HETEROSIS AND COMBINING ABILITY OF A FIVE PARENTS DIALLEL OF BREAD WHEAT

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Abstract

A half diallel set among five genetically diverse bread wheat (*Triticum aestivum, L.*) genotypes were done in 2001/2002 growing season, The F1's of the ten crosses and the five parents were grown in a filed experiment at Giza experimental research farm, ARC next season (2002/2003), in a randomized complete blocks with three replications. Days to heading, Plant height, days to maturity, number of spikes per plant, number of kernels per spike, 100-kernel weight, straw yield per plant, grain yield per plant and harvest index were studied. The mean squares of genotypes, parents and crosses were highly significant for all studied traits. Positive heterosis over the better parent for three crosses for number of spikes/plant, one cross for straw yield per plant and one cross for grain yield per plant. Negative heterosis over the better parent was detected in four crosses for plant height, ten crosses for days to heading and one cross for days to maturity. The variances associated with general combining ability reached the level of significance for all studied traits except for harvest index. Specific combining ability was recorded for all traits except for grain yield. General combining ability variance was higher than the specific one for all characters except for days to maturity and 100 Kwt. Both types were of the same importance for days to maturity, while 100 kwt showed effects due specific combining ability. Four crosses were promising for early heading and/or early maturity. Also, several crosses were promising for improving grain yield plant.

INTRODUCTION

Wheat is one of the major cereal crops in Egypt, which receives great attention in plant breeding. Increasing grain yield per unit area is the main or the only solution for overcoming the increased demand for wheat by developing high yielding wheat cultivars, that resist both biotic and a biotic stresses.

The assessment of nature of genetic variation is very crucial in any breeding program, since the choice of an appropriate breeding method depends on the relative importance of variances and genetic parameters. In wheat, plant height and spike characters are important plant attributes that determine the desirability of progeny of any cross. The appropriate selection of these traits may greatly contribute towards enhancement of high yielding ability. Thus, information about the nature of gene action with respect to these traits would be useful in development of better cultivars e. g. dominance gene action would tend to favor the production of hybrids, whereas, additive gene action signifies that standard selection procedures would be effective in breeding for advantageous changes in these characters (Edwards et al., 1976).

Successful breeding programs need continued information on the genetic variation and systems governing grain yield and its components. Contradictory results were obtained by differ authors with respect to genetic systems governing grain yield and its components. Ikram and Tanah (1991) indicated that both additive and non-additive gene effects played an equal role in the inheritance of grain yield, number of spike/plant, number of kernels/spike and 1000-kernel weight. Salem and Hassan (1991) reported that non-additive gene effects were more important for grain yield/plant and number of spikes/plant. Dawam and Hendawi (1990), and Darwish (1992) found that dominance gene effects were significant for grain yield/plant, number of kernels/spike and 1000-kernel weight. Meanwhile, El-Hennaway (1992) revealed that both additive and dominance gene effects were important for grain yield and number of kernels/spike. On the other hand, Mekhamer (1995) reported that additive gene effects were significant for number of kernels/spike and 1000-kernel weight. Mohamed (1999) found that additive and non-additive gene effects were controlling the genetic systems of grain yield and its components. The additive gene effect mainly influenced the inheritance of the studied characters. Also, El-Sayed et al., (2000) found that both additive and dominance variances were significant for number of spikes/plant, number of kernels/spike, 1000-kernel weight and grain yield/plant. Moreover, Mostafa (2002) Showed that both additive and non-additive gene effects contributed in controlling the genetic system for plant height, number of spikes/plant, number of kernels/spike, 100-kernel weight and grain yield/plant.

The present study was carried out to study the types of gene action controlling some of the economic characters in five parental diallel crosses of bread wheat.

MATERIALS AND METHODS

The fieldwork of this study was conducted at El-Giza Agricultural Research Center (ARC), Egypt. Five bread wheat cultivars representing a wide range of genetic variability were selected for this study during the two successive growing seasons 2001/2002 and 2002/2003. Names and Pedigree of the studied parents are presented in Table 1.

Table 1. Names and Pedigree of the five parents of bread wheat.

No.	Name	Pedigree	Origin
P_1	Gemmeiza 9	ALD "S"/HAVAC "S"//CMH74A.630/SX	Egypt
P_2	Sids I	HD21/PAVON "S"//1158.57/MAYA74 "S"	Egypt
P_3	Dovin - 2	CM84655-02AP-300AP-300L-3AP-300L-3AP-OL-OAP	ICARDA
P_4	Sakha 93	Sakha 92 / TR 810328	Egypt
P_5	Giza 168	MRL/BUC/SERI	Egypt

In 2001/2002 season all possible crosses among the five selected parents (without reciprocals) were made to produce hybrid seeds of the ten crosses. In the second season, 2002/2003 the 15 entries (10 F1'S and 5 Parents) were planted in the field using the randomized complete block design with three replications. Each entry was planted in two rows 2 m long, 30 cm apart and the distance between plants within row was 10 cm. Data were recorded on a random sample of 10 guarded plants/entry. Data were recorded for nine characters i.e. No. of days to heading, No. of days to maturity, plant height, number of spike/plant, number of kernel/spike, 100-kernel weight, straw yield/plant (gm) grain yield/plant (gm) and harvest index.

The analysis of variance for combining ability effects was done following Griffing's (1956) method 2 model 1. Heterosis was computed with respect to better and mid parent according to Bhatt (1971) formula.

RESULTS AND DISCUSSION

Analysis of variance for the days to heading, plant height, days to maturity, number of spikes/plant, number of kernel/spike, 1000-kernel weight, straw yield /plant, grain yield/plant and harvest index are presented in Table 2. Test of significance indicated that mean squares of genotypes were highly significant for all studied characters. The significance of the mean squares indicated the presence of true differences among these genotypes. Mean squares due to parents and F_1's were significant for all studied characters, except for number of spike/plant of the parents. These findings indicate that parental cultivars differed in their mean performance in all characters.

Table 2: shows the result of analysis of combining ability. The variance associated with general combining ability reached the level of significant in all character, except for harvest index. The same level of significance was found for specific combining ability for all studied character, except for grain yield. The significant variances due to both general and specific combining ability revealed the presence of both additive and non-additive types of gene effects. Relatively large general combining ability effects were recorded for days to heading, plant height, days to maturity, number of spike/plant, number of kernel/spike, 100-kernel weight, straw yield/plant, grain yield/plant and harvest index suggesting the predominant role of additive type of gene action for these characters and thus selection could be successfully practiced to improve them.

The mean performance of the five wheat parental genotypes is presented in Table 3. The parental cultivar Gemmeiza 9 (P_1) ranked the first for straw and grain yield/plant and the second for plant height and days to maturity. The parental cultivar Sids 1 (P_2) ranked first in plant height, number of kernel/spike and maximum days to heading and maturity, and second for number of spikes/plant, 100-kernel weight and straw/plant without significant difference and was the second in grain yield/plant and the latest in harvest index.

The parental cultivar Dovin-2 (P_3) ranked first in number of spikes/plant and 100-kernel weight/plant. The parental cultivar Sakha 93 (P_4) ranked last for plant height and days to maturity (desirable) and moderately for all studied character.

The parental cultivar Giza 168 (P_5) ranked the first for harvest index, the last for straw yield per plant and moderately for all studied character.

The mean performance of the tested ten crosses are presented in Table 3. For plant height the tallest two crosses were $P_4 \times P_5$ and $P_1 \times P_4$.

The two crosses $P_1 \times P_5$ and $P_4 \times P_5$ were the earliest in days to heading and maturity. The three crosses $P_3 \times P_5$, $P_1 \times P_3$ and $P_1 \times P_5$ possessed the highest number of spikes/plant, while the five crosses $P_1 \times P_2$, $P_1 \times P_4$, $P_1 \times P_5$, $P_1 \times P_3$ and $P_2 \times P_4$ possessed the highest number of kernels/spike. For heavy 100-kernel weight the best four crosses were $P_1 \times P_4$, $P_1 \times P_2$, $P_2 \times P_3$ and $P_1 \times P_3$. The three crosses $P_1 \times P_3$, $P_3 \times P_5$ and $P_1 \times P_5$ were the highest in straw yield /plant, while the three crosses $P_3 \times P_5$, $P_1 \times P_2$ and $P_2 \times P_4$ were the highest in harvest index. The two crosses $P_3 \times P_5$ and $P_1 \times P_2$ gave the highest grain yield/plant.

Table 2. Mean squares of ordinary analysis and combining ability analysis for 15 Wheat Genotypes.

Source of variation	Days to heading	Plant height(cm)	Days to maturity	No. of spikes/plant	No. of kernel / spike	100-Kernel weight(gm)	Straw yield /plant (gm)	Grain yield/ plant (gm	Harvest index
Replication	2.4	5.755	3.29	2.52	131.15	0.015	27.18	32.21	9.34
Genotypes	64.038**	124.565**	82.51**	65.56**	281.58**	1.274**	1922.08**	495.20**	30.067**
Parents (P)	14.43**	288.499**	148.73**	1.322	127.32*	0.438**	1803.38**	282.458**	28.146*
Croes(C)	20.30**	59.81**	60.386**	66.311**	254.22**	1.466**	2109**	637.375**	24.885*
P vs C	656.1**	51.38	21.51**	315.812**	1144.90**	2.887**	714.63	66.547	84.392**
GCA	6.99**	115.877**	54.017**	14.698*	114.49**	0.423**	1065.475**	134.39**	4.78
SCA	27.15**	12.036*	17.064**	23.473**	85.59**	0.425**	470.89**	17.72	12.12**
Error	2.35	13.732	1.003	13.22	47.192	0.079	415.25	39.75	9.64
GCA/SCA	0.257	9.628	3.166	0.626	1.338	0.995	2.263	7.584	0.394

Table 3. Mean Performance of The Studied characters in Fifteen bread Wheat Genotypes.

Parents		Days to heading	Plant height(cm)	Days to maturity	No. of spikes/plant	No. of Kernel spike	100-Kernel weight(gm)	Straw yield / plant (gm)	Grain yield/ plant (gm	Harvest index
P1		94.0	106.67	152.33	19.33	76.0	4.73	145.67	78.8	35.5
P2		94.33	119.67	155.0	20.4	88.0	4.93	138.33	60.33	30.47
P3		91.33	101.67	146.33	20.83	71.0	5.18	104.51	54.65	34.44
P4		90.0	93.33	136.67	19.50	73.83	4.57	96.55	57.36	37.38
P5		89.67	100.33	147.67	19.50	75.67	4.17	93.28	57.97	38.32
$P_1 x P_2$		85.33	110.0	152.67	25.67	79.83	4.86	129.97	72.36	35.84
$P_1 x P_3$		87.0	108.0	146.67	31.03	69.50	4.59	168.92	65.58	28.02
$P_1 x P_4$		85.0	102.67	146.67	17.33	77.33	4.95	103.79	50.54	32.83
$P_1 x P_5$		81.33	111.0	139.33	29.33	74.67	4.13	140.17	56.83	28.81
$P_2 x P_3$		81.30	109.67	145.0	22.50	64.67	4.86	119.46	55.71	31.73
$P_2 x P_4$		81.30	104.33	151.0	22.83	68.83	3.38	117.16	61.17	34.54
$P_2 x P_5$		83.0	110.67	148.0	24.50	54.83	4.47	106.68	46.15	30.23
$P_3 x P_4$		87.33	105.67	147.67	23.67	57.17	2.86	103.5	50.33	31.61
$P_3 x P_5$		85.67	107.33	146.0	33.00	58.5	3.93	163.28	91.72	36.90
$P_4 x P_5$		80.33	96.67	138.33	24.67	56.67	3.75	88.31	42.07	32.67
L.S.D	5%	2.57	6.2	1.677	6.09	11.5	0.74	10.55	10.55	5.197
	1%	3.45	8.35	2.258	8.19	15.48	0.633	14.21	14.21	7.00

Parents VS crosses mean squares (Table 2), as an indication to average heterosis overall crosses, were found to be highly significant for all characters, except for plant height, straw yield /plant and grain yield/plant.

The heterosis estimates are given in Table 4. High positive values would be of interest in all studied traits except for plant height, days to heading and maturity where negative values would he useful from the breeder point of view. For plant height, useful heterotic effects toward shortness were found in four crosses, also ten and one F1'S crosses had lower days to heading and maturity than their corresponding better parents. At the same time, three, one and one F1'S crosses had higher number of spikes/plant, straw yield/plant and grain yield/plant, respectively, than the corresponding better parents, One cross, out of the ten crosses, seems to be promising (P3 x P). It gave positive heterosis for grain yield/plant and straw yield/plant and also gave negative heterosis for days to heading. Cross (P1 x P5) gave negative heterosis for days to heading and maturity, beside positive heterosis for number of spikes/plant comparing to better parents. Walton (1971) emphasized that a parent superior for one yield components character should be crossed with parent superior for the other components to obtain heterosis in a complex trait such as grain yield. The particular components contributing to high yielding crosses were not consistent from cross to cross. Mahrous (1998), and Abdel Hamid (2002) detected significant heterosis for early heading and/or early maturity in different wheat crosses. Mahrous (1998) and Abdel Wahed (2001) recorded significant positive heterosis for tall plant height, higher number of spikes/plant, heavy 1000-kernels weight and higher grain yield/ plant. Moreover, Mahrous (1998) reported significant heterosis for increased number of kernels/spike, straw yield/plant and harvest index.

Estimates of general combining ability effects for each parent are presented in Table 5. High positive values would be of great interest in all studied characters except for plant height, days to heading and maturity in which negative values would be more useful from the breeder point of view. Results indicate that the cultivar Gemmeiza 9 (P1) showed significant positive general combining ability effects for number of kernel/spike, 100-kernel weight, straw yield/plant and grain yield/plant. Meanwhile, the cultivar Sids 1 (P2) proved to be a good combiner for plant height, number of kernels/spike and 100-kernel weights. In addition, (P3) Dovin-2 showed positive and significant values for general combining ability effects for plant height, days to heading. On the other the cultivar Sakha93 (P4) showed significant negative general combining ability effects for all character to be valuable for short plants earier in heading and maturity. The cultivar Giza 168 (P5) showed highly significant negative general combining ability effects for earliness days to heading and maturity, i.e as well as heavier kernels.

Specific combining ability effects calculated for each cross are presented in Table 6. The crosses P1 x P3, P1 x P5, P2xP3, P4xP5 showed significant specific combining ability effects for earliness in heading and maturity. Also, three two, two and two crosses showed significant positive specific combining ability effects for number of spikes/plant, 100-kernel weight, straw yield/plant and harvest index, respectively. None of them was significant in more than one of yield component. The crosses P3 x P5, P2 x P4 and P1 x P2 are considered to be promising hybrids for grain yield improvement as they showed high specific combining ability effects each of the three crosses utilized as good combiners for different yield component. In such hybrids, desirable transgressive segregates would be expected in the subsequent generations, if additive genetic system present in the good combiner and the complementary epistatic effects in the F1's acts in the same direction to maximize the yielding ability.

The main objective of plant breeding program is to produce plants that perform certain functions better than the existing types. For this reason the plant breeder must have sufficient information on the inheritance of economic character, if he is intending for efficient planning of the breeding program.

Table 4. Percentage of heterosis over better parent values for all characters studied in the F_1 diallel.

Parents		Days to heading	Plant height(cm)	Days to maturity	No. of spikes/plant	No. of kernel / spike	100-Kernel weight(gm)	Straw yield /plant (gm)	Grain yield/ plant (gm	Harvest index
$P_1 \times P_2$		-9.22**	-8.08**	0.223	25.83	-9.28	-1.42	-10.78	-8.17	0.96
$P_1 \times P_3$		-4.74**	.47	0.232	50.8**	-8.55	-11.389**	15.96	-16.78*	-21.07**
$P_1 \times P_4$		-5.556**	-3.75	7.317**	11.13	1.75	4.651	-28.75*	-35.86**	-12.17
$P_1 \times P_5$		-9.301**	4.06	-5.648**	50.41**	-1.75	-12.68*	-3.78	-27.08**	-24.82**
$P_2 \times P_3$		-10.98**	-8.36**	-0.909	8.02	-26.51**	-6.178	-13.64	-7.66	-7.87
$P_2 \times P_4$		-9.667**	-12.82**	10.485**	11.91	-21.78**	-31.44**	-15.3	1.39	-7.6
$P_2 \times P_5$		-7.438**	-7.52**	0.223	20.1	-37.69**	-9.33	-22.88	-23.5*	-21.11**
$P_3 \times P_4$		-2.967**	3.93	8.049**	13.63	-22.57**	-44.787**	-0.97	-12.26	-15.44
$P_3 \times P_5$		-4.461**	5.57	-0.226	58.43**	-22.69**	-24.13**	56.23**	58.22**	-3.71
$P_4 \times P_5$		-10.416**	-3.65	1.215*	26.51	-25.11**	-17.943**	-8.53	-27.43**	-14.74*
L.S.D	5%	2.566	6.2	1.676	6.086	6.64	0.47	10.55	10.55	5.197
	1%	3.455	8.35	2.257	8.194	8.94	0.633	14.208	14.208	6.997

Table 5. Estimate of general combining ability effects (g_i) on five wheat parents for the studied character.

Parents	Plant height(cm)	Days to heading	Days to maturity	No. of spikes/plant	No. of kernel / spike	100-Kernel weight(gm)	Straw yield /plant (gm)	Grain yield/ plant (gm)	Harvest Index
P1	1.42	1.127**	1.466**	0.054	4.96**	0.264**	15.19**	6.04**	-0.46
P2	5.56**	0.117	3.847**	-0.762	3.65*	0.184**	3.16	-0.654	-0.92
P3	-0.15	0.742*	-0.248	1.461*	-3.82**	0.065	5.19	1.716	-0.37
P4	-5.58**	-0.687*	-3.246**	-2.019**	-1.56	-0.295**	-17.42**	-5.97**	0.96
P5	-1.25	-1.299**	-1.819**	1.266	-3.23*	0.218**	-6.12	-1.132	0.79
L.S.D. g_i 5%	1.435	0.613	0.401	1.455	2.749	0.112	8.15	2.522	1.242
L.S.D. g_i 1%	1.933	0.826	0.539	1.96	3.698	0.15	10.98	3.395	1.673
L.S.D. g_i-g_j 5%	2.27	0.97	0.633	2.3	4.346	0.177	12.89	3.99	1.964
L.S.D. g_i-g_j 1%	3.056	1.306	0.853	3.1	5.851	0.238	17.36	5.371	2.644

Table 6. Estimate of specific combining ability for crosses studied in the F_1 diallel.

Parents	Days to heading	Plant height(cm)	Days to maturity	No. of spikes/plant	No. of kernel / spike	100-Kernel weight(gm)	Straw yield /plant (gm)	Grain yield/ plant (gm	Harvest index
P_1 x P_2	-2.374**	-2.823	0.73	2.77	1.45	0.055	-9.68	6.87*	3.88**
P_1 x P_3	-1.331*	0.886	-1.171**	5.91**	-1.41	-0.097	27.23**	-2.28	-4.43**
P_1 x P_4	1.902**	0.973	1.827**	-4.31	4.16	0.623**	-15.28	-9.64**	-1.01
P_1 x P_5	-4.959**	4.983**	-6.94**	4.4**	-9.69**	-0.274*	9.79	-8.19**	-4.86**
P_2 x P_3	-5.991**	-1.587	-5.22**	-1.81	-4.93	0.253*	-10.19	-5.46*	0.32
P_2 x P_4	-4.562**	-1.497	3.776**	2.0	-3.03	-0.867**	10.13	7.69**	1.16
P_2 x P_5	-2.279**	0.51	-0.651	0.39	-15.36**	0.146	-11.66	-12.17**	-2.98
P_3 x P_4	0.814	5.557**	4.541**	0.62	-7.22*	-1.268**	-5.57	-5.52*	-2.32
P_3 x P_5	-0.233	2.885	1.444**	6.67**	-4.23	-0.275*	42.9**	31.03**	3.14*
P_4 x P_5	-4.145**	-2.345	-3.227**	1.83	-8.32*	-0.095	-9.45	-10.93	-2.42
L.S.D. S_{ij} 5%	1.253	2.93	0.818	2.97	5.61	0.228	16.64	5.15	2.536
L.S.D. S_{ij} 1%	1.686	3.945	1.101	4.11	7.56	0.307	22.41	6.933	3.414
L.S.D. S_{ij}- S_{ik} 5%	2.377	5.559	1.551	5.635	10.645	0.433	31.58	9.77	4.812
L.S.D. S_{ij}- S_{ik} 1%	3.2	7.485	2.088	7.587	14.33	0.583	42.52	13.15	6.487
L.S.D. S_{ij}- S_{kl} 5%	2.17	5.075	1.416	5.144	-8.32	0.385	28.83	8.919	4.393
L.S.D. S_{ij}- S_{kl} 5%	2.92	6.833	1.906	6.926	13.08	0.532	38.81	12.008	5.914

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قوة الهجين والقدرة علي الائتلاف في الهجن التبادلية لخمس أصناف من قمح الخبز

نادية عدلي رياض عبد النور

قسم بحوث القمح – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – الجيزة

أجرى تهجين دائري في اتجاه واحد بين خمس تراكيب وراثية من قمح الخبز (أربعة من الأصناف التجارية وصنف من المستوردات) خلال الموسم ٢٠٠٢/٢٠٠١ وفى موسم ٢٠٠٣/٢٠٠٢ زرعت الآباء وهجنها العشر (الجيل الأول) في تجربة حقلية بالمزرعة التجريبية لمركز البحوث الزراعية بالجيزة ، في تصميم قطاعات كاملة العشوائية من ثلاث مكررات . أخذت القراءات علي صفات : عدد الأيام حتى التزهير ، عدد الأيام حتى النضج ، طول النبات ، عدد السنابل بالنبات ، عدد حبوب السنبلة ، وزن المائة حبة ، وزن القش بالنبات ، وزن محصول النبات من الحبوب و دليل الحصاد .

أجري التحليل الإحصائي علي القراءات المسجلة علي الآباء ونباتات الجيل الأول للتعرف علي طبيعة الفعل الوراثي الذي حكم هذه الصفات والقدرة العامة والخاصة علي الائتلاف بين هذه الآباء وكذا قوة الهجين . ويمكن تلخيص أهم النتائج كما يلي :

أظهرت النتائج وجود قوة هجين بالنسبة لأعلي الأبوين في ثلاث هجن بالنسبة لعدد السنابل ، وهجين واحد بالنسبة للقش وواحد بالنسبة لصفة محصول الحبوب بالنبات . كانت القدرة العامة علي الائتلاف عالية المعنوية ما عدا صفة دليل الحصاد كما كانت القدرة الخاصة عالية المعنوية لجميع الصفات ما عدا صفة محصول الحبوب بالنبات . وكان النسبة لتباين القدرة العامة علي الائتلاف والقدرة الخاصة علي الائتلاف عالية بالنسبة لطول النبات ، عدد الأيام حتى النضج ، عدد الحبوب بالسنبلة ، وزن القش بالنبات ووزن الحبوب بالنبات. مما يوضح أهمية الفعل الجيني المضيف في السلوك الوراثي لهذه الصفات . بينما كان التأثير الراجع إلي السيادة معنويا وأكبر من تأثير الإضافة بالنسبة لباقي الصفات (عدد الأيام حتى التزهير ، عدد السنابل بالنبات ودليل الحصاد) أما بالنسبة لصفة وزن الـ ١٠٠ حبة فقد كان تأثير الإضافة مساوي للسيادة. وقد أوضحت الدراسة إمكانية الانتخاب في الأجيال المتقدمة بنجاح للتبكير في التزهير والنضج في أربعة هجن وللمحصول في نحو أربعة هجن أخرى وذلك للاستفادة من بعض العوامل السائدة والمتوفرة في هذه الهجن .