Minia J. of Agr ic. Res. & Develop.
Vol. (35), No. 1, pp. 59-67, 2015

FACULTY OF AGRICULTURE

HETEROSIS AND COMBINING ABILITY IN BREAD WHEAT (*TRITICUM AESTIVUM, L.)*.

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Received: 27 July (2015) Accepted:11August (2015)

ABSTRACT

Six parents of bread wheat genotypes were crossed in a diallel mating to obtain information about performance, combining ability and heterosis for yield and its components . The results highly significant differences among genotypes for all studied traits. Variance due to general and specific combining ability was highly significant for all studied traits. Additive gene effects were predominant in the inheritance of all studied traits, where the ratio of GCA/SCA was more than the unity. Desirable significant heterosis effects over mid and better parents were shown in all studied traits. Desirable significant GCA and SCA effects were found for all studied traits.

INTRODUCTION

Wheat is one of the major cereal crops in Egypt, which receives the most attention of specialists in plant breeding. Development of new high yielding ability wheat cultivars has become a permanent goal in all breeding programs to reduce the gap between production and consumption. For any breeding program aiming at hybridization, knowledge of better combiner parents is a pre-requisite. It is important to achieve genetic gain within limited resources and minimum time. The combining ability analysis provides a guide line to the breeder in evaluating and selecting the elite parents and desirable cross combinations. The analysis further elucidates the nature and the magnitude of various types of gene actions involved in the expression of quantitative characters which help in choosing the parents for hybridization program. The performance of the hybrids is estimated in terms of the percentage increase or decrease of their performance over the mid-parent (heterosis) and better parent (heterobeltiosis) (Inamullah *et al* 2006 and Hochholdinger and Hoecker 2007). From the perspective of the breeder, heterobeltiosis is more effective than heterosis, particularly in the breeding of self-pollinating crops, where the objective is to identify superior hybrids (Lamkey and Edwards 1999). Positive heterosis is desired in the selection for yield and its components, whereas negative heterosis is desired for early cycling and low plant height (Lamkey and Edwards 1999 and Alam *et al* 2004).

MATERIALS AND METHODS

The present investigation was carried out at Experimental Farm, Faculty of Agriculture, Al-Azhar University, Assiut Branch, Egypt during 2013/2014 and 2014/2015 growing seasons. The breeding materials used in this study were Giza 155 (P_1), Giza 164 (P_2), Sids 12 (P_3), Giza 168 (P_4), Giza 162 (P_5) and Sakha 93 (P_6). The studied traits were plant height (cm), spike length (cm), number of spikes/plant, 100-grain weight (gm) and grain yield/plant (gm).

Experimental layout:

In 2013/2014 growing season the tested varieties were crossed in all possible combinations excluding reciprocals, to generate 15 F_1 crosses.

In 2014/2015 growing season the 15 F_1 crosses and their parents were grown in a randomized complete block design of three replications. Each entry was grown in1row, 3 m in long with 50 cm between rows. Planting was done in hills spaced 15 cm apart.The recommended agronomic practices of wheat production were applied at the proper time.The data were recorded on 10 randomly selected plants from each cross and parent. The data were statistically analyzed by using the ordinary analysis of variance to test the significance of differences among genotypes according to Snedecor and Cochran (1982). The variation among parents and F_1 crosses were partitioned into general and specific combining abilities as illustrated by Griffing (1956)Method 2, Model 1. The heterotic effects of F_1 crosses were estimated as percentage from mid and better parent according to Fonseca and Patterson (1968) as follows:

Mid parents heterosis (%) = (F_1 - mid parent/mid parent) x 100.

Better parents heterosis (%)= (F_1 - better parent/better parent) x 100.

RESULTS AND DISSCUSION

Analysis of variance and mean performance:

The analysis of variance (Table (1) cleared the highly significant differences that were found among genotypes for all the studied traits, indicating a wide genetic variability in these materials and the genetic analysis could be performed.

Mean of the six parents and their fifteen F_1 crosses are presented in Table 2. The results revealed that mean of parents was wide extended with a range of 78.56(P_4)-121.05(P_1), 11.11(P_1)-13.29(P_2), 7.48(P_6)-14.63(P_2), 3.12(P_6)-5.26(P_5) and 24.05(P_6)-32.28(P_3) for plant height (cm), spike length (cm), number of spikes/plant, 100-grain weight (gm) and grain yield/plant(gm), respectively. Meanwhile, means of F_1 crosses were extended with a range of 81.63(P_4 x P_6)-125.45(P_1 x P_5), 11.99(P_1 x P_6)-15.63(P_4 x P_5), 8.04(P_2 x P_4)-13.96(P_2 x P_3), 2.45(P_1 x P_2)-5.80(P_4 x P_5) and 8.20(P_1 x P_2)-39.19(P_2 x P_3) for the above mentioned traits, respectively. Apparently, the different means among the six parents and their F_1 crosses seemed to be valuable in improving the studied traits in bread wheat breeding programs. These results are in agreement with those reported by Saad *et. al* ,(2010 and Beche *et. al* ,2013).

Heterosis:

Data in Table 3 showed that there were significant values for the heterosis over mid and better parent for all studied traits, indicating that heterosis played an important role in the inheritance of these traits. For plant height 10 crosses out of 15 had desirable highly negative significant values for the heterosis over mid parent and 1 of them P_4 x P_6 (Giza 168 x Sakha 93) also, showd highly negative significant value for the heterosis over better parent.

For spike length 10 crosses had desirable highly positive significant values for the heterosis over mid and better parent. The three crosses P_4 x P_5 (Giza 168 x Giza 162), P_4 x P_6 (Giza 168 x Sakha 93) and P_5 x P_6 (Giza 162 x Sakha 93) showed desirable highly positive significant values for the heterosis over mid and better parent for number of spikes/plant. For 100-grain weight 8 crosses had desirable highly positive

significant values for the heterosis over mid and better parent. For grain yield/plant 9 crosses showed desirable positive significant or highly significant values for the heterosis over mid and better parent. Generally, the cross P_4 x P_6 (Giza 168 x Sakha 93) showed desirable highly significant values for the heterosis over mid and better parent for all studied traits. As well as, the two crosses P_4 x P_5 (Giza 168 x Giza 162) and P_5 x P_6 (Giza 162 x Sakha 93) showed desirable highly significant values for the heterosis over mid and better parent for all studied traits, except heterosis over mid parent for the two crosses for plant height and P_5 x P_6 (Giza 162 x Sakha 93) for 100-grain weight. These results are supported with the findings of Kobiljski *et. Al*,(2002), Abd El-Aty 2004, Faiz *et. Al*,(2006), Al-Ashkar (2007) and Cific(2012).

Table 1: Mean squares of genotypes, general combining ability (GCA) and specific combining ability (SCA) and their ratios for grain yield and its components.

S.O.V	d.f	Plant height (cm)	Spike length (cm)	Number of Spikes /plant	100-grain weight (gm)	Grain yield/plant (gm)
Replicates	2	1.19	2.30	1.26	2.29	3.44
Genotypes	20	414.98**	4.25**	13.06**	3.00**	240.23**
Error	40	1.28	1.19	1.06	0.35	1.38
GCA	5	497.85**	2.16**	7.64**	1.51**	142.78**
SCA	15	18.49**	1.17**	3.26**	0.83**	59.18**
Error	40	0.43	0.40	0.35	0.12	0.46
GCA/SCA		26.93	1.85	2.34	1.82	2.41

Table 2: Mean performance of six parents and fifteen F_1 crosses for all studied traits.

Geno**types**	Traits				
	Plant height (cm)	Spike length (cm)	Number of Spikes /plant	100-grain weight (gm)	Grain yield/plant (gm)
P_1	121.05	11.11	13.40	4.35	26.36
P_2	96.54	13.29	14.63	4.30	31.20
P_3	95.10	12.92	12.62	4.75	32.28
P_4	78.56	12.66	9.74	4.22	24.51
P_5	102.05	12.37	7.69	5.26	26.69
P_6	91.24	11.50	7.48	3.12	24.05
P_1 x P_2	109.27	12.19	10.27	2.45	8.20
P_1 x P_3	107.46	12.26	10.01	2.91	10.15
P_1 x P_4	103.42	13.14	12.05	2.77	14.75
P_1 x P_5	125.45	13.92	13.45	3.39	12.95
P_1 x P_6	115.45	11.99	12.37	4.67	27.03
P_2 x P_3	97.93	15.19	13.96	5.22	39.19
P_2 x P_4	90.97	14.39	8.04	5.46	30.58
P_2 x P_5	99.42	13.42	11.87	5.22	34.42
P_2 x P_6	101.11	14.93	10.03	4.65	32.82
P_3 x P_4	88.35	13.10	11.42	5.68	30.78
P_3 x P_5	105.49	14.38	11.06	4.66	38.28
P_3 x P_6	93.62	12.95	9.42	5.08	35.88
P_4 x P_5	91.25	15.36	11.04	5.80	33.58
P_4 x P_6	81.63	13.13	10.65	4.62	32.67
P_5 x P_6	99.30	14.50`	8.14	4.93	30.38
L.S.D 0.05	1.86	1.80	1.70	0.98	1.94
L.S.D 0.01	2.50	2.41	2.27	1.31	2.59

Table 3: Heterosis as percentage of mid parent (M.P) and better parent (B.P) in the F_1 crosses for all studied traits.

Genotypes	Traits									
	Plant height (cm)		Spike length (cm)		Number of Spikes /plant		100-grain weight (gm)		Grain yield/plant (gm)	
	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P	M.P	B.P
P_1 x P_2	0.44	- 9.73**	- 0.11	- 8.28**	-26.73**	-29.81**	- 34.40**	- 43.72**	- 71.52**	- 73.73**
P_1 x P_3	-0.57	- 11.23**	2.05*	- 5.08**	-23.02**	- 25.26**	- 35.99**	- 38.67**	- 65.37**	- 68.55**
P_1 x P_4	3.62**	-14.57**	10.56**	3.79**	4.18**	- 10.03**	- 35.38**	- 36.37**	- 42.02**	- 54.31**
P_1 x P_5	12.46**	3.63**	18.55**	12.53**	27.59**	0.40	- 29.43**	- 35.53**	- 51.18**	- 51.48**
P_1 x P_6	8.77**	- 4.63**	6.12**	4.35**	18.54**	- 7.64**	24.98**	7.27**	7.21**	2.52**
P_2 x P_3	2.20**	2.97**	15.95**	14.35**	2.50**	- 4.54**	15.32**	9.90**	23.47**	21.40**
P_2 x P_4	3.91**	- 4.35**	10.93**	8.33**	- 34.02**	- 45.03**	28.20**	26.96**	9.80**	- 1.97**
P_2 x P_5	0.13	- 2.58**	4.59**	0.98	6.42**	- 18.82**	9.13**	- 0.82	18.91**	10.32**
P_2 x P_6	7.69**	4.74**	20.46**	12.34**	- 9.29**	- 31.45**	25.37**	8.13**	18.79**	5.19**
P_3 x P_4	1.75*	- 7.09**	2.44**	1.42	2.13**	- 9.51**	26.72**	19.65**	8.41**	- 4.64**
P_3 x P_5	7.01**	3.37**	13.72**	11.30**	8.96**	- 12.34**	- 6.92**	- 11.46**	29.83**	18.59**
P_3 x P_6	0.48	- 1.56	6.10**	0.26	- 6.24**	- 25.33**	29.18**	7.02**	27.40**	11.16**
P_4 x P_5	1.04	- 10.59**	22.74**	21.32**	26.64**	13.27**	27.87**	15.20**	31.18**	25.83**
P_4 x P_6	-3.68**	- 10.54**	8.69**	3.69**	23.67**	9.31**	25.89**	9.48**	34.54**	33.27**
P_5 x P_6	2.75**	- 2.69**	21.48**	17.19**	7.30**	5.86**	17.61**	- 6.33**	21.50**	15.50**
L.S.D 0.05	1.62	1.87	1.56	1.80	1.47	1.70	0.85	0.98	1.68	1.94
L.S.D 0.01	2.16	2.50	2.08	2.41	1.97	2.27	1.13	1.30	2.24	2.59

Combining ability:

The analysis of variance (Table 1) emphasized that mean squares due to general combining ability (GCA) and specific combining ability (SCA) were highly significant for all studied traits, indicating that additive and non-additive effects were involved in the control of studied traits. Suggesting the predomirnat effect of the additive gene (s) hnvolvedThe ratio of GCA/SCA was more than the unity for all studied traits, in the inheritance of studied traits. Similar results were reported by Gorjanovic and Balalic 2005, Hassan *et al* 2007, Saad *et. al,(* 2010), Zaazaa (2010), Anwar *et. al,(* 2011), Khodadadi *et. al,(* 2012), Yilbirim *et. al,(* 2014) and Ashraf *et. al,(* 2015). .

Table 4: Estimates of general and specific combining ability effects for all studied traits.

Genotypes	Traits				
	Plant height (cm)	Spike length (cm)	Number of Spikes /plant	100-grain weight (gm)	Grain yield/plant (gm)
P_1	13.12*	- 0.90*	1.06*	- 0.80**	- 8.33*
P_2	- 0.81*	0.47	0.87*	0.04	1.90*
P_3	- 1.90**	0.10	0.58**	0.22*	3.31**
P_4	- 10.69*	0.1	-0.47	0.22	- 0.1
P_5	3.35**	0.43*	- 0.69**	0.44**	1.38**
P_6	- 3.08**	- 0.30	- 1.36**	-0.12	1.87**
L.S.D 0.05	0.43	0.41	0.39	0.22	0.44
L.S.D 0.01	0.57	0.55	0.52	0.30	0.59
P_1 x P_2	- 2.79**	- 0.66	- 2.59**	- 1.27**	- 12.86**
P_1 x P_3	- 3.51**	- 0.22	- 2.56**	- 0.98**	- 12.31**
P_1 x P_4	1.24*	0.57	0.54	- 1.12**	- 4.29**
P_1 x P_5	9.24**	1.12*	2.16**	- 0.72	- 7.59**
P_1 x P_6	5.67**	- 0.08	1.75**	1.13**	6.00**
P_2 x P_3	0.88	1.35**	1.59**	0.49	6.50**
P_2 x P_4	2.71**	0.45	- 3.28**	0.73*	1.32*
P_2 x P_5	- 2.87**	- 0.76	0.77	0.27	3.65**
P_2 x P_6	5.25**	1.48**	- 0.41	0.28	1.57**
P_3 x P_4	1.19*	- 0.47	0.39	0.77*	0.12
P_3 x P_5	4.29**	0.58	0.25	- 0.47	6.11**
P_3 x P_6	- 1.15*	- 0.12	- 0.72	0.53	3.23**
P_4 x P_5	- 1.16*	1.47**	1.28**	0.93**	4.84**
P_4 x P_6	- 4.36**	- 0.04	1.56**	0.07	3.44**
P_5 x P_6	- 0.71	1.10*	- 0.74	0.16	0.10
L.S.D 0.05	0.97	0.93	0.88	0.61	1.00
L.S.D 0.01	1.29	1.25	1.18	0.82	1.34

A-General combing ability

Data in table 4 revealed that P_2 (Giza 164) has a desirable significant GCA effects for all studied traits, except 100-grain weight. As well as, the P_3 (Sids 12) had desirable significant GCA effects for all studied traits, except spike length, thusthese two parents can be good general combiners for grain yield/plant along with most of the yield contributing traits and can be recommended as a donor in wheat breeding programs.

B-Specific combing ability

Data in table 4 cleared that desirable negative significant SCA effects were found in plant height. On the other hand desirable positive significant SCA effects were found in the other traits. The cross P_4 x P_5 (Giza 168 x Giza 162) had desirable significant SCA effects for all studied traits, so it can be a good specific combination for grain yield/plant along with most of the yield contributing traits

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الملخص العربي

قوة الهجين والقدرة على الائتلاف في قمح الخبز

مختار حسن هريدي – ابراهيم نجاح عبد الظاهر
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أجريت هذه الدراسة خلال موسمي الزراعة 2014/2013–2015/2014 بمزرعه كليه الزراعة بجامعه الأزهر بأسيوط لدراسة قوه الهجين والقدرة على الائتلاف للمحصول ومكوناته باستخدام الهجن الدائريه (ما عدا الهجن العكسيه) لسته أصناف من القمح هى : جيزه 155– جيزه 164– سدس 12– جيزه 168– جيزة 162– سخا 93. والصفات المدروسة هي ارتفاع النبات (سم) – طول السنبله (سم)–عدد السنابل/نبات – وزن الـ 100 حبه (جم) – محصول الحبوب/نبات (جم).

اظهر تحليل التباين وجود اختلافات عاليه المعنويه بين الآباء والهجن لكل الصفات تحت الدراسة. الفعل المضيف كان هو المتحكم في وراثه الصفات التي درست حيث كانت النسبة بين القدره العامه على الإئتلاف والقدره الخاصه على الإئتلاف اكبر من الواحد.

سجل الهجين (جيزه 168 x سخا 93) قيما مرغوبه وعاليه المعنويه لقوه الهجين بالنسبه لمتوسط الأبوين وافضل الأبوين لكل الصفات تحت الدراسة.

سجل الصنف جيزه 164 قيما مرغوبه ومعنويه لتأثيرات القدرة العامة على الائتلاف لكل الصفات فيما عدا وزن الـ 100 حبه. كما سجل الأب سدس 12قيما مرغوبه ومعنويه لتأثيرات القدره العامه على الائتلاف لكل الصفات فيما عدا طول السنبلة مما يدل على اهميه استخدام هذان الصنفان فى برامج التربيه لتحسين محصول حبوب القمح.

سجل الهجين (جيزه 168 x جيزه 162) قيما مرغوبه ومعنويه لتأثيرات القدره الخاصه على الائتلاف لكل الصفات.