xEnv.		14			3.65			20.31**
p vsF1 x Env.		1			0.96			9.70
Error	40	80	6.03	1.18	3.60	9.48	6.09	7.78

S.O.V.	df		1000-grain weight			Grain yield/plant		
	S	Comb.	N	D	Comb.	N	D	Comb.
Env.		1			1,596.95**			1154.73**
Rep x Env.	2	4	0.90	21.02**	10.96*	3.88	0.66	2.27
Genotypes (G)	20	20	37.31**	91.94**	110.96**	221.61**	189.45**	393.24**
Parents (P)	5	5	17.67**	26.00**	38.04**	70.39**	82.21**	128.5**
Crosses (F1)	14	14	33.26**	103.54**	112.86**	206.15**	203.05**	397.02**
P vs F1	1	1	192.22**	259.19**	448.91**	1194.18**	535.21**	1664.14**
GxEnv.		20			18.28**			17.81
PxEnv.		5			5.63			24.11
F1xEnv.		14			23.93**			12.18
p vsF1 x Env.		1			2.50			65.23*
Error	40	80	3.43	2.79	3.11	14.32	12.41	13.37

***and ** significant at 0.05 and 0.01 respectively**

Table (5): The genotype mean performance for no. of spikes/plant, no. of grains/spike, 1000-grain weight and grain yield/plant in both environments as well as the combined data.

Genotype	No of spikes/plant			No of grains/spike			1000 grain weight (g)			Grain yield/plant (g)		
	N	S	Comb	N	S	Comb	N	S	Comb	N	S	Comb
sham 6	18.67	16.61	17.64	65.33	59.01	62.17	44.38	35.73	40.06	37.50	33.13	35.32
Ug2	18.33	17.19	17.76	82.33	72.97	77.65	41.27	36.80	39.04	45.00	39.54	42.27
Sids 1	19.16	16.18	18.54	70.20	62.98	66.59	42.87	35.93	39.40	37.13	41.09	39.11
Ug3	21.10	19.52	20.31	73.90	61.23	67.56	40.28	32.55	36.42	41.62	37.21	39.41
Gem 9	22.94	21.54	22.26	91.33	84.50	87.92	46.99	39.67	43.33	49.17	44.57	46.87
Sahel 1	16.91	13.66	15.29	72.86	64.37	68.61	41.88	31.58	36.73	38.16	30.36	34.26
Sham 6 x Ug2	21.83	19.63	20.73	82.67	74.28	78.48	48.10	33.27	40.68	45.08	35.53	40.31
Sham 6 x sids1	21.56	18.32	19.94	76.53	71.21	73.87	42.78	32.33	37.56	51.33	42.44	46.89
Sham 6 x Ug3	16.92	14.51	15.71	73.93	69.37	71.65	47.12	37.70	42.41	47.67	39.67	43.67
Sham 6 x Gem 9	22.17	21.06	21.61	77.25	73.60	75.43	46.98	35.85	41.42	49.17	43.73	46.45
Sham 6 x Sahel 1	20.67	18.47	19.57	75.58	74.27	74.93	43.95	37.90	40.93	47.92	47.21	47.56
Ug2 x Sids 1	21.66	18.08	19.88	75.89	64.90	70.39	48.04	43.23	45.64	60.67	54.61	57.64
Ug2 x Ug3	16.92	11.15	14.03	78.50	70.55	74.52	44.88	32.33	38.61	48.42	41.11	44.76
Ug2 x Gem 9	25.47	24.50	24.56	74.44	72.05	73.25	50.60	47.10	48.85	69.42	58.41	63.91
Ug2 X Sahel1	23.38	21.02	22.20	94.76	83.72	89.24	44.24	42.47	43.35	61.76	56.48	59.12
Sids 1 x Ug3	18.08	15.59	15.99	62.25	50.03	56.14	51.71	46.43	49.07	44.75	34.26	39.51
Sids 1 x Gem 9	17.94	11.65	14.30	67.03	55.17	61.10	48.67	46.33	47.50	41.81	32.72	37.26
Sids 1 x Sahel 1	22.00	17.85	19.93	77.58	68.22	72.90	41.94	33.33	37.64	56.17	50.12	53.15
Ug3 x Gem 9	22.08	19.42	18.75	64.53	53.83	59.18	52.41	47.83	50.12	44.72	38.39	41.56
Ug3 x Sahel 1	22.50	21.30	22.0	75.44	71.06	73.25	48.21	45.29	46.75	54.56	49.27	51.91
Gem 9 x Sahel 1	20.56	19.47	20.01	72.22	67.49	69.86	42.52	36.62	39.57	40.22	37.55	38.89
Mean	20.52	17.94	19.10	75.46	67.85	71.65	45.71	38.59	42.15	48.20	42.26	45.23
L.S.D. 5 %	4.05	1.82	3.08	9.92	4.13	7.47	3.05	2.80	2.86	11.33	5.90	8.87
L.S.D. 1 %	5.42	2.40	4.08	13.28	5.45	9.87	4.09	3.69	3.78	15.16	7.78	11.72

N= normal , S= stress and Comb= Combined

Table (6): Mean squares from general and specific combining ability from diallel cross analysis for total soluble solids, total chlorophyll , relative water content, flag leaf area, flag leaf angle and plant height in both environments as well as the combined data.

S.O.V.	df		Total soluble solids			Total Chlorophyll			Relative water content		
	S	Comb	N	S	Comb.	N	S	Comb.	N	S	Comb.
GCA	5	5	4.29**	4.67**	1.77**	23.25**	6.79**	6.82**	229.25**	53.63**	174.40**
SCA	15	15	4.19**	1.47**	4.03**	16.51**	14.07**	14.77**	66.10**	40.95**	43.57**
GCA x Env.		5			7.19**			23.22**			108.49**
SCA x Env.		15			1.62**			15.81**			63.49**
Error	40	80	0.03	0.04	0.04	1.59	1.80	1.70	1.72	2.15	1.94
GCA/SCA			1.02	3.18	0.44	1.41	0.48	0.46	3.47	1.31	4.00
GCAxEnv./ GCA					4.07			3.40			0.62
SCAxEnv./ SCA					0.40			1.07			1.46
GCAxEnv/ SCAxEnv.					4.43			1.47			1.71

S.O.V.	df		Flag leaf area			Flag leaf angle			Plant height		
	S	Comb	N	S	Comb.	N	S	Comb.	N	S	Comb.
GCA	5	5	78.12**	89.05**	160.32**	20.54**	16.42**	8.69**	4.27**	32.19**	28.01**
SCA	15	15	58.92**	75.74**	128.12**	56.87**	42.95**	68.99**	15.36**	19.71**	33.34**
GCA x Env.		5			6.85**			28.27**			8.45**
SCA x Env.		15			6.55**			30.84**			1.74**
Error	40	80	1.68	0.00	0.84	3.65	1.63	2.64	0.81	0.50	0.65
GCA/SCA			1.33	1.18	1.25	0.36	0.38	0.13	0.28	1.63	0.84
GCAxEnv./ GCA					0.04			3.25			0.30
SCAxEnv./ SCA					0.05			0.45			0.05
GCAxEnv/ SCAxEnv.					1.05			0.92			4.86

N= normal , S= stress and Comb= Combined.

Table (7): Mean squares from general and specific combining ability from diallel cross analysis for for no of spikes/plant , no fo grains/spike, 1000-grain weight and grain yield/plant in both environments as well as the combined data.

S.O.V	df		No of spikes/plant			No of grains/spike		
	S	Comb	N	S	Comb.	N	S	Comb.
GCA	5	5	7.26**	8.07**	14.60**	92.63**	123.63**	207.88**
SCA	15	15	8.97**	11.74**	19.69**	53.13**	62.87**	111.36**
GCA x Env.		5			0.72			8.38*
SCA x Env.		15			1.02			4.65
Error	40	80	2.01	0.39	1.20	3.16	2.03	2.59
GCA/SCA			0.81	0.69	0.74	1.74	1.97	1.87
GCAxEnv./ GCA					0.05			0.04
SCAxEnv./ SCA					0.05			0.04
GCAxEnv/ SCAxEnv.					0.71			1.80

S.O.V.	df		1000-grain weight			Grain yield/plant		
	S	Comb.	N	S	Comb.	N	S	Comb.
GCA	5	5	12.47**	28.97**	35.41**	54.96*	42.52**	94.79**
SCA	15	15	12.43**	31.20**	37.51**	77.35**	70.02**	140.55**
GCA x Env.		5			6.03**			2.69
SCA x Env.		15			6.11**			6.83
Error	40	80	1.14	0.93	1.04	15.72	4.14	9.93
GCA/SCA			1.00	0.93	0.94	0.71	0.61	0.67
GCAxEnv./ GCA					0.17			0.03
SCAxEnv./ SCA					0.16			0.05
GCAxEnv/ SCAxEnv.					0.99			0.39

N= normal , S= stress and Comb= Combined.

Table (10): Estimates of specific combining ability effects of crosses for total soluble solids, total chlorophyll and relative water content in both environments as well as the combined data.

Cross	Total soluble solids			Total Chlorophyl			Relative water content		
	N	S	Comb	N	S	Comb	N	S	Comb
Sham 6 x Ug2	-2.43**	1.74**	-0.35**	-3.35**	-1.30	-2.32**	8.21**	3.02*	5.61**
Sham 6 x sids1	1.59**	0.96**	1.27**	-0.23	-0.54	- 0.38	-1.88	-1.48	-1.68
Sham 6 x Ug3	-1.52**	-1.48**	-1.50**	1.99	0.22	1.11	9.71**	-17.01**	-3.65**
Sham 6 x Gem 9	2.45**	1.83**	2.14**	-0.17	0.80	0.32	-12.38**	-4.59**	-8.49**
Sham 6 x Sahel 1	-0.97**	-0.87**	-0.92**	3.65**	4.04**	3.85**	-4.21**	4.36**	0.07
Ug2 x Sids 1	1.75**	0.48**	1.12**	2.64*	- 1.22	0.71	-0.86	- 2.43	-1.64
Ug2 x Ug3	0.34*	0.51**	0.43**	-7.41**	0.87	-3.27**	-1.53	4.91**	1.69
Ug2 x Gem 9	-2.28**	-1.08**	-1.68**	-3.00*	-0.81	-1.91*	7.42**	0.09	3.75**
Ug2 X Sahel1	2.56**	1.22**	1.89**	6.62**	0.13	3.37**	-4.99**	-0.54	-2.76**
Sids 1 x Ug3	1.59**	-0.57**	0.51**	-0.56	-1.10	- 0.83	-8.62**	5.50**	-1.56
Sids 1 x Gem 9	1.37**	0.44*	0.90**	2.65*	-4.88**	-1.12	3.17**	2.62	2.90**
Sids 1 x Sahel 1	2.01**	1.04**	1.53**	3.67**	3.25**	3.46**	11.81**	-3.85**	3.98**
Ug3 x Gem 9	0.86**	-0.67**	0.09	2.47*	-1.06	0.71	-11.43**	0.83	- 5.30
Ug3 x Sahel 1	-0.90**	- 0.03	-0.47**	-3.21**	7.75**	2.27**	2.94*	-7.54**	-2.30*
Gem 9 x Sahel 1	-1.39**	-0.79**	-1.09**	0.50	-4.04**	-1.77*	10.23**	4.05**	7.14**
LSD Sij 5%	0.33	0.34	0.23	2.26	2.41	1.63	2.35	2.63	1.74
LSD Sij 1%	0.44	0.46	0.31	3.03	3.22	2.16	3.15	3.52	2.30
LSD sij-sik 5%	0.49	0.51	0.35	3.37	3.59	2.43	3.51	3.92	2.59
LSD sij-sik 1%	0.66	0.68	0.46	4.51	4.80	3.22	4.70	5.25	3.44
LSD sij-skl 5%	0.45	0.47	0.13	3.12	3.32	0.92	3.25	3.63	0.98
LSD sij-sik 1%	0.61	0.63	0.17	4.18	4.45	1.22	4.35	4.86	1.30

N= normal , S= stress and Comb= Combined.

Table (11): Estimates of specific combining ability effects of crosses parents for flag leaf area, flag leaf angle and plant height in both environments as well as the combined data.

Cross	Flag leaf area			Flag leaf angle			Plant height		
	N	S	Comb	N	S	Comb	N	S	Comb
Sham 6 x Ug2	-6.64**	-4.74*	-2.85**	-2.15	6.09**	1.97	-7.83**	-5.50**	-6.67**
Sham 6 x sids1	4.64**	1.90**	3.27**	-6.02**	-7.48**	-6.75**	0.26	- 0.44	-0.09
Sham 6 x Ug3	-12.81**	2.19**	-5.31**	-2.77	6.94**	2.08*	2.98**	2.04**	2.51**
Sham 6 x Gem 9	4.95**	-2.31**	1.32*	-14.27**	-13.27**	-13.77**	2.21**	0.49	1.35**
Sham 6 x Sahel 1	-0.19	-2.60**	-1.39*	13.79**	4.34**	9.06**	2.04*	3.35**	2.69**
Ug2 x Sids 1	-2.94*	-2.43**	-2.69**	-5.54**	2.42*	-1.56	0.49	0.18	0.33
Ug2 x Ug3	-3.02*	-1.81**	-2.42**	-0.79	-11.00**	-5.89**	0.08	1.29*	0.69
Ug2 x Gem 9	3.07*	0.36	1.71**	6.21**	-7.04**	-0.42	5.59**	9.01**	7.30**
Ug2 X Sahel1	5.07**	-2.93**	1.07	1.27	-0.77	0.25	3.50**	3.34**	3.42**
Sids 1 x Ug3	13.49**	-2.51**	5.48**	4.83**	0.77	2.80**	2.21**	2.64**	2.43**
Sids 1 x Gem 9	-9.99**	-1.68**	-5.83**	14.33**	5.90**	10.12**	-0.02	-0.22	- 0.12
Sids 1 x Sahel 1	-10.63**	4.36**	-3.14**	1.90	-4.33**	-1.22	3.75**	5.35**	4.55**
Ug3 x Gem 9	-3.90**	1.27**	-1.31*	-0.08	0.32	0.12	0.12	-3.01**	-1.44**
Ug3 x Sahel 1	10.51**	3.32**	6.91**	- 2.02	-0.41	-1.22	1.73*	2.07**	1.90**
Gem 9 x Sahel 1	0.23	-1.18**	-0.48	-3.02	1.21	-0.90	1.27	0.82	1.05*
LSD Sij 5%	2.32	0.85	1.22	3.42	2.29	2.03	1.61	1.27	1.01
LSD Sij 1%	3.10	1.14	1.61	4.58	3.06	2.69	2.15	1.69	1.34
LSD sij-sik 5%	3.46	1.27	1.82	5.11	3.42	3.03	2.40	1.89	1.50
LSD sij-sik 1%	4.63	1.70	2.41	6.83	4.57	4.01	3.21	2.53	1.99
LSD sij-skl 5%	3.21	1.17	0.69	4.73	3.16	1.14	2.22	1.75	0.57
LSD sij-sik 1%	4.29	1.57	0.91	6.33	4.23	1.52	2.97	2.34	0.75

N= normal , S= stress and Comb= Combined.

Table (12): Estimates of specific combining ability effects of crosses for no. of spikes/plant, no. of grains/spike, 1000-grain weight and grain yield/plant in both environments as well as the combined data..

Cross	No of spikes/plant			No of grains/spike			1000-grain wieght			Grain yield/plant		
	N	S	Comb	N	S	Comb	N	S	Comb	N	S	Comb
Sham 6 x Ug2	1.06	1.49*	1.28	3.31*	1.15	2.23	2.87**	-2.86**	0.002	-5.12*	-7.78**	-6.45**
Sham 6 x Sids1	2.08	0.59	1.34	6.09**	7.57**	6.83**	-2.51*	-3.98**	-3.25**	6.63**	2.73	4.68*
Sham 6 x Ug3	-2.45	-2.68**	-2.57**	3.14	5.50**	4.32**	1.08	1.24	1.16	3.96*	2.37	3.17
Sham 6 x Gem 9	0.37	0.96	0.67	2.00	3.00*	2.50	-0.34	-2.91**	-1.63*	2.92	3.57	3.24
Sham 6 x Sahel 1	0.77	2.02**	1.40*	-0.07	3.37*	1.65	0.44	3.43**	1.94**	2.22	6.88**	4.55*
Ug2 x Sids 1	1.02	0.01	0.52	-1.34	-2.58*	-1.96	2.66**	3.98**	3.32**	8.57**	8.61**	8.60**
Ug2 x Ug3	-3.63**	-6.38**	-5.01**	0.92	2.84*	1.88	-1.25	-7.07**	-4.16**	- 2.68	-2.49	- 2.63
Ug2 x Gem 9	6.50**	5.23**	5.86**	-7.60**	-2.39	-4.99**	3.19**	5.40**	4.29**	15.77**	11.96**	13.87**
Ug2 X Sahel1	2.30	2.22**	2.26**	12.32**	8.99**	10.65**	0.64	5.06**	2.85**	8.67**	9.85**	9.36**
Sids 1 x Ug3	-1.17	-1.22*	-1.20	-6.43**	-8.18**	-7.30**	5.52**	6.84**	6.18**	-0.85	-5.73**	-3.18
Sids 1 x Gem 9	-3.74**	-3.37**	-3.55**	-6.11**	-9.77**	-7.94**	1.19	4.45**	2.82**	-6.33**	-10.12**	-8.22**
Sids 1 x Sahel 1	2.22	3.47**	2.84**	4.05*	2.98*	3.52*	-1.72	-4.26**	-2.99**	10.91**	7.11**	9.01**
Ug3 x Gem 9	0.51	-0.06	0.23	-8.95**	-11.34**	-10.15**	4.18**	5.80**	4.99**	- 2.50	-2.05	-2.27
Ug3 x Sahel 1	2.83*	4.46**	3.64**	1.57	5.60**	3.58*	3.80**	7.55**	5.67**	7.98**	8.65**	8.31**
Gem 9 x Sahel 1	-1.54	-1.27*	-1.41*	- 6.12**	-4.70**	-5.41**	-3.18**	-3.42**	-3.30**	-8.91**	-5.92**	-7.41**
LSD Sij 5%	2.54	1.12	1.37	3.18	2.55	2.87	1.91	1.73	1.27	3.91	3.64	3.77
LSD Sij 1%	3.40	1.50	1.81	4.26	3.41	4.39	2.56	2.31	1.68	5.24	4.88	5.06
LSD sij-sik 5%	3.79	1.68	2.04	4.75	3.81	4.94	2.86	2.58	1.89	5.84	5.44	6.64
LSD sij-sik 1%	5.07	2.24	2.71	6.36	5.10	6.73	3.82	3.45	2.51	7.82	7.28	7.55
LSD sij-skl 5%	3.51	1.55	0.77	4.40	3.53	3.96	2.65	2.39	0.72	5.41	5.04	5.22
LSD sij-sik 1%	4.69	2.08	1.02	5.89	4.72	5.30	3.54	3.19	0.95	7.24	6.74	6.99

N= normal , S= stress and Comb= Combined.

Table (13): Percentage of heterosis over mid-parent for total soluble solids, total chlorophyll, relative water content, flag leaf area, flag leaf angle and plant height in both environments as well as the combined data.

Cross	Total soluble solids			Total Chlorophyll			Relative water content		
	N	S	Comb	N	S	Comb	N	S	Comb
Sham 6 x Ug2	-27.59**	39.30**	1.93	-8.70*	2.13-	-5.28	13.47**	0.43	6.67**
Sham 6 x Sids1	43.58**	26.32**	34.95**	5.76	-1.66	1.58	-1.32	-6.55*	3.88-
Sham 6 x Ug3	-19.08**	-16.19**	-17.58**	1.70	5.86	3.78	9.97**	-30.50**	-11.04**
Sham 6 x Gem 9	25.65**	29.87**	27.52**	2.29	-1.68	0.04	-16.46**	-9.56**	-13.00**
Sham 6 x Sahel 1	-8.67**	- 2.10	-5.60	17.51**	16.07**	16.72**	-0.53	0.54-	-0.54
Ug2 x Sids 1	59.48**	19.35**	35.82**	7.92	-5.58	0.65	2.87	-1.33	0.67
Ug2 x Ug3	5.83	6.31*	6.11*	-19.92**	4.17	-8.38*	2.69-	3.60	0.81
Ug2 x Gem 9	-25.05**	- 4.81	-14.45**	-7.76	-7.25	-7.48*	12.51**	2.59	7.18**
Ug2 X Sahel1	33.73**	20.73**	26.68**	18.53**	4.80	11.38**	1.54	-0.19	0.58
Sids 1 x Ug3	69.75**	- 5.07	19.79**	- 0.45	1.14-	-0.80	-13.79**	2.89	-5.11
Sids 1 x Gem 9	57.51**	10.23**	29.59**	13.60**	-15.53**	- 3.42	4.22	4.32	4.27
Sids 1 x Sahel 1	65.43**	17.10**	36.20**	22.15**	9.88*	15.23**	22.10**	-5.76*	7.71**
Ug3 x Gem 9	16.74**	-12.23**	- 0.56	3.08	-3.80	- 0.51	-21.10**	-2.24	-11.01**
Ug3 x Sahel 1	-6.46	-3.85	-4.87	-4.64	27.33**	11.30**	7.19*	-14.87**	-4.94
Gem 9 x Sahel 1	-9.59**	-7.08*	-8.23**	10.06*	-7.35	0.19	18.76**	4.85	11.39**

Crosses	Flag leaf area			Flag leaf angle			Plant height		
	N	S	Comb	N	S	Comb	N	S	Comb
Sham 6 x Ug2	-18.76**	-11.11	-18.18**	-19.03	8.65	-4.42	-7.31**	-3.68**	- 5.58**
Sham 6 x Sids1	1.25	47.83**	3.98	-23.35*	-34.62**	-28.79**	1.81	1.43	1.62
Sham 6 x Ug3	-28.49**	130.77**	-21.88**	-22.15*	19.27**	-1.09	4.62**	3.35**	3.99**
Sham 6 x Gem 9	1.83	-65.52**	-3.52	-56.65**	-59.77**	-58.21**	4.40**	2.30*	3.37**
Sham 6 x Sahel 1	- 2.67	-63.64**	-6.53	54.40**	14.58	35.13**	4.97**	7.25**	6.09**
Ug2 x Sids 1	-9.55**	-92.31**	-15.43**	-15.02	-2.70	-7.93	2.60*	4.42**	3.47**
Ug2 x Ug3	- 6.81	-100**	-12.01*	-5.88	-44.94**	-29.38**	2.32	5.01**	3.61**
Ug2 x Gem 9	1.07	-37.5**	-2.59	28.42*	-37.93**	-10.56	8.43**	13.98**	11.10**
Ug2 X Sahel1	10.52**	-100**	1.93	19.51	-11.56	1.35	7.06**	9.96**	8.45**
Sids 1 x Ug3	25.38**	-100**	20.74**	32.56*	-2.75	12.82	5.64**	5.90**	5.77**
Sids 1 x Gem 9	-22.03**	-57.14**	-24.65**	72.92**	6.90	36.79**	3.96**	3.52**	3.74**
Sids 1 x Sahel 1	-19.08**	128.57**	-10.44*	34.94*	-20.83**	5.03	8.48**	11.25**	9.85**
Ug3 x Gem 9	-9.15*	33.33	-6.57	2.22	-12.40*	-6.16	4.27**	0.03	2.17
Ug3 x Sahel 1	28.66**	227.27**	36.48**	3.90	-4.95	-1.12	6.65**	7.32**	6.98**
Gem 9 x Sahel 1	0.14	-40.74**	-3.19	3.45	-7.41	-2.56	6.77**	6.59**	6.68**

N= normal , S= stress and Comb= Combined.

Table (14): Percentage of heterosis over mid-parent for No. of spikes/plant, No. of grains/spike, 1000-grain weight and grain yield in both environments as well as the combined data.

Cross	No of spikes/plant			No of grains/spike			1000-grain weight			Grain yield/plant		
	N	S	Comb	N	S	Comb	N	S	Comb	N	S	Comb
Sham 6 x Ug2	18.02	16.19**	17.14	11.96**	12.57**	12.25**	12.32**	-8.28*	2.87	9.29	- 2.21	3.91
Sham 6 x Sids1	13.97	6.14	10.23	12.94**	16.76**	14.75**	-1.92	-9.76*	-5.46	37.57*	14.36	26.00**
Sham 6 x Ug3	14.92-	-19.69**	-17.19*	6.20	15.39**	10.46**	11.33**	10.42*	10.92**	20.50*	12.80	16.88*
Sham 6 x Gem 9	6.54	10.11*	8.25	1.38-	2.57	0.51	2.85	- 4.91	-0.66	13.46	12.56	13.04
Sham 6 x Sahel 1	16.18	35.26**	24.95**	9.39*	20.39**	14.58**	1.91	12.61**	6.60	26.67**	48.72**	36.73**
Ug2 x Sids 1	15.63	3.01	9.53	0.50-	-4.52	-2.39	14.21**	18.88**	16.37**	47.74**	35.46**	41.66**
Ug2 x Ug3	-14.20	-39.25**	-26.28**	0.49	5.14	2.64	10.08**	- 6.76	2.34	11.80	7.13	9.60
Ug2 x Gem 9	42.80**	32.16**	37.64**	-14.27**	-8.49**	-11.52**	14.67**	23.17**	18.62**	47.43**	38.89**	43.40**
Ug2 X Sahel1	32.66**	36.25**	34.34**	22.12**	21.92**	22.03**	6.40	24.21**	14.44**	48.53**	61.61**	54.50**
Sids 1 x Ug3	-10.17	-15.08**	-12.54	-13.60**	-19.44**	-16.30**	24.38**	35.60**	29.44**	13.66	12.49-	0.62
Sids 1 x Gem 9	-14.76	- 15.83	-15.28*	-17.01**	-25.18**	-20.91**	8.32*	22.57**	14.83**	- 3.11	-23.59**	-13.31
Sids 1 x Sahel 1	21.98	38.38**	29.64**	8.47*	7.15*	7.84*	-1.02	-1.24	-1.12	55.42**	40.31**	44.88**
Ug3 x Gem 9	0.28	-5.61	-2.56	-21.89**	-26.12**	-23.87**	20.11**	32.45**	25.70**	1.47-	- 6.10	-3.67
Ug3 x Sahel 1	18.39	34.42**	25.86**	2.82	13.16**	7.59*	17.35**	41.24**	27.83**	36.78**	45.84**	40.93**
Gem 9 x Sahel 1	3.15	10.33*	6.52	-12.03**	-9.32**	-10.74**	4.32-	2.78	1.16-	-7.88	0.24	-4.13