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Heterosis, Combining Ability and Some Genetic Parameters in Wheat Using Half Diellil Mating Design

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ABSTRACT

This study was carried out in University of Anbar Alternation location which is located in Abo Ghareeb, the longitude 44^{o} and latitude 33^{o}. Six genotypes of bread wheat (AlIraq, ALRashed, AboGhraib 3, API 95, AlHashmya and Tmaze2) were crossed in half diallel, in winter season of 2013-2014, to produce fifteen f4 crosses. The parent and crosses were grown in winter season 2015-2016 using randomized complete block design with four replications to determine, general and specific combining ability effects and gene action. Significant differences were found among parents and their crosses for all traits. The variance due to GCA and SCA were highly significant for all studied traits. The cultivrRashed had the best GCA effects for grain yield of single plants. The heterosis and highest SCA effect was expressed in Alrashe×Aboghraib 3 for grain yield, . The variance ratio of GCA to SCA was less than one for all characters, except plant height. The traits were controlled by the dominance effect while the plant height was controlled by additive effect. The values of dominance variance were more than an additive variance for all characters, except plant height. These results reduce the value of the narrow sense heritability for all characters, except plant height. The results reveal that several genotypes could be used to develop new versions of high yield per plant and SCA to produce a better grain yield selects in breeding program.

Keywords: Combining ability, Genetic parameters, Heterosis, Half diallel, Wheat

INTRODUCTION

Wheat is a worldwide field crop with massive adaptation ability. Increasing the production of wheat is very important to provide the needs of an increasing human population. Researchers are working intensively in order to overcomes the problem of increased demands that come with an increasing population (Pradeep *et al*., 2015). Since expanding present agricultural lands is not possible, the way to resolve this problem may be through increasing yield in the unit area one way to increase yield in the unit area is developing genotypes with good adaptation ability and high yield characteristic selection of suitable parents due to their phenotypic performance only is not a right method, since phenotypically superior lines may be gives poor cross combination of yield. Therefore, it is important that parents should be selected on the basis of their genetic value. The general combining ability effects were due to additive gene action and specific combining ability effects were due to non additive gene effects which are important to selects the best parents for hybridization to produce a superior cross combination and to launch a successful wheat-breeding program. Parents performance may not necessarily reveal it to be good or poor combiners. Therefore, it is necessary to collect information about nature of gene effects and their expression in term of combining ability. At the same time, it also elucidates the nature of gene action involved in the inheritance of the characters. Many researchers gives reviews, which revealed that both general and specific combining abilities were involved in improving yield and its contributing traits in wheat (Singh *et al*., 2012 and Singh *et al*., 2014). In the systematic breeding program, selection of parents with desirable characteristics having good general combining ability effects for grain yield and its components, high heterosis and high estimates of specific combining ability effects are essential. These parameters help in contrive an functional and operative breeding way to achieve fast and suitable crop enhancement. Deciding the next phase of the breeding program depend on general and specific combining ability effects which are so effective genetic parameters. Heterosis is the genetic expression of the superior of hybrid in relation to its parents. This phenomenon manifests in increased size, or other parameters resulting from the increase in hetrozygosity in the F1 generation of crosses between two genotypes and are associated with environment. In general, based on parents used, two major types of estimation of heterosis are reported in literature: Mid-parents or average heterosis, which is the increased vigor of the F1 over the mean of two parents.

The objective of this study was to determine the best single formulated hybrids, which give a significant heterosis in many traits, in addition to determine the parents using in formulating these distinguishing hybrids, through estimating general and specific combining ability and effects and some genetic parameters to identify the nature of gene action in order to enable plant breeders for the selection of the suitable breeding method toward improving the bread wheat

MATERIALS AND METHODS

Six genotypes of bread wheat (*Triticum astivum* L.) namely (1- ALiraq, 2-ALrashed, 3- Aboghraib3, 4-API.95, 5- ALhashmya and 6- Tmoze.2) were sown in rows at Field of Agricultur Faculty of AL-Anbar University, Abu-Ghraibp-Iraq (Longitude 44 and Latitude 33) during winter season 2013-2014 for attempting crossing programe in 6 x 6 diallel fashion to produce 15 F_1 seed of diallel cross, excluding reciprocales seeds. In the same season the six parents were increased by selfing to obtain enough seeds of genotypes in the next season the parents and their 15 F_1. S crosses were sown in a reandomized complete block design (RCBD) with four replicates. Each plot consisted of three rows for each genotype. The row length was 10 meter. Data recorded on 10 individual plants for each the parent and F1 to study, plant height (cm), No. of leaves/stem, flag leaf area (cm^2), No. of spikes per plant, No. of grains per spike, 1000-grains weight (g), grain yield per plant (g) and harvest index (%). The obtained data for each trait were subjected, firstly to analysis of variance to test the significance (Steel and Torrie 1980). The model 1 was used to estimate the general and specific combining ability variances, Method 2 of Griffing (1956). The combining ability analysis was calculated according to the following mathematical model:

$$Xij=M+gi+gj+sij+eijk$$

Where: Xij= value of the cross between parent (i) and parent(j).

M =is the population mean.

gi and gj :are the general combining ability effects (SCA) for the cross between the (i) and (j) parents .

eij =error effect

The components of genetic variance and gene values for GCA and SCA sum Squares calculated due to the following formula :

$$\textbf{Ssgca}\ \frac{1}{p+2} = [\sum(xi.+x.j)^{2} - \frac{4}{p}(x..)^2]$$

$$\textit{Sssca} = \sum xij^2 - \frac{1}{p+2}\sum [(xi. + x.j)^2 + \frac{2}{(p+1)(p+2)} \times (x..)^2] \text{(Singh and Chaudhry, 1985)}$$

Estimation of standard error

$$\textbf{Segi} = [(p\text{-}1)\ \delta^2 e\ /\ p\ (p+1)^{1/2}$$

$$\textbf{SEsij} = [(p\text{-}1)\ \delta^2 e\ /\ (p+1)\ (p+2+]^{1/2}$$

Heterosis of $\bar{F_1}$ generation was determined for all characters by comparing each hybrid was calculated (in per cent) as an increase or decrease in relation to mid parent. The formulae used is given below:

Heterosis over mid parent %= ($\bar{F_1}$ - $\bar{MP}$ / $\bar{MP}$) x 100

Where $\bar{F1}$ and $\bar{MP}$ are the mean of F_1 and mid parents, respectively.

RESULTS AND DISCUSSION

Data presented in Table 1 indicated that there were highly singificant differences among genotypes for all studied traits. The analysis of variance for combining ability showed that GCA and SCA variance was highly significant differences for all the studied traits (Table 2) showed the importance of additive and non additive effects for all the studied traits except plant height was more than one. The ratio of δ^2gca / $^2\delta$sca was less than one, suggesting the predominance of non additive gene action in the inheritance of these traits. These results showed concordance with those of (Muhammed and Khan, 2006; Yadav *et al*. 2011; Yao *et al*. (2014); Khiabani *et al*. 2015; Kumar *et al*. 2015 and Baktash and Naes, 2016).

Table 1. Analysis of variance for randomized complete block design of mean squares for characters.

SV	d.f	Plant height (cm)	No. of leaves /stem	Flag leaf area (cm^2)	No. of spikes/ plant	No. of grains/ spike	1000- grains weight (g)	Yield of Grain/ plant (g)	Harvest index
Block	3	15.1	16.19	0.51	59.7	4.28	10.05	6.10	24.42
Genotype	20	** 3126	** 70.482	** 25.29	** 2351.7	** 223.26	** 102.4	** 104.96	** 189.8
Error	60	20.8	10.6	6.86	157.16	20.67	19.7	12.4	9 .31

Table 2. Mean square of general (GCA) and specific combining(SCA) for characters

S.O.V	d.f	Plant height (cm)	No. of leaves /stem	Flag leaf area (cm^2)	No. of spikes/ plant	No. of grains/ spike	1000- grains weight (g)	Yield of Grain/ plant (g)	Harvest index
Block	3	15.1	16.19	0.51	59.7	4.28	10.05	6.10	24.42
Genotype	20	** 3126.3	** 70.482	** 25.29	** 2351.7	** 223.26	** 102.4	** 104.96	** 189.8
GCA	5	353.57	55.68	26.77	1119.18	95.33	82.74	53.35	193.1
SCA	15	34.05	12.77	5.53	955.30	27.43	31.11	16.75	58.33
Error	60	5.20	2.65	1.72	39.29	5.16	4.90	3.10	2.32
/ GCA$^2\delta$ SCA $^2\delta$		1.38	0.53	0.69	0.02	0.38	0.18	0.33	0.30

The analysis of variance for all studied traits in (Table 3) showed that variations among genotypes were highly significant. The parent 2 was given a higher mean for 1000-grains weight 41.7 g and for grain yield per plant (39.85 g). The hybrid 2 x 3 was given a higher mean for flag leaf area (38.60 cm^2), number of spikes /m^2 (371.0), grain yield per plant (48.70 g) and the hybrid 2 x 5 was given a higher mean for plant height (97.8 cm). Whereas, the hybrid 2 x 6 gave a higher mean for the number of grains per spike (72.4), while the hybrid 2 x 4 gave a highest 1000-grains weight (49.7 g). These findings are in agreement with the findings of (Khattab *et al*. 2010; Akram *et al*. 2011; Ali *et al*. 2014; Dholariya *et al*. 2014 and Kumar *et al*. 2015).

Table 3. Mean performance of wheat parents and their F_1 crosses for all studied traits.

Parents and crosses	Plant height (cm)	No. of leaves /stem	Flag leaf area (cm^2)	No. of spikes /m^2	No. of grains /spike	1000- grains weight (g)	Yield of grain/ plant (g)	Harvest index
1	97.0	78	30.87	333.7	62.2	37.1	35.41	44.44
2	95.9	94	36.40	324.4	67.3	41.7	39.85	43.98
3	83.4	81	34.10	307.5	68.1	32.5	30.75	42.37
4	80.4	84	29.79	299.1	58.8	29.3	27.91	40.36
5	93.6	80	30.00	291.3	56.7	33.7	31.20	41.77
6	86.1	81	33.90	311.9	66.9	40.4	37.12	42.73
1 ×2	96.4	118	31.70	341.9	64.9	37.4	41.31	43.78
1 ×3	85.2	105	31.92	327.2	69.1	30.2	39.10	45.03
1 ×4	90.1	97	32.40	350.2	59.4	42.9	37.70	43.54
1 ×5	95.4	76	31.71	300.4	48.5	39.9	32.92	41.07
1 ×6	94.3	79	34.12	368.0	62.1	29.1	38.30	39.88
2 ×3	85.4	119	38.60	371.0	70.2	39.2	48.70	43.86
2 ×4	88.8	122	33.21	307.0	66.7	49.7	46.31	45.43
2 ×5	97.8	112	34.10	298.2	68.4	40.2	40.12	41.94
2 ×6	87.4	109	38.00	337.1	72.4	31.3	38.90	42.66
3 ×4	90.2	100	30.74	305.1	66.4	41.4	33.33	39.91
3 ×5	84.1	95	35.12	297.7	59.7	35.2	31.43	38.72
3 ×6	80.2	99	33.20	315.5	73.1	33.7	40.10	44.16
4 ×5	91.2	112	30.90	297.2	55.7	42.3	34.21	40.02
4 ×6	85.7	80	34.40	312.7	64.2	37.7	35.11	42.94
5 ×6	91.2	84	33.99	313.8	68.6	34.4	38.20	44.01
L.S.D 5 %	6.64	4.74	3.81	18.26	6.62	6.46	5.13	4.11

Table (4) shows significant and positive heterosis over the mid parents existed for two hybrids, The hybrid 2 x 3 revealed a positive significant increase for the number of spikes per (m^2) 17.42 % and for grain yield per plant 37.96, also the hybrid 2 x 4 revealed a positive significant increase for 1000 grain weight 40 % and for grain yield per plant 36.68 %. This agreed with the finding of (Bhatt, 2005; Akbar *et al*. (2010); Kundan *et al*. (2010) and Desale and Mehta, 2013).

Table 4. Heterosis in different cross combinations of bread wheat genotypes for all studied traits.

Crosses	Plant height (cm)	No. of leaves /stem	Flag leaf area (cm^2)	No. of spikes /m^2	No. of grains /spike	1000- grains weight (g)	Yield of grain/ plant (g)	Harvest index
1 ×2	-2.21	37.21	-5.75	3.90	0.23	-5.07	9.78	-0.97
1 ×3	-5.54	32.07	-1.74	2.05	6.06	-13.21	18.19	3.74
1 ×4	1.57	19.45	6.82	10.86	-1.81	29.21	19.07	2.69
1 ×5	0.10	-3.79	4.19	-3.87	-18.41	12.71	-1.15	-5.81
1 ×6	3.00	-0.62	5.35	14.00	-3.79	-24.90	5.61	-8.50
2 ×3	-4.74	36.00	9.50	17.42	3.69	5.66	37.96	1.58
2 ×4	0.73	37.07	0.95	-1.52	5.79	40.00	36.68	7.73
2 ×5	3.21	28.73	2.71	-3.13	10.32	6.63	12.93	-2.18
2 ×6	-3.95	24.57	8.10	5.95	7.90	-23.75	1.07	-1.60
3 ×4	10.13	21.21	-3.77	0.59	4.65	33.98	13.63	-3.51
3 ×5	-4.97	18.01	9.57	-0.56	-4.32	6.34	1.46	-7.96
3 ×6	-10.64	22.22	-2.35	1.87	8.29	-7.54	18.16	3.78
4 ×5	4.82	36.58	3.36	0.67	-3.55	34.28	15.75	-2.54
4 ×6	2.94	-3.03	8.02	2.35	2.14	8.17	7.98	3.35
5 ×6	1.50	4.34	6.38	4.04	11.00	-7.15	11.82	4.16
S.E	4.97	14.60	5.82	6.88	7.54	8.93	11.39	3.98

The GCA effects of the studied traits (Table 5 (indicated positive and significant GCA effects parent 2 was the best parent with the highest GCA effects for grain yield per plant (5.57), for number of spikes/m^2 (19.31) while the parent 5 was the best parent for 1000 grains weight (3.92) and for flag leaf area (8.09), whereas the parent 1 was the best parent for plant height (1.97) and for harvest index (9.02). The parent 6 gave the highest GCA effect for leaves per stem (1.89), whereas parent 3 gave the highest GCA effect for average of plant height. The parents that showed positive and significant GCA effects were found as well general combiners with other parents for a trait can be used for crossing program to transfer the trait to their crosses.

Table 5. Estimates of general combining ability (gca) effects of parents and variances in bread wheat for all studied straits.

Parents	Effect of variance	Plant height (cm)	No. of leaves /stem	Flag leaf area (cm^2)	No. of spikes /m^2	No. of grains /spike	1000- grains weight (g)	Yield of grain/ plant (g)	Harvest index
1	$\hat{g}i$	1.97	-0.442	-0.29	-2.63	-1.40	2.78	1.68	9.02
	$\hat{g}i^2$б	2.06	12.72	7.57	0.37	1.5	4.95	25.71	-18.40
2	$\hat{g}i$	1.1	0.267	0.75	19.31	1.6	-6.17	5.57	-0.964
	$\hat{g}i^2$б	0.82	-0.182	11.16	3.36	381.93	9.35	13.16	55.19
3	$\hat{g}i$	-1.5	-2.680	-0.25	-4.6	1.10	0.51	1.10	0.84
	$\hat{g}i^2$б	0.05	14.18	21.90	291.2	399.57	102.64	114.91	3.82
4	$\hat{g}i$	-0.71	0.712	-7.06	-9.50	0.94	1.96	0.56	-10.30
	$\hat{g}i^2$б	0.66	0.540	3.37	43.71	9.78	0.92	-4.09	60.12
5	$\hat{g}i$	0.27	0.280	8.09	4.50	-3.13	3.92	-9.07	-0.91
	$\hat{g}i^2$б	2.26	0.202	9.26	152.7	2031.60	31.26	0.21	32.77
6	$\hat{g}i$	-0.99	1.890	0.07	-7.22	0.12	-2.91	-0.19	1.77
	$\hat{g}i^2$б	-0.02	4.42	-1.37	36.05	512.50	11.18	-2.96	-0.55
($\hat{g}i$-$\hat{g}j$)S. E.		1.14	1.31	0.65	3.13	1.13	1.10	0.88	1.03

SCA effects of the crosses in F_1 generation give in Table (6). It was observed that the hybrid 2 x 3 exhibited high and significant SCA effects in a desirable direction for a number of spikes /m^2, (19.57) for 1000 grains weight (10.02) and for grain yield per plant (14.61). While the hybrids 1 x 4, 2 x 3, 5 x 6 and the hybrid 2 x 4 had a SCA effect in the desirable direction for number of spikes/m^2. This result are in accordance with those of Mahpara *et al*. (2008); Ali and Sulaiman, 2014; Yildirim *et al*. (2014) and Kandil *et al*. (2016).

Table 6. The estimates of specific combining ability (sca) effects of crosses in bread wheat for all studied traits

Crosses	Plant height (cm)	No. of leaves /stem	Flag leaf area (cm^2)	No. of spikes /m^2	No. of grains /spike	1000- grains weight (g)	Yield of grain/ plant (g)	Harvest index
1 ×2	-2.23	-0.230	3.45	10.06	-3.4	6.1	7.61	0.040
1 ×3	1.27	-0.490	-3.80	-3.15	-3.7	7.8	-2.73	-2.280
1 ×4	-1.34	-0.142	3.80	11.28	6.5	9.6	-10.41	-4.072
1 ×5	1.14	1.087	2.10	2.18	5.1	-6.1	6.32	-2.014
1 ×6	-2.48	0.320	5.52	4.95	-6.4	3.6	7.31	5.381
2 ×3	-7.53	-0.791	3.23	19.57	3.4	10.02	14.61	1.860
2 ×4	1.35	1.650	-3.50	14.13	6.9	5.7	7.33	-3.011
2 ×5	3.14	-2.212	-1.76	-7.22	2.4	1.7	-4.41	-1.880
2 ×6	-1.35	-0.140	-0.75	10.43	-5.4	-1.1	2.92	0.221
3 ×4	2.02	1.360	1.14	-3.67	1.3	8.70	5.14	3.951
3 ×5	-1.34	-0.012	4.40	-14.34	-0.7	-3.61	-4.11	1.356
3 ×6	1.14	-1.804	-2.88	-5.54	-0.9	-3.1	3.30	-2.210
4 ×5	-1.48	2.090	4.61	-4.04	4.6	5.72	-2.21	-0.061
4 ×6	-2.47	-2.151	0.93	9.69	1.6	-4.1	-0.79	0.224
5 ×6	-1.67	3.240	4.51	18.30	-1.1	-7.60	5.78	5.980
S.E ($s\hat{i}j$- $s\hat{i}k$)	3.01	3.46	1.73	8.29	3.00	2.92	2.32	2.73

Table (7) shows the variance due to the dominance (δ^2D) was higher than the variance due to the additive (δ^2A) for all the studied traits, except plant height and flag leaf area which were the variance due to the additive (δ^2A) was higher than the variance due to the variance dominance (δ^2D), and this reflects the reduction of the values of narraw sense heritability for all studied traits, except plant height and flag leaf area 70 % and 48.9 %, respectively, and the estimate of the average degree of dominance were exceeded one for all studied traits, except plant height, which is an indications that heterosis for these traits due to dominant gen action. These results go in line with (Pearson *et al*. 2007; Ajmal *et al*. 2009; Erkul *et al*. 2010; Ullah *et al*. 2010; Bilgin *et al*. 2011 and Yao *et al*. 2014).

Table 7. Estimates of genetic parameters in bread wheat for all studied traits.

Genetic parameters	Plant height (cm)	No. of leaves /stem	Flag leaf area (cm^2)	No. of spikes /m^2	No. of grains /spike	1000- grains weight (g)	Yield of grain/ plant (g)	Harvest index
δ^2A	79.88	2.70	5.31	40.97	19.96	12.9	9.14	8.42
δD^2	28.85	5.90	3.81	916.01	22.27	36.01	13.65	56.01
$G\delta^2$	108.7	8.60	9.12	956.98	42.23	48.91	22.79	64.43
$E\delta^2$	5.20	6.87	1.72	39.29	5.16	4.9	3.1	2.32
$P\delta^2$	113.9	15.47	10.84	996.27	47.39	53.81	25.89	66.75
%H^2.b.s	95	55.56	84.13	96	89.1	90.8	88	96.5
%h^2.n.s	70	17.45	48.9	4.1	42.1	23.9	35.3	12.61
a	0.85	2.09	1.19	6.68	1.49	2.36	1.72	3.64

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قوة الهجين و قابلية الأتحاد وبعض المعالم الوراثية في حنطة الخبز بأستخدام التهجين النصف تبادلـي

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طبق البحث في جمهورية العراق حقول كلية الزراعة جامعة الانبار في ابو غريب (الموقع البديل) الواقعة على خط طول 44^0 ودائرة عرض 33^0 استخدمت في البحث ستة أصناف من حنطة الخبز العراق, الرشيد , ابو غريب 3 , اباء 95 , الهاشمية , تموز2. أدخلت في تضريبات تبادلية باتجاه واحد في الموسم الشتوي 2013 -2014 لإنتاج 15 هجينا فرديا. تم تكثير بذور الهجن في الموسم الشتوي 2014 – 2015 زرعت حبوب الإباء وتضريباتها النصف تبادلية في الموسم الشتوي 2015 –2016 وفق تصميم القطاعات الكاملة المعشاة بأربعة مكررات. بهدف تقدير تأثيرات المقدرة العامة والخاصة على الاتحاد والفعل الجيني . كان تباين المقدرة الاتحادية العامة والخاصة عالي المعنوية في جميع الصفات المدروسة . كان صنف الرشيد هو أفضل الأصناف من حيث المقدرة الاتحادية العامة لحاصل الحبوب , بينما كان أفضل التضريبات من حيث قوة الهجين والمقدرة الاتحادية الخاصة هو الرشيد × أبو غريب 3 في حاصل حبوب النبات . كانت النسبة بين تباين المقدرة العامة GCA ألى الخاصة SCA على الاتحاد اقل من واحد لجميع الصفات المدروسة عدا أرتفاع النبات يدل ذلك على إن هناك فعلا جينيا سياديا يتحكم في وراثة الصفات عدا أرتفاع النبات يتحكم في وراثته الفعل الجيني ألمضيف. كانت قيم التباين الوراثي السيادي اكبر من قيم التباين الوراثي المضيف لجميع الصفات المدروسة باستثناء أرتفاع النبات و مساحة ورقة العلم ، انعكس ذلك على انخفاض قيم نسبة التوريث بالمفهوم الضيق وزيادة معدل درجة السيادة عن واحد لجميع الصفات المدروسة باستثناء أرتفاع النبات. يمكن الاستفادة من التوليفات الجديدة في إنتاج هجن فردية ذات مقدرة اتحادية خاصة لإنتاج حاصل عالي لان معظم صفاتها كانت تحت تأثير السيادة والسيادة الفائقة