Egypt. J. Plant Breed. 15 (3): 85 – 107 (2011)

GENETIC PARAMETERS OF DIALLEL CROSSES IN BREAD WHEAT UNDER NORMAL IRRIGATION AND DROUGHT CONDITIONS

S.H. Saleh

Dept. of Agron., Fac. of Agric., Ain Shams Univ., Cairo, Egypt

ABSTRACT

Seven parents of bread wheat were used in a diallel cross without reciprocals in 2008/2009 season. In 2009/ 2010 season, the 7 parents and their 21 F_1 crosses were grown to study heterosis, combining ability and nature of gene action for ten traits under two different water regimes, i.e. normal irrigation (plants gave 5 irrigations during growth season) and water stress (plants gave 3 irrigations where the 2^{nd} and 4^{th} irrigations were prevented during vegetative and anthesis stages, respectively). A field experiment was devoted for each irrigation treatment and laid out in a randomized complete blocks design with three replicates. Mean squares due to parents vs. crosses (average heterosis) were significant for all studied traits under both irrigation treatments as well as their combined data except for spike length and no..of spikelets/ spike under both water regimes, no. of spikes/ plant and grain yield/ plant under normal irrigation and 1000-kernel weight under normal irrigation and combined data. The variance due to interaction of parents vs. crosses with irrigation regimes was significant for all studied traits except for spike length, no. of spikelets/ spike and no. of spikes/ plant. The mean squares due to general (GCA) and specific (SCA) combining ability were significant for all studied traits under each treatment and combined data. The ratios of GCA/SCA variances were less than unity under both water regimes and combined data for all studied traits except spike length and no. of spikelets/ spike, indicating that the main genetic variation for these traits was due to non-additive gene action. The two crosses; Giza 168 (P_1) x Sakha-94 (P_3) and IB18 (P_6) x Maryout 5 (P_7) was identified as promising for wheat breeding for improving yielding ability under target environments because the parental cultivars and crosses possessed the highest general and specific combining ability effects for grain yield and its contributors. The high expression of heterosis for the two crosses also reflected that the genetic composition of the parents was different with respect to favorable additive genes. All traits were under the control of both additive and non-additive gene effects under the two irrigation regimes. Besides, the dominance gene effects played a major role in the inheritance of most traits. Overdominance and dominant genes were exhibited in most traits under both irrigation regimes. The narrow sense heritability estimates in narrow sense were relatively high to moderate for most traits giving values ranging from 33.74% for plant height to 83.75% for spike length under drought conditions.

Key words: ***Wheat, Triticum aestivum, Water regimes, Drought tolerance, Heterosis, General and specific combining ability, Types of gene action, Heritability***

INTRODUCTION

Increasing wheat production to decrease national gab between production and consumption could be achieved through increasing the production per unit area, via improving agronomic management practices as well as the genetic potentiality of cultivars. Irrigation is one of the most important limiting factors in wheat production. For starting a breeding programme to improve any crop variety, the breeders need to know the type of gene action and genetic system controlling the inheritance of the interest characters. Therefore, many genetic models were introduced to estimate the different genetic parameters such as heterosis, combining ability and nature of gene action. Abd El-Aty (2000), Koumber and Esmail (2005), Salama (2007) and El-Hosary *et al* (2009) studied heterosis, combining ability, gene action and other genetic attributes that controlled yield and yield contributing characters under normal irrigation and drought conditions.

The investigation aimed to: 1- estimate better parent heterosis under the two water regimes, 2- evaluate the general (GCA) and specific (SCA) combining ability and their interactions with irrigation treatments and 3- to get some information on the nature of genetic system controlling yield and yield contributing characters and the importance which should be given to the wheat studied materials in a breeding programme.

MATERIALS AND METHODS

The field work of this study was conducted at the Experimental Farm of the Faculty of Agriculture, Ain Shams University, at Shalakan, Kalubia Governorate, Egypt. Seven different bread wheat genotypes representing a wide rang of genetic variability were used during the two successive growing seasons (2008/2009 and 2009/2010). Name and pedigree of the seven parental genotypes are presented in Table (1).

Table 1. Names, pedigree and / or selection history of the seven bread wheat parents used in the study.

Name		Pedigree and / or selection history
Giza 168	**(P_1)**	MRL/Buc//Seri CM93046-8M-oY-oM-2Y-oB
Cham 6	**(P_2)**	CM39992-8M-7Y-OM-OAPMex/syr/orgin
Line-1	**(P_3)**	Giza 157 × Bow "S"//YD "S"/ZZ "S"
Line-2	**(P_4)**	MD689/B/Chere "S" × KvZ//Con/Pj 62
Sakha-94	**(P_5)**	OPATA / RAYON // KAUZ
IB18	**(P_6)**	ICW88-040b-OL-2AP-OL-OAP
Maryout 5	**(P_7)**	Improved Cheek

In 2008/2009 season, all diallel crosses without reciprocals, were made among seven parents to produce 21 hybrids. In 2009/2010 season, the

parents and their respective F_1 crosses were grown under two different water regimes, i.e. normal irrigation (plants gave 5 irrigations during growth season) and water stress (plants gave 3 irrigations where the 2^{nd} and 4^{th} irrigations were prevented during vegetative and anthesis stages, respectively). A field experiment was devoted for each irrigation treatment and each experiment was designed in a randomized complete blocks with three replications. Each parent and hybrid was sown in three rows in each replicate and row was 3 m long. Plants spaced 15 cm within row and the rows were 25 cm apart and one plant left per hill. Sowing date was on November 17^{th} and the preceding summer crop was maize. The other cultural practices were followed as recommended for wheat production in the region. Data were collected on ten random competitive plants of each parent and F_1 hybrid from each replicate to determine number of days to heading, flag leaf area (cm^2), relative water content % , plant height (cm), spike length (cm), number of spikes/ plant, number of spikelets/ spike, number of kernels/ spike, 1000-kernel weight (g) and grain yield/ plant(g)
Heterobeltiosis was estimated according to Mather and Jinks (1982) as follows:

Heterobeltiosis (heterosis over the better parent (BP) = ($\bar{F}_1$ - $\bar{BP}$/ $\bar{BP}$) x 100. The variation among parents and F_1 crosses was partitioned into general and specific combining ability as illustrated by Griffing (1956), method (2), model (1). The relative importance of GCA to SCA was expressed as explained by Singh and Chaudhary (1995). Also, type of gene action, genetic ratios and heritability were calculated as developed by Hayman (1954).

RESULTS AND DISCUSSION

Heterosis

The analysis of variance for each normal and drought conditions as well as for the combined data for all studied characters are presented in Table (2). Mean squares due to irrigation, genotypes, parents and crosses were significant for all the studied characters under the two irrigation regimes as well as for the combined data. The mean squares, due to the interaction of genotypes, parents and crosses with the two irrigation regimes were significant for days to heading, flag leaf area, relative water content, number of kernels/ spike, 1000-kernel weight and grain yield/ plant (except for parents x irrigation), indicating inconsistent responses of these populations from normal irrigation to drought conditions. Mean square due to parents vs. crosses (average heterosis) were significant for all studied characters under both irrigation treatments as well as their combined data except for spike length and no. of spikelets/ spike under both experiments, no. of spikes/ plant and grain yield/ plant under normal irrigation and 1000-kernel weight under normal irrigation and combined data. The variance due to interaction of parents *vs* crosses with irrigation regimes was significant for all studied characters except for spike length, no. of spikelets/ spike and no. of spikes/ plant. It could be concluded that the test of potential parents for the expression of heterosis would be necessarily conducted across a number of environmental conditions. These findings are in agreement with those of Hendawy (1994), Awaad (2002), El-Borhamy (2005), Dawwam *et al* 2007 and El-Hosary *et al* (2009).

Heterosis expressed as the percentage deviation of the F_1 performance from its better parent for all studied traits under the two irrigation treatments are presented in Table (3). High positive percentages of heterosis would be of interest in most traits under investigation, however for days to heading, high negative values would be useful from the breeders point of view. For days to heading four and six out of the 21 crosses exhibited negative significant heterosis ranging from -2.53% (P_2 x P_5) to -4.35% (P_2 x P_4) and from -2.81% (P_3 x P_6) to -7.44% (P_2 x P_4) under normal and drought conditions, respectively.

With respect to flag leaf area one cross P_1 x P_5 (8.53%) expressed significant positive heterotic effect under normal irrigation while, six out of the 21 crosses exhibited positive significant heterosis ranging from 9.79% (P_4 x P_7) to 39.94% (P_6 x P_7) under drought conditions. Regarding relative water content, two crosses (P_4 x P_7 andP_6 x P_7) expressed significant positive heterotic effects under normal irrigation while, five out of 21 crosses showed positive significant heterosis ranging from 14.63% (P_1 x P_7) to 63.52% (P_6 x P_7) under drought conditions. For plant height one cross P_1 x P_2 (9.00%) and two crosses (P_1 x P_2 and P_1 x P_3) out of the 21 crosses expressed significant positive heterotic effects under normal and drought conditions, respectively. Concerning spike length and no. of spikelets/ spike, non of the hybrids exhibited significant positive heterotic effect under both water regimes. For no. of spikes/ plant, one cross only P_6 x P_7 (16.86%) expressed significant positive heterotic effect under normal irrigation. Regarding the number of kernels/ spike, one cross P_1 x P_4 (16.28%) and two crosses (P_1 x P_5 and P_6 x P_7) out of the 21 crosses expressed significant positive heterotic effects under normal and drought conditions, respectively. With respect to 1000-kernel weight, one cross P_1 x P_5 (11.79%) and two crosses (P_1 x P_5 and P_1 x P_6) out of the 21 crosses exhibited significant positive heterotic effects under normal and drought conditions, respectively. Regarding grain yield/ plant, two crosses P_2 x P_7 (17.43%) and P_6 x P_7 (24.00%) showed positive significant heterosis under normal irrigation; while one cross P_6 x P_7 (24.25%) exhibited positive significant heterosis under drought condition.

Table 2. Mean squares of single and combined analysis of variance across the two irrigation regimes for the traits studied in bread wheat genotypes.

	D.f		Days to heading			Flag leaf area		
SOURCE	S	Comb.	I_1	I_2	Combined	I_1	I_2	Combined
Irrigation (I)		1			680.02*			3055.10**
Genotypes (G)	27	27	19.21**	28.36**	39.95**	109.23**	107.68**	163.29**
Parents (P)	6	6	32.41**	60.42**	86.08**	187.663**	51.87**	206.62**
Crosses (C)	20	20	14.34**	10.64**	18.21**	85.24**	129.59**	156.51**
P VS C	1	1	37.33**	190.32**	198.13**	118.62**	4.28**	38.92**
G X I		27			7.61**			53.62**
P X I		6			6.76**			32.87**
C X I		20			6.77**			58.33**
P VS C X I		1			29.53**			83.99**
GCA	6	6	48.49**	43.85**	86.33**	286.42**	196.06**	444.95**
SCA	21	21	10.84**	23.93**	26.70**	58.58**	82.40**	82.79**
GCA X I		6			6.01**			37.52**
SCA X I		21			8.07**			58.19**
Error	54	108	0.38	0.55	0.23	0.59	0.52	0.28
GCA/SCA			0.51	0.21	0.36	0.55	0.27	0.60
SOURCE			Relative water content			Plant height		
Irrigation (I)		1			5326.31**			1639.43*
Genotypes (G)	27	27	198.90**	135.55**	256.23**	47.56**	33.04**	75.01**
Parents (P)	6	6	270.75**	389.56**	606.36**	92.08**	77.60**	165.88**
Crosses (C)	20	20	179.49**	61.90**	163.73**	30.30**	20.04**	44.88**
P VS C	1	1	155.86**	84.40**	5.44**	125.54**	25.62**	132.27**
G X I		27			78.21**			5.59
P X I		6			53.95**			3.81
C X I		20			77.66**			5.47
P VS C X I		1			234.81**			18.88**
GCA	6	6	211.34**	137.75**	203.81**	85.58**	63.29**	144.29**
SCA	21	21	195.35**	134.91**	271.21**	36.69**	24.39**	55.21**
GCA X I		6			145.28**			4.59**
SCA X I		21			59.05**			5.88**
Error	54	108	0.02	0.3	0.08	3.13	1.34	1.12
GCA/SCA			0.12	0.11	0.08	0.27	0.30	0.29

Table 2. Cont.

	D.f		Spike length			No. of spikelets/spike		
SOURCE	**S**	**Comb.**	**I_1**	**I_2**	**Combined**	**I_1**	**I_2**	**Combined**
Irrigation (I)		1			16.16*			113.63**
Genotypes (G)	27	27	2.58**	2.44**	4.91**	2.77**	4.45**	6.48**
Parents (P)	6	6	5.38**	4.52**	9.74**	5.09**	5.13**	10.08**
Crosses (C)	20	20	1.86**	1.94**	3.69**	2.17**	4.40**	5.72**
P VS C	1	1	0.26	0.01	0.15	0.71	1.41	0.07
G X I		27			0.13			0.75
P X I		6			0.16			0.14
C X I		20			0.12			0.86
P VS C X I		1			0.12			2.06
GCA	6	6	10.33**	9.81**	20.01**	10.05**	14.65**	23.53**
SCA	21	21	0.37**	0.34**	0.58**	0.69**	1.54**	1.61**
GCA X I		6			0.13**			1.15**
SCA X I		21			0.13**			0.62**
Error	54	108	0.08	0.06	0.04	0.22	0.21	0.11
GCA/SCA			**3.93**	**3.87**	**4.11**	**2.32**	**1.21**	**1.73**
SOURCE				**No. of spikes/plant**			**No.of kernels/spike**	
Irrigation (I)		1			110.66*			668.28**
Genotypes (G)	27	27	2.70**	3.23**	5.30**	91.82**	57.53**	119.95**
Parents (P)	6	6	7.48**	7.03**	14.01**	33.14**	26.10**	32.22**
Crosses (C)	20	20	1.35*	1.69*	2.47**	95.75**	65.43**	131.96**
P VS C	1	1	1.11	11.15**	9.63**	365.28**	88.09**	406.06**
G X I		27			0.63			29.41**
P X I		6			0.49			27.02**
C X I		20			0.57			29.23**
P VS C X I		1			2.62			47.30**
GCA	6	6	7.63**	7.72**	13.95**	36.64**	67.83**	68.67**
SCA	21	21	1.30**	1.95**	2.84**	107.59**	54.60**	134.63**
GCA X I		6			1.39**			35.80**
SCA X I		21			0.41**			27.56**
Error	54	108	0.22	0.26	0.12	0.32	0.85	0.29
GCA/SCA			**0.76**	**0.49**	**0.56**	**0.04**	**0.14**	**0.06**

Table 2. Cont.

SOURCE	D.f S	D.f Comb.	1000-kernel weight I_1	1000-kernel weight I_2	1000-kernel weight Combined	Grain yield/plant I_1	Grain yield/plant I_2	Grain yield/plant Combined
Irrigation (I)		1			499.52**			787.80**
Genotypes (G)	27	27	26.55**	23.39**	37.51**	12.49**	8.01**	14.00**
Parents (P)	6	6	38.30**	40.14**	72.75**	6.99**	4.55**	9.98**
Crosses (C)	20	20	24.33**	19.24**	28.72**	14.67**	8.54**	16.32**
P VS C	1	1	0.331	41.77**	1.67	1.96	18.21**	16.07**
G X I		27			12.43**			5.60**
P X I		6			5.69*			1.56
C X I		20			14.86**			6.89**
P VS C X I		1			4.45*			4.10*
GCA	6	6	33.22**	35.99**	67.41**	9.11**	13.99**	16.54**
SCA	21	21	24.66**	19.78**	28.96**	13.49**	6.31**	14.44**
GCA X I		6			1.81**			6.56**
SCA X I		21			15.48**			5.34**
Error	54	108	0.49	0.69	0.29	0.25	0.24	0.12
GCA/SCA			**0.15**	**0.21**	**0.26**	**0.07**	**0.25**	**0.13**

I_1 and I_2: Normal irrigation and drought condition, respectively.

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

From the previous results, it is indicated that three hybrids were of common superiority under normal and drought conditions (P_1 x P_4, P_1 x P_5 and P_6 x P_7) and showed considerable heterosis for grain yield/ plant and most of the studied traits. Therefore, these three crosses would be efficient and prospective in wheat breeding programs for improving these traits. Heterotic effect has been extensively investigated in wheat by many researches (Abd El-Aty 2000, Salama 2000, Awaad 2002, El-Borhamy 2005, Dawwam *et al.* 2007 and El-Hosary *et al* 2009).

Combining ability

The analysis of variance of combining ability for two irrigation treatments and combined data for all studied traits is shown in Table (2). General and specific combining ability mean squares were found to be highly significant for all studied traits at each environment and combined analysis indicating the importance of both additive and non-additive gene effects in the expression of these traits. The ratios of GCA/SCA variance were less than unity under both water regimes and combined data for all studied traits except spike length and no. of spikelets/ spike, indicating that the inheritance of these traits were mainly controlled be the non-additive gene effects. The mean squares of interaction between irrigation treatments and both GCA and SCA were also highly significant for all studied traits, revealing that the variance magnitude of different types of gene action were fluctuated from one irrigation treatment to the other. These results are generally in agreement with those obtained by Yadav and Singh (1988), Hendawy (1994), Abd El-Aty (2000), Salama (2000), Koumber and Esmail (2000), Salama (2007) and El-Hosary *et al* (2009).

Table 3. Heterosis percentage relative to better parent for the traits studied in a seven-parent diallel cross of bread wheat under normal irrigation (I1) and drought conditions (I2).

	Days to heading		Flag leaf area		Relative water content		Plant height		Spike length	
Crosses	I_1	I_2	I_1	I_2	I_1	I_2	I_1	I_2	I_1	I_2
P1 x P2	1.92*	0.42	-23.79**	13.60**	-23.46**	-8.65**	9.00**	7.45**	-5.63	-2.05
P1 x P3	0.79	3.73**	3.72	-7.63*	-18.71**	-17.99**	2.85	6.28**	-9.47**	-4.10
P1 x P4	1.53	4.16**	-4.76*	24.06**	-15.78**	-16.92**	1.77	2.40	-1.19	5.69
P1 x P5	0.77	4.57**	8.53**	14.90**	-15.51**	30.02**	-3.21	-3.15	-9.47**	-3.64
P1 x P6	0.38	4.98**	-17.59**	-0.48	-5.50**	0.150	-7.36*	-2.40	-4.27	-2.61
P1 x P7	3.10**	2.91*	-15.85**	-23.39**	-2.08**	14.63**	-4.72	-4.75*	-10.36**	-5.29
P2 x P3	3.17**	-2.41**	-10.96**	-17.48**	-30.37**	-17.28**	0.89	1.80	-4.11	-6.11
P2 x P4	-4.35**	-7.44**	-3.87	-1.92	-23.52**	-18.47**	5.36	1.24	-14.45**	-13.71**
P2 x P5	-2.53*	-5.49**	-25.72**	-33.61**	-29.04**	-20.63**	-2.77	-1.84	-7.22*	-9.82*
P2x P6	0.74	-3.48**	-9.93**	-15.47**	-6.81**	-20.46**	4.41	-1.23	-6.37	-8.95*
P2 x P7	-3.87**	-2.40	-8.05**	14.56**	-21.94**	-11.88**	-4.44	-7.13**	-19.15**	-16.20**
P3 x P4	1.19	-2.41	-25.27**	-9.32**	-23.14**	-18.37**	1.79	1.09	-12.02**	-8.48*
P3 x P5	3.96**	3.61**	-6.63**	-16.75**	-15.42**	-14.27**	-1.18	-3.23	-4.81	-9.61*
P3 x P6	4.74**	-2.81*	-24.24**	-7.41*	-22.57**	-17.81**	0.57	-0.75	-6.65	-9.43*
P3 x P7	-1.58	-2.41	-28.61**	2.03	-25.86**	-7.16**	-3.49	-7.76	-14.72**	-11.59**
P4 x P5	-2.90**	-5.21**	-21.57**	-31.00**	-10.13**	-30.34**	-0.68	-0.52	-8.30*	-5.14
P4 x P6	-1.48	-2.32	-19.99**	-14.71**	-12.98**	-26.81**	-2.11	-7.45**	-7.35*	-4.15
P4 x P7	5.81**	3.60**	-16.27**	9.79**	9.90**	-10.10**	-0.23	-4.31*	-1.58	-5.80
P5 x P6	-1.48	-6.56**	-28.59**	-32.44**	-1.52**	15.76**	0.55	-3.15	-1.94	-5.84
P5 x P7	1.55	-1.60	-28.61**	-9.09**	-3.12**	20.09**	-0.83	-5.75**	-14.32**	-13.30**
P6 x P7	-0.38	0.41	-22.22**	39.94**	38.93**	63.52**	-4.79	-4.56*	-5.06	-2.47
Heterosis mean	0.53	-0.77	-15.73	-4.85	-12.32	-5.38	-0.41	-1.80	-8.02	-6.79

Table 3. cont.

Crosses	No. of spikelets/spike I_1	No. of spikelets/spike I_2	No. of spikes/plant I_1	No. of spikes/plant I_2	No. of kernels/spike I_1	No. of kernels/spike I_2	1000-kernel weight I_1	1000-kernel weight I_2	Grain yield/plant I_1	Grain yield/plant I_2
P1 x P2	0.34	0.00	-32.10**	-33.12**	-12.88**	2.81	-15.46**	4.45	-10.87*	-10.04
P1 x P3	-0.89	-0.91	-9.16	-24.40*	-6.84**	-8.38**	0.77	-14.75**	5.70	-26.10**
P1 x P4	0.06	-0.67	-23.40**	-19.52*	16.28**	-2.01	2.31	-3.63	-13.58**	-1.69
P1 x P5	-0.50	-1.33	4.28	-0.86	-3.77**	7.30**	11.79**	15.28**	6.09	0.79
P1 x P6	-0.33	-0.44	0.14	-14.17	-11.33**	-14.96**	-0.11	6.87*	-0.08	1.46
P1 x P7	-0.22	-0.58	4.24	-21.77	-11.77**	-2.12	-3.33	-3.50	-17.07**	-11.96
P2 x P3	-0.33	-0.73	-19.98**	-33.12**	-28.94**	-15.95**	-10.99**	-7.73**	-30.47**	-34.86**
P2 x P4	-1.17	-2.89**	-12.12	-24.81**	-5.86**	-6.14**	-2.8	3.03	-3.87	-14.54*
P2 x P5	0.12	-1.56*	-20.08**	-33.12**	-10.51**	-14.16**	-16.66**	-6.48*	-22.07**	-25.62**
P2x P6	-0.28	-0.67	-25.28**	-31.95**	-23.40**	-1.99	-10.77**	-2.67	-5.17	-17.19**
P2 x P7	-1.33*	-2.11**	-16.86**	-27.26**	-5.94**	3.43	-7.33**	2.79	17.43**	-13.57*
P3 x P4	-2.00**	-3.72**	-15.16*	-27.20**	-30.08**	-21.42**	-16.10**	-6.04*	-23.85**	-30.84**
P3 x P5	-0.55	-1.34*	-14.61*	-25.96*	-11.57**	-5.81**	-1.75	-6.09*	3.34	-49.50**
P3 x P6	-1.01	-0.78	-18.87*	-19.57	-16.31**	-13.66**	-3.55	-11.88**	-36.24**	-33.48**
P3 x P7	-1.11	-2.11**	-19.41**	-29.08**	-17.37**	-2.7	-7.51**	-8.37**	-5.24	-36.54**
P4 x P5	-0.89	-1.55*	-14.13	-13.98	-20.19**	-22.00**	-1.04	-16.18**	-3.38	-11.82
P4 x P6	-0.72	-1.23	-18.43*	-19.52	-17.87**	-23.05**	-10.35**	-11.74**	-19.48**	-9.51
P4 x P7	0.28	1.05	-5.52	-9.70	-6.49**	-3.65	2.81	-4.24	-4.55	4.44
P5 x P6	-0.44	-0.45	-9.70	-24.89*	0.29	-7.69**	2.98	3.24	-12.25*	-18.14*
P5 x P7	-1.00	-1.34*	-8.31	-26.47*	-11.59**	-12.41**	-2.92	1.17	-20.31**	-15.06*
P6 x P7	0.11	0.61	16.86	7.01	2.01	9.43**	2.36	2.33	24.00**	24.25**
Heterosis mean	-2.49	-5.06	-12.27	-21.59	-11.15	-7.39	-4.18	-3.06	-8.19	-15.69

*and** = denote significant differences at 0.05 and 0.01 levels, respectively.

P_1 (Giza 168), P_2 (Cham 6), P_3 (Line 1), P_4 (Line 2), P_5 (Sakha 94), P_6 (IB 18) and P_7 (Maryout 5).

Estimates of GCA effects of each parental genotype for all studied characters under normal and drought environments as well as their combined data are presented in Table (4). High positive values of GCA effects would be of interest in all characters studied except days to heading, negative values would be preferred from the wheat breeder point of view. For days to heading, significant negative GCA effects were detected for P_1 (Giza 168), P_3 (Line 1) and P_7 (Maryout 5) under both irrigation treatments and their combined data, indicating that the three genotypes could be considered as good general combiners for developing early wheat genotypes. Regarding flag leaf area, the three genotypes P_2 (Cham 6), P_4 (Line 2) and P_7 (Maryout 5) under both water regimes as well as the combined data and cultivar Giza 168 (P_1) under drought condition and combined data gave the highest significant positive GCA effects. Therefore, these parental genotypes were considered as the best general combiners for this trait. For relative water content, significant positive GCA effects were detected for P_2 and P_4 under both irrigation treatments and their combined data, P_3 under drought condition and combined data and P_2, P_6 and P_7 under normal irrigation. Therefore, these genotypes were considered as the best general combiners for this trait. Concerning plant height, the two parental cultivars P_5 (Shakha 94) and P_7 (Maryout 5) under both water regimes as well as the combined data and the cultivar Giza 168 (P_1) under drought condition expressed significant positive general combining ability effects for this trait. For spike length, the three genotypes P_1, P_4 and P_7 under both irrigation treatments as well as the combined data and cultivar 1B (P_6) under drought condition and combined data gave significant positive GCA effects. With respect to no. of spikelets/ spike, the best general combiners were the line 2 (P_4) and the cultivar Maryout 5 (P_7) under both regimes and combined data, P_1 (Giza 168) under drought condition and combined data and the cultivar 1B (P_6) under drought condition. Parental cultivar P_2 (Cham 6) and the parental line 2 (P_4) expressed significant positive general combining ability effects for no. of spikes/ plant under both water regimes and their combined data. Regarding no. of kernels/ spike the two cultivars Giza 168 (P_1) and Maryout 5 (P_7) under both treatments and combined data, the cv. Shakha 94 under normal irrigation and the two genotypes P_2 and P_4 under drought condition expressed significant positive GCA effects for this trait. Concerning 1000-kernel weight, the three genotypes P_2, P_4 and P_7 showed significant positive GCA values under both water treatments and combined data. Therefore, these genotypes were considered as the best combiners for this trait. With respect to grain yield/ plant, the parental line 2 (P_4) under both irrigation treatments and combined data, the cultivar Cham 6 (P_2) under drought condition and combined data and the cultivar Maryout 5 (P_7) under normal irrigation gave significant positive GCA effects. Therefore,

Table 4. Estimates of general combining ability effects of parents for all traits studied under normal irrigation (I1) and drought conditions (I2) and their combined data.

		Days to heading			Flag leaf area			Relative water content	
Parents	I_1	I_2	Combined	I_1	I_2	Combined	I_1	I_2	combined
P1 (Giza 168)	-0.43*	-1.33**	-0.88**	0.31	1.61**	0.96**	-5.47**	-1.23**	-3.35**
P_2 (Cham 6)	0.80**	0.67**	0.73**	2.26**	1.00**	1.63**	0.70**	2.87**	1.78**
P_3 (Line 1)	-2.06**	-1.37**	-1.72**	0.01	-1.11**	-0.55**	-1.38**	2.02**	0.32**
P_4 (Line 2)	1.24**	1.26**	1.25**	2.11**	1.41**	1.76**	3.36**	2.06**	2.71**
P_5 (Sakha 94)	1.28**	1.82**	1.55**	-4.96**	-5.31**	-5.14**	0.78**	-2.16**	-0.69**
P_6 (IB)	0.65**	-0.19	0.23	-3.70**	-0.48*	-2.09**	1.60**	-2.67**	-0.53**
P_7 (Maryout 5)	-1.47**	-0.85**	-1.16**	3.97**	2.89**	3.43**	0.42**	-0.89**	-0.24**
S.E(gi)	0.19	0.23	0.15	0.24	0.22	0.16	0.04	0.17	0.09
LSD (gi-gj) 0.05	0.58	0.70	0.45	0.73	0.68	0.49	0.13	0.52	0.27
0.01	0.78	0.94	0.60	0.97	0.91	0.65	0.18	0.70	0.35
		Plant height			Spike length			No. of spikelets/spike	
P1 (Giza 168)	0.15	0.94*	0.54	0.49**	0.55**	0.52**	0.28	0.52**	0.40**
P_2 (Cham 6)	-1.84**	-1.91**	-1.88**	-0.87**	-0.90**	-0.88**	-0.54**	-0.79**	-0.66**
P_3 (Line 1)	0.21	-0.45	-0.12	-0.64**	-0.53**	-0.59**	-1.02**	-1.09**	-1.05**
P_4 (Line 2)	-0.73	-0.60	-0.67*	0.34**	0.19*	0.27**	0.46**	0.41**	0.43**
P_5 (Sakha 94)	1.20*	0.77*	0.99**	-0.27**	-0.31**	-0.29**	0.15	-0.29*	-0.07
P_6 (IB 18)	-2.05**	-1.32**	-1.68**	0.12	0.23**	0.17**	-0.09	0.33*	0.12
P_7 (Maryout 5)	3.06**	2.57**	2.82**	0.83**	0.77**	0.80**	0.76**	0.91**	0.84**
S.E(gi)	0.55	0.36	0.33	0.09	0.08	0.06	0.14	0.14	0.10
LSD (gi-gj) 0.05	1.68	1.10	0.99	0.27	0.24	0.18	0.44	0.43	0.30
0.01	2.24	1.46	1.31	0.36	0.33	0.24	0.59	0.57	0.40

Table 4. cont.

	No. of spikes/plant			No. of kernels/spike			1000-kernel weight		
Parents	I_1	I_2	Combined	I_1	I_2	Combined	I_1	I_2	Combined
P1 (Giza 168)	-0.59**	-0.31	-0.45**	0.96**	0.94**	0.95**	-0.33	-0.50	-0.42*
P_2 (Cham 6)	0.90**	0.87**	0.88**	-0.37*	0.91**	0.27	0.53*	1.10**	0.82**
P_3 (Line 1)	0.28	-0.3	-0.01	-0.21	-1.12**	-0.67**	-0.49*	-0.05	-0.27
P_4 (Line 2)	0.31*	0.60**	0.46**	-1.03**	1.24**	0.10	1.43**	1.02**	1.23**
P_5 (Sakha 94)	-0.04	-0.07	-0.06	0.65**	-2.23**	-0.79**	-0.87**	-0.92**	-0.89**
P_6 (IB 18)	-0.47**	-0.19	-0.33**	-1.67**	-1.54**	-1.60**	-1.54**	-1.82**	-1.68**
P_7 (Maryout 5)	-0.39**	-0.61**	-0.50**	1.67**	1.80**	1.74**	1.26**	1.17**	1.21**
S.E(gi)	0.14	0.16	0.11	0.17	0.29	0.17	0.22	0.26	0.17
LSD (gi-gj) 0.05	0.44	0.49	0.33	0.54	0.88	0.51	0.67	0.79	0.51
0.01	0.59	0.65	0.43	0.71	1.17	0.67	0.89	1.05	0.68

	Grain yield/plant		
P1 (Giza 168)	-0.45**	0.01	-0.22*
P_2 (Cham 6)	0.25	0.93**	0.59**
P_3 (Line 1)	-0.21	-1.16**	-0.68**
P_4 (Line 2)	0.84**	0.78**	0.81**
P_5 (Sakha 94)	-0.07	-0.54**	-0.30**
P_6 (IB 18)	-0.87**	0.03	-0.42**
P_7 (Maryout 5)	0.51**	-0.04	0.24*
S.E(gi)	0.15	0.15	0.11
LSD (gi-gj) 0.05	0.47	0.46	0.33
0.01	0.63	0.61	0.43

*and** =denote significant differences at 0.05 and 0.01 levels, respectively.

these parents appeared to be the best combiners for grain yield/ plant and can be utilized as promising progenitors for high yielding ability.

Estimates of the specific combining ability effects of the F_1 hybrid for the studied traits under normal and drought conditions as well as their combined data are presented in Table (5). Significant negative specific combining ability effects under both water regimes and their combined data were obtained for days to heading in the crosses; P_2 x P_4, P_2 x P_7, P_3 x P_4, P_4 x P_5 and P_5 x P_6 followed by the three crosses; P_1 x P_2, P_2 x P_3 and P_5 x P_7 under drought condition and combined data. Also, the two crosses; P_1 x P_5 and P_6 x P_7 under normal irrigation and the cross P_3 x P_6 under drought condition exhibited significant negative SCA effects. These crosses are considered to be promising for earliness as they showed highly SCA effects and involved at least one parent as a good general combiner. Regarding flag leaf area, the four crosses P_1 x P_4, P_1 x P_5, P_2 x P_7 and P_3 x P_5 manifested significant positive SCA effects under both water regimes and combined data as well as the two crosses P_1 x P_3 and P_6 x P_7 under all environments except under normal and drought conditions, respectively. Also, the two crosses P_2 x P_4 and P_2 x P_6 under normal irrigation and the two crosses P_1 x P_2 and P_4 x P_7 under drought conditions manifested significant positive SCA effects, therefore they considered as good F_1 hybrids for improving this trait. Out of these crosses, the cross P_4 x P_7 included high x high general combiner parents, while five of the above crosses included only one good general combiner parent. For relative water content, the five crosses; P_1 x P_2, P_4 x P_7, P_5 x P_6, P_5 x P_7 and P_6 x P_7 exhibited significant positive SCA effects under both water regimes and combined data as well as the three crosses P_1 x P_3, P_1 x P_4 and P_2 x P_6 under normal irrigation and combined data and the cross P_1 x P_5 under drought conditions and combined data. Also, the three crosses; P_1 x P_7, P_2 x P_7 and P_3 x P_7 under drought conditions had significant positive SCA effects.

Table 5. Estimates of specific combining ability effects of F_1 crosses for all traits studied under normal irrigation (I_1) and drought conditions (I_1) and their combined data.

Crosses	Days to heading			Flag leaf area			Relative water content		
$P_1 x P_2$	0.36	-2.58**	-1.11*	-7.05**	4.91**	-1.07*	0.82**	3.53**	2.17**
$P_1 x P_3$	-0.45	2.12**	0.83	4.86**	-2.58**	1.14*	3.84**	-2.61**	0.62*
$P_1 x P_4$	-0.42	-0.17	-0.30	2.60**	7.69**	5.15**	1.23**	0.43	0.83**
$P_1 x P_5$	-1.12*	-0.40	-0.76	7.14**	8.39**	7.77**	-0.15	8.92**	4.39**
$P_1 x P_6$	-0.83	1.93**	0.55	-4.35**	-1.28	-2.81**	-2.21**	-2.87**	-2.54**
$P_1 x P_7$	2.62**	0.94	1.78**	-0.28	-10.69**	-5.49**	-3.79**	1.32**	-1.23**
$P_2 x P_3$	0.32	-2.21**	-0.94*	-0.77	-3.04**	-1.91**	-8.26**	-4.74**	-6.50**
$P_2 x P_4$	-1.97**	-2.84**	-2.41**	1.07**	-0.21	0.43	-8.06**	-4.60**	-6.33**
$P_2 x P_5$	-0.34	-0.40	-0.37	-2.69**	-4.37**	-3.53**	-9.47**	-2.51**	-5.99**
$P_2 x P_6$	1.29*	-1.07	0.11	3.41**	-2.97**	0.22	5.76**	-1.91**	1.93**
$P_2 x P_7$	-4.60**	-2.40**	-3.50**	1.85**	3.97**	2.91**	-3.97**	1.31*	-1.33**
$P_3 x P_4$	-1.79**	-2.81**	-2.30**	-6.80**	-0.95	-3.87**	-7.96**	-3.68**	-5.82**
$P_3 x P_5$	0.51	1.64*	1.08*	5.61**	1.44*	3.53**	-0.13	0.42	0.14
$P_3 x P_6$	1.80**	-1.69*	0.06	-3.32**	-0.42	-1.87**	-5.90**	-1.07*	-3.49**
$P_3 x P_7$	-1.42*	-0.69	-1.06*	-6.65**	0.41	-3.12**	-6.98**	3.14**	-1.92**
$P_4 x P_5$	-1.12*	-1.99**	-1.56**	-0.08	-4.11**	-2.10**	-1.11**	-6.59**	-3.85**
$P_4 x P_6$	-1.15*	-0.66	-0.91*	-0.59	-3.40**	-2.00**	-3.90**	-4.00**	-3.95**
$P_4 x P_7$	3.29**	2.01**	2.65**	-2.31**	1.56*	-0.37	13.13**	4.13**	8.63**
$P_5 x P_6$	-1.19*	-4.88**	-3.03**	-4.77**	-4.85**	-4.81**	1.77**	3.37**	2.57**
$P_5 x P_7$	-0.42	-2.88**	-1.65**	-1.69*	0.95	-0.37	1.93**	3.33**	2.63**
$P_6 x P_7$	-1.45**	0.79	-0.33	0.39	12.30**	6.35**	16.88**	16.84**	16.86**
S.E(sij)	0.55	0.67	0.43	0.69	0.65	0.47	0.13	0.49	0.26
LSD (sij-sik)0.05	1.65	1.99	1.27	2.05	1.93	1.39	0.38	1.48	0.75
0.01	2.20	2.66	1.69	2.74	2.57	1.84	0.51	1.97	1.00
LSD (sij-skl)0.05	1.55	1.86	1.19	1.92	1.80	1.30	0.35	1.38	0.71
0.01	2.06	2.49	1.58	2.56	2.40	1.73	0.47	1.84	0.94

Table 5. Cont.

Crosses		Plant height I1	Plant height I2	Plant height Combined	Spike length I1	Spike length I2	Spike length Combined	No. of spikelets/spike I1	No. of spikelets/spike I2	No. of spikelets/spike Combined
$P_1 \times P_2$		8.88**	6.23**	7.56**	0.76**	0.79**	0.77**	0.87*	1.18**	1.02**
$P_1 \times P_3$		1.43	3.82**	2.63**	0.08	0.20	0.14	0.12	0.57	0.34
$P_1 \times P_4$		1.43	0.81	1.12	0.07	0.53*	0.30	0.37	-0.02	0.18
$P_1 \times P_5$		-2.45	-2.17*	-2.31*	-0.29	0.03	-0.13	-0.55	-0.66	-0.60*
$P_1 \times P_6$		-5.26**	-2.31*	-3.78**	-0.07	-0.40	-0.23	-0.25	-0.38	-0.31
$P_1 \times P_7$		-2.03	-1.03	-1.53	-0.67*	-0.27	-0.47**	0.01	-0.43	-0.21
$P_2 \times P_3$		1.25	1.45	1.35	-0.06	-0.02	-0.04	-0.4	-0.1	-0.25
$P_2 \times P_4$		2.70	1.94	2.32*	-0.26	-0.29	-0.28	-0.05	-0.92*	-0.48
$P_2 \times P_5$		-0.07	1.79	0.86	0.10	-0.03	0.04	0.89*	-0.34	0.27
$P_2 \times P_6$		3.62*	1.49	2.56**	0.21	0.27	0.24	0.07	0.16	0.11
$P_2 \times P_7$		0.23	-0.29	-0.03	-0.42	-0.10	-0.26	-0.29	-0.65	-0.47
$P_3 \times P_4$		0.92	0.36	0.64	-0.21	-0.11	-0.16	-0.4	-1.46**	-0.93**
$P_3 \times P_5$		-0.68	-0.84	-0.76	0.12	-0.37	-0.13	0.7	0.17	0.44
$P_3 \times P_6$		1.18	0.42	0.8	-0.04	-0.14	-0.09	-0.18	0.34	0.08
$P_3 \times P_7$		-0.94	-2.31*	-1.62	-0.09	0.07	-0.01	0.41	-0.35	0.03
$P_4 \times P_5$		0.71	1.59	1.15	-0.15	0.02	-0.06	-0.45	-0.09	-0.27
$P_4 \times P_6$		-2.99	-4.88**	-3.93**	-0.43	-0.31	-0.37*	-0.04	-0.38	-0.21
$P_4 \times P_7$		3.07	0.90	1.98*	0.59*	0.03	0.31	0.32	1.32**	0.82**
$P_5 \times P_6$		3.14	0.09	1.61	0.10	0.01	0.06	-0.12	-0.13	-0.12
$P_5 \times P_7$		0.58	-1.76	-0.59	-0.40	-0.35	-0.38*	-0.64	-0.38	-0.51
$P_6 \times P_7$		0.10	1.40	0.75	0.38	0.38	0.38*	0.71	0.96*	0.83**
S.E(sij)		1.59	1.04	0.95	0.25	0.23	0.17	0.42	0.41	0.29
LSD (sij-sik)	0.05	4.74	3.11	2.79	0.76	0.69	0.51	1.26	1.22	0.86
	0.01	6.32	4.14	3.71	1.01	0.92	0.67	1.68	1.62	1.15
LSD (sij-skl)	0.05	4.44	2.91	2.61	0.71	0.65	0.47	1.18	1.14	0.81
	0.01	5.91	3.87	3.47	0.95	0.86	0.63	1.57	1.52	1.07

Table 5. Cont.

Crosses	No. of spikes/plant I_1	I_2	Combined	No. of kernels/spike I_1	I_2	Combined	1000-kernel weight I_1	I_2	Combined
P_1 x P_2	-1.02*	-0.54	-0.78*	-2.41**	2.26**	-0.08	-3.68**	2.47**	-0.61
P_1 x P_3	0.76	-0.32	0.22	3.48**	-1.43	1.03*	2.47**	-3.44**	-0.49
P_1 x P_4	-0.67	-0.16	-0.41	10.74**	3.71**	7.23**	3.15**	1.24	2.19**
P_1 x P_5	1.03*	1.01*	1.02**	0.29	5.94**	3.12**	3.95**	5.04**	4.50**
P_1 x P_6	0.12	-0.37	-0.12	-5.00**	-6.24**	-5.62**	-0.96	1.35	0.20
P_1 x P_7	-0.02	-0.56	-0.29	-4.40**	-2.24**	-3.32**	-0.70	-0.91	-0.8
P_2 x P_3	-0.61	-0.55	-0.58	-9.19**	-5.46**	-7.33**	-1.08	-1.57*	-1.32**
P_2 x P_4	0.19	-0.67	-0.24	3.85**	1.35	2.60**	1.48*	2.95**	2.22**
P_2 x P_5	-0.3	-0.78	-0.54	-0.66	-3.63**	-2.15**	-3.80**	-2.28**	-3.04**
P_2x P_6	-0.42	-0.55	-0.48	-6.18**	2.18*	-2.00**	0.09	0.42	0.25
P_2 x P_7	0.39	0.31	0.35	1.10*	1.73*	1.41**	-0.83	0.49	-0.17
P_3 x P_4	-0.69	-0.78	-0.74*	-9.25**	-5.46**	-7.35**	-6.40**	-0.42	-3.41**
P_3 x P_5	-0.29	-0.67	-0.48	0.79	3.12**	1.95**	1.73**	1.26	1.50**
P_3 x P_6	-0.25	-0.1	-0.17	0.11	-1.78*	-0.84	1.48*	-0.71	0.39
P_3 x P_7	-0.38	-0.35	-0.37	-3.90**	0.76	-1.57**	-2.69**	-1.95*	-2.32**
P_4 x P_5	-0.37	0.04	-0.17	-7.39**	-4.68**	-6.04**	1.92**	-4.60**	-1.34**
P_4 x P_6	-0.33	-0.28	-0.31	-5.86**	-5.98**	-5.92**	-2.32**	-1.49	-1.91**
P_4 x P_7	0.76	0.91	0.83**	0.76	1.90*	1.33**	1.83**	-0.73	0.55
P_5 x P_6	-0.2	-0.78	-0.49	5.31**	-0.29	2.51**	0.08	1.15	0.61
P_5 x P_7	-0.17	-0.47	-0.32	-3.98**	-4.46**	-4.22**	0.05	1.74*	0.89
P_6 x P_7	1.09*	1.26**	1.17**	6.50**	6.29**	6.40**	3.46**	3.18**	3.32**
S.E(sij)	0.42	0.46	0.31	0.51	0.83	0.49	0.63	0.75	0.49
LSD (sij-sik) 0.05	1.26	1.38	0.92	1.52	2.48	1.43	1.89	2.24	1.44
0.01	1.68	1.83	1.22	2.02	3.30	1.90	2.52	2.98	1.92
LSD (sij-skl) 0.05	1.18	1.29	0.86	1.42	2.32	1.34	1.77	2.09	1.35
0.01	1.57	1.72	1.14	1.89	3.09	1.78	2.36	2.79	1.79

Table 5. cont.

	Grain yield/plant		
Crosses	**I_1**	**I_2**	**Combined**
$P_1 \times P_2$	-0.28	0.66	0.19
$P_1 \times P_3$	2.86**	-0.24	1.31**
$P_1 \times P_4$	-0.26	0.67	0.21
$P_1 \times P_5$	1.74**	1.10*	1.42**
$P_1 \times P_6$	-0.29	0.12	-0.09
$P_1 \times P_7$	-2.38**	-1.47**	-1.93**
$P_2 \times P_3$	-3.36**	-1.26**	-2.31**
$P_2 \times P_4$	0.63	-0.67	-0.02
$P_2 \times P_5$	-2.35**	-0.73	-1.54**
$P_2 \times P_6$	1.00*	-0.25	0.38
$P_2 \times P_7$	3.03**	0.27	1.65**
$P_3 \times P_4$	-2.17**	-1.44**	-1.81**
$P_3 \times P_5$	2.11**	-2.29**	-0.09
$P_3 \times P_6$	-3.13**	-1.08*	-2.10**
$P_3 \times P_7$	0.22	-1.35**	-0.57
$P_4 \times P_5$	1.02*	0.08	0.55
$P_4 \times P_6$	-0.80	-0.23	-0.51
$P_4 \times P_7$	0.25	1.41**	0.83**
$P_5 \times P_6$	-0.47	-0.83	-0.65*
$P_5 \times P_7$	-3.00**	-0.46	-1.73**
$P_6 \times P_7$	3.78**	2.35**	3.07**
S.E(sij)	0.45	0.44	0.31
LSD (sij-sik) 0.05	1.34	1.30	0.92
0.01	1.79	1.74	1.22
LSD (sij-skl) 0.05	1.25	1.22	0.86
0.01	1.67	1.63	1.14

*and** =denote significant differences at 0.05 and 0.01 levels, respectively.
P_1 (Giza 168), P_2 (Cham 6), P_3 (Line 1), P_4 (Line 2), P_5 (Sakha 94), P_6 (IB 18) and P_7 (Maryout 5).

Thus, these crosses are considered as good F_1 hybrid for improving this trait. Concerning plant height, the cross $P_1 \times P_2$ showed significant positive SCA effects under both water regimes and combined data as well as the two crosses $P_1 \times P_3$ and $P_2 \times P_6$ under all environments except under normal and drought conditions, respectively. With respect to spike length, the cross $P_1 \times P_2$ manifested significant positive SCA effects under both water regimes and combined data as well as the two crosses $P_4 \times P_7$ and $P_1 \times P_4$ under normal and drought conditions, respectively which were considered as the best F_1- cross combinations for this trait. For no. of spikelets/ spike, the cross $P_1 \times P_2$ showed significant positive SCA effects under both water regimes and combined data as well as the two crosses $P_4 \times P_7$ and $P_6 \times P_7$ under drought conditions and combined data and the cross P_2

x P_5 under normal irrigation. For no. of spikes/ plant, the two crosses; P_1 x P_5 and P_6 x P_7 exhibited significant positive SCA effects under both water regimes and combined data. Regarding no. of kernels/ spike, the three crosses; P_1 x P_4, P_2 x P_7 and P_6 x P_7 manifested significant positive SCA effects under both water regimes and combined data as well as the three crosses P_1 x P_3, P_2 x P_4 and P_5 x P_4 and P_5 x P_6 under normal irrigation and combined data. Also, the two crosses P_1 x P_2 and P_2 x P_6 under drought conditions had significant positive SCA effects. Thus, these crosses are considered as good F_1 hybrids for improving this trait. For 1000-kernel weight, the three crosses; P_1 x P_5, P_2 x P_4 and P_6 x P_7 exhibited significant positive SCA effects under both water regimes and combined data as well as the two crosses P_1 x P_4 and P_3 x P_5 under normal irrigation and combined data. Also, the two crosses P_1 x P_3 and P_4 x P_7 under normal irrigation and the two crosses P_1 x P_2 and P_5 x P_7 under drought condition manifested significant positive SCA effects. Concerning grain yield/ plant, the two crosses P_1 x P_5 and P_6 x P_7 manifested significant positive SCA effects under both water regimes and combined data as well as the two crosses P_1 x P_3 and P_2 x P_7 under normal irrigation and combined data, the cross P_4 x P_7 under drought condition and combined data and the two crosses P_2 x P_6 and P_3 x P_5 under normal irrigations, revealing that these crosses seemed to be good F_1-cross combinations for increasing grain yield/ plant under their respective environments. Out of these crosses, the two crosses, P_2 x P_7 and P_4 x P_7 included high x high general combiner parents whereas the two crosses P_2 x P_6 and P_6 x P_7 included high x low general combiner parents for this trait. In such crosses especially the two crosses P_2 x P_7 and P_4 x P_7 desirable transgressive segregates could be expected in the segregating generations and high yielding genotypes may be raised.

Types of gene action, genetic ratios and heritability

According to Hayman (1954), the half diallel analysis provides six genetic components, i.e., D, H_1, H_2, F, h^2 and E and several ratios could be derived from the analysis. As shown in Table (6), the values of additive genetic component (D) were significant for all traits under the two irrigation treatments (normal and drought conditions), except no. of spikes/ plant and grain yield/ plant under both water regimes and flag leaf area under drought condition the value of component (D) was insignificant. The presence of dominance effects were substantiated by significant estimates of H_1 for all traits under both water regimes except spike length under both water regimes and days to heading and no. of spikelets/ spike under normal irrigation was insignificant. These results illustrated that both additive and dominance genetic components are important in the inheritance of the traits studied. However values of H_1 were greater than the respective D for all studied traits under both water regimes except spike length and no. of

Table 6. Estimates of genetic and environmental components of variation and some of its derived ratios in F_1 diallel crosses analysis for the traits studied in bread wheat genotypes under normal irrigation (I1) and drought conditions (I2).

Traits	Days to heading		Flag leaf area		Relative water content		Plant height	
Genetic parameters	I_1	I_2	I_1	I_2	I_1	I_2	I_1	I_2
D	9.96**	19.19**	61.94**	16.59	90.23*	129.53**	25.12*	24.46**
H_1	11.84	28.54**	79.69*	113.47**	316.24*	230.63**	38.09	35.58*
H_2	11.20*	21.25**	68.57*	103.91**	208.04*	133.86*	28.23	23.02
F	4.42	22.39**	33.98	-8.30	159.93	215.69**	25.97	29.74*
h^2	6.54	35.02**	21.83	0.46	29.09	15.59*	20.68	4.10
E	0.85	0.97	0.59	0.69	0.04	0.31	5.57	1.40
$(H_1/D)^{0.5}$	1.09	1.22	1.13	2.62	1.87	1.33	1.23	1.21
$H_2/4H_1$	0.24	0.19	0.22	0.23	0.16	0.15	0.19	0.16
h^2/H_2	0.58	1.65	0.32	0.00	0.14	0.12	0.73	0.18
KD/KR	-3.21	-20.91	-32.73	9.20	-158.46	-214.07	-24.55	-28.23
Hn.s.	45.89	24.56	52.42	39.24	27.00	13.57	26.32	33.74
R	0.18	0.83**	-0.06	0.25	-0.38*	-0.41*	-0.87**	-0.66**
r^2	0.03	0.69**	0.00	0.06	0.14	0.17	0.75**	0.44*
	Spike length		No. of spikelets/spike		No. of spikes/plant		No. of kernels/spike	
D	1.63**	1.42**	1.42**	1.46**	2.19**	2.02**	10.72	7.87
H_1	0.08	0.29	0.22	1.52*	1.17**	1.83**	143.01**	74.77**
H_2	0.15	0.22	0.32	1.37*	0.83**	1.32	124.57**	63.44**
F	0.15	0.05	-0.06	-0.69	1.76**	1.66**	21.28	6.35
h^2	-0.03	-0.04	0.00	0.14	0.05	1.92**	67.99*	16.05
E	0.16**	0.08**	0.27**	0.25*	0.31**	0.32**	0.32	0.83
$(H_1/D)^{0.5}$	0.22	0.45	0.39	1.02	0.73	0.95	3.65	3.08
$H_2/4H_1$	0.45	0.19	0.37	0.23	0.18	0.18	0.22	0.21
h^2/H_2	-0.21	-0.18	-0.01	0.10	0.06	1.45	0.55	0.25
KD/KR	1.05	0.99	1.01	1.46	-0.21	-0.22	-20.01	-5.22
Hn.s.	78.27	83.75	65.88	65.99	42.64	40.01	11.13	27.78
R	0.28	-0.39*	-0.52**	0.58**	0.49**	0.02	0.01	0.75**
r^2	0.08	0.15	0.27	0.33	0.24	0.00	0.00	0.57**
	1000-kernel weight				Grain yield/plant			
D	12.25*	12.67**			1.96	1.21		
H_1	36.02**	28.64*			17.68**	9.20**		
H_2	28.19*	21.35*			16.55**	5.60**		
F	15.72	15.39			1.81	1.81		
h^2	-0.19	0.73			0.18	3.25*		
E	0.52	0.70			0.37	0.32		
$(H_1/D)^{0.5}$	1.71	1.50			3.01	2.76		
$H_2/4H_1$	0.20	0.19			0.23	0.15		
h^2/H_2	-0.01	0.03			0.01	0.58		
KD/KR	-14.35	-13.98			-0.65	-0.54		
Hn.s.	22.33	27.42			12.39	46.57		
R	0.43*	0.27			-0.09	-0.31		
r^2	0.18	0.07			0.01	0.10		

spikes/ plant under both water regimes and no. of spikelets/ spike under drought condition, indicating that the dominance gene effects played the major role in the inheritance of the most traits. These findings coincided with those obtained previously from variance analysis of combing ability. The component of variation due to dominance effects associated with gene distribution (H_2) was significant for all studied traits under both water regimes except plant height and spike length under both water regimes, no. of spikelets/ spike under normal irrigation and no. of spikes/ plant under drought condition. Moreover, H_2 values were smaller than H_1 values for all traits except spike length and no. of spikelets/ spike under normal irrigation, which mean that the positive and negative alleles at the relevant loci are in unequal proportion in the parents for these traits. The covariance of additive and dominance gene effects in the parents revealed significant and positive "F" values for no. of spikes/ plant under both water regimes and days to heading, relative water content and plant height under drought condition, indicating excess of dominant alleles in the parental genotypes while, the other cases for the studied traits under their respective environments exhibited insignificant values for this parameters revealing that no excess of either dominant or recessive alleles was verified. The overall dominance effects of heterozygous loci (h^2) was significant for days to heading, relative water content, no. of spikes/ plant and grain yield/ plant under drought condition and no. of kernels/ spike under normal irrigation, illustrating that the dominance effect was mainly attributed to heterozygous phase in all crosses for these traits. On the hand, (h^2) was insignificant for the other studied traits, revealing the little importance of dominance effects in the inheritance of these traits. The environments effects indicated by (E) values did not reach the significant level in all traits under both water regimes except spike length, no. of spikelets/ spike and no. of spikes/ plants, revealing less sensitivity of the most studied traits to environmental changes.

The degree of dominance $(H_1/D)^{0.5}$ was less than unity for spike length and no. of spikes/ plant under both water regimes and no. of spikelets/ spike under normal irrigation, indicating the presence of partial dominance for these traits. On contrast, the ratio was higher than unity for the other traits under their respective environments revealing the presence of over dominance in the expression of these traits. Values of $H_2/4H_1$ under both water regimes for all traits were less than 0.25 except spike length and no. of spikelets/ spike under normal irrigation, revealing asymmetric distributions of positive and negative alleles among parents. The h^2/H_2 values for all studied traits under both water regimes suggested that there was about one pair of gene affecting the inheritance of these traits. The ratio of (KD/KR) that represent the total number of dominant to recessive alleles in the parents was more than unity for the studied traits under both water regimes, suggesting greater frequency for dominant genes as compared with recessive ones in the parents, except no. of spikes/ plant and grain yield/ plant under both water regimes and spike length under drought conditions for this proportion was less than unity, indicating that the proportion of recessive alleles was greater for these traits. The correlation (r) between the parental order of dominance (Wr+Vr) and the parental mean performance (Yr) was found to be positive and significant for no. of spikes/ plant and 1000-kernel weight under normal irrigation and days to heading, no. of spikelets/ spike and no. of kernels/ spike under drought conditions, revealing that the dominant genes were operating towards decreasing these traits under these water treatments. On the other hand, significant negative correlation coefficients were detected for relative water content and plant height under both water regimes, no. of spikelets/ spike under normal irrigation and spike length under drought conditions, indicating that the dominant genes were operating towards increasing these traits under these specific environments. However, the other traits were insignificant, indicating ambidirectional dominance. The square values of (r^2) were less than unity for all traits studied under both water regimes, suggesting that none of parental genotypes was completely dominant or recessive for genes controlling any of traits under both water regimes. Similar results concerning components of variation and ratios derived from Hayman's analysis were obtained for one or more of the studied traits by El-Marakby *et al* (1993), Awaad (2002), Hamada (2003), Koumber and Esmail (2005) and Salama (2007).

High estimates of narrow sense heritability (Hn.s) were detected for spike length and no. of spikelets/ spike under both water regimes and flag leaf area under normal irrigation. Values of heritability for these traits ranged from 52.42% for flag leaf area under normal irrigation to 83.75% for spike length under drought conditions, indicating the importance of additive gene effects in the inheritance of these traits. However, moderate heritability values were obtained for no. of spikes/ plant under both water regimes; flag leaf area, plant height and grain yield/ plant under drought conditions and days to heading under normal irrigation giving values ranging from 33.74% for plant height to 46.57% for grain yield/ plant under drought conditions. On the other hand, low heritability values were found for relative water content, no. of kernels/ spike and 1000-kernel weight under both water regimes; plant height and grain yield/ plant under normal irrigation and days to heading under drought conditions giving values ranging from 11.13% to 27.78% for no. of kernels/ spike under normal and drought conditions, respectively. These results are generally in agreement with those obtained by El-Marakby *et al* (1993), Awaad (2002), Hamada (2003), Koumber and Esmail (2005) and Salama (2007).

REFERENCES

Abd El-Atty, M.S. (2000). Estimates of heterosis and combining ability in diallel wheat crosses (*T. aestivum* L.). J. Agric. Res. Tanta Univ. 26(3): 486-498.

Abd El-Aty, M.S. and H.S. El-Borhamy (2007). Estimates of combining ability and susceptibility index in wheat diallel crosses under stress and normal irrigation treatments. Egypt. J. Plant Breed. 11(2):651-667.

Awaad, H.A. (2002). Assessment of some genetic parameters using diallel cross fashion and their implications in breeding programs of bread wheat (*Triticum aestivum* L.). Zagazig J. Agric. Res. 29(4): 1123-1141.

Dawwam, H.A., F.A.Hendawy and Mona M. Serage El-Din (2007). Heterosis and combining ability analysis of some quantitative characters in bread wheat (*Triticum aestivum* L.). Menofiya J.Agric.Res. 32(4):1087-1108.

EL-Borhamy, H.S. (2005). Estimation of heterosis and combining ability in some bread wheat crosses (*Triticum aestivum* L.). J. Agric. Sci. Mansoura Univ. 30(2): 755-762.

El-Hosary, A.A., S.A. Omar and Wafaa A. Hassan (2009). Improving wheat production under drought conditions by using diallel crossing system. Proc. 6th Plant Breed. Conf. May 3-5. Egypt. J. Plant Breed. 12(1): 127-141.

EL-Marakby, A.M., A.A. Mohamed and M.F. Abd EL-Rahman (1993). Studies on types of gene action and heritability in bread wheat crosses. 4th Conf. Agric. Dev. Res., 151-159, Ain Shams Univ., Cairo, Feb. 13-18.

Griffing B. (1956). Concept of general and specific combining ability in relation to diallel crossing system. Aust. J. Biol. Sci. 9: 463 – 493.

Hamada, A.A. (2003). Heterosis and gene action of yield and its components and some growth traits in an eight parent diallel cross of bread wheat under three sowing dates. Minufiya J. Agric. Res. 28(3): 787-819.

Hayman, B.L. (1954). The theory and analysis of diallel crosses. Genetics 39: 789-809.

Hendawy, F.A. (1994). General and specific combining ability estimates in a diallel cross of seven bread wheat varieties. Menofiya J. Agric. Res.19(1): 75-93.

Koumber, R.M. and R.M. Esmail (2005). Breeding bread wheat for low and full-input production system. Annals Agric. Sci., Ain Shams Univ., Cairo 50(1): 103-122.

Mather, K. and J.L. Jinks (1982). Biometrical Genetics. 3rd ed. Chapman and Hall, London.

Salama, S.M. (2000). Partial diallel analysis and heterosis in bread wheat (*Triticum aestivum* L.). Zagazig J. Agric. Res. 27: 1371-1384.

Salama, S.M. (2007). Gene action and heritability of diallel crosses in bread wheat (*Triticum aestivum* L.) under various numbers of irrigation. J. Agric. Sci., Mansoura Univ. 32(9): 7099-7109.

Singh, R.K and B.D. Chaudhary (1995). Biometrical Methods in Quantitive Genetic Analysis. New delhi – Ludhiana.

Yadav, M.S. and I. Singh (1988). Combining ability analysis over environments in spring wheat. Wheat Information Service 67: 21-24.

المعالم الوراثية لهجن الداليل في قمح الخبز تحت ظروف الري العادي والجفاف

سمير حسن صالح
قسم المحاصيل- كلية الزراعة- جامعة عين شمس- شبرا الخيمة- القاهرة- مصر

أجريت جميع التهجينات التبادلية دون العكسيه بين سبعة آباء شملت ٥ أصناف وسلالتين من قمح الخبز في الموسم الزراعي ٢٠٠٨/٢٠٠٩. ثم قيمت الهجن وأبائها الأصلية (٢٨ تركيب وراثي) في المزرعة التجريبية لكلية الزراعة- جامعة عين شمس بشلقان خلال الموسم الزراعي ٢٠٠٩/٢٠١٠م بغرض تقدير قوة الهجين، القدرة العامة والخاصة على الإئتلاف ونوع الفعل الجيني تحت معاملتين من الري هما ري عادي (٥ ريات) واجهاد مائي (٣ ريات بحيث تم اسقاط الرية الثانية والرابعة في فترتي النمو الخضري والأزهار علي الترتيب) في تصميم قطاعات كاملة العشوائية حيث خصص لكل معاملة تجربة مستقلة في ثلاث مكررات. ويمكن تلخيص أهم النتائج فيما يلي:

١- كان التباين الراجع إلى قوة الهجين معنوياً لمعظم الصفات المدروسة تحت معاملتي الري والتحليل المشترك لهما فيما عدا طول السنبلة وعدد السنيبلات/ سنبلة تحت كلا المعاملتين وعدد السنابل/ نبات ومحصول الحبوب/ نبات تحت الري العادي ووزن الألف حبة تحت الري العادي والتحليل المشترك. كان التباين الراجع إلى التفاعل بين كل من معاملتي الري وقوة الهجين معنوياً لجميع الصفات المدروسة فيما عدا طول السنبلة وعدد السنيبلات/ سنبلة وعدد السنابل/ نبات.

٢- كان التباين الراجع إلى القدرة العامة والخاصة على التآلف معنوي لجميع الصفات المدروسة تحت كل معاملة والتحليل المشترك لهما وأظهرت النسبة بين تباين القدرة العامة إلى تباين القدرة الخاصة على التآلف والتي قلت عن الوحدة لجميع الصفات فيما عدا طول السنبلة وعدد السنيبلات/ سنبلة مما يدل على أن التباين الوراثي غير المضيف هو الأكثر أهمية في وراثة معظم الصفات المدروسة.

٣- تم تحديد الهجين $P_1 \times P_5$ و$P_6 \times P_7$ كأفضل مادة وراثية حيث تفوقا في قدرتهما الائتلافية الخاصة وقوة الهجينين لصفة كمية المحصول ومساهماته وبالتالي يمكن استغلالها مباشرة في تحسين القدرة المحصولية تحت ظروف الري العادي والجفاف في برامج تربية القمح.

٤- تأثرت الصفات المدروسة بالفعل الجيني المضيف وغير المضيف تحت معاملتي الري مع أهمية التأثير السيادي للجينات في وراثة معظم الصفات ، كما وجد سيادة فائقة مع زيادة في تكرار الجينات السائدة لمعظم الصفات المدروسة تحت معاملتي الري.

٥- كانت قيم كفاءة التوريث بمعناها الضيق عالية إلى متوسطه في معظم الصفات المدروسة تحت معاملتي الري معطية قيم تتراوح ما بين ٣٣.٧٤% لإرتفاع النبات إلى ٨٣.٧٥% لطول السنبلة تحت ظروف الجفاف.

المجله المصريه لتربية النبات ١٥(٣): ٨٥ - ١٠٧ (٢٠١١)