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HETEROSIS AND NATURE OF GENE ACTION FOR EARLINESS AND YIELD COMPONENTS IN BREAD WHEAT *(Triticum aestivum L.)*

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ABSTRACT

Three Egyptian and four exotic parental varieties of bread wheat were crossed in half diallel crosses mating design to study heterosis and nature of gene action for earliness and yield components. Mean squares of genotypes were found to be highly significant for all studied traits, providing evidence for presence of considerable amount of genetic variation among studied genotypes. The results showed that the majority of crosses exhibited significant heterosis values versus the mid parents for all studied traits. The results revealed that the general combining ability (GCA) and specific combining ability (SCA) mean squares were highly significant for all studied traits, indicating that both additive and non additive genetic variances were important in the inheritance of these traits. The results also indicated that the magnitudes of additive genetic variances (σ^2A) were positive and lower than those of non additive genetic variances including dominance (σ^2D) one for earliness, indicating that non additive gene action played a major role in the inheritance of earliness. Whereas, the magnitudes of additive genetic variances (σ^2A) were positive and larger than those of non additive (σ^2D) ones for yield components, suggesting that the inheritance of yield component traits was mainly controlled by additive gene effects. The broad sense heritability estimates (h^2_b%) were more than 89% and larger than their corresponding narrow sense heritability (h^2_n%) for all studied traits. However, the estimates of narrow sense heritability were 39.11% for earliness and more than 50% for yield components. The results showed that Sakha 8 (P_2), Gemmeiza 3 (P_3) and Kal/Bb (P_6) were excellent general combiners for earliness and yield components. The cross combinations (P_1xP_3), (P_2xP_4), (P_4xP_5) and (P_4xP_7) showed desirable SCA effects and significant heterosis values for most studied traits. These promising crosses could be used for wheat hybrids and segregating generations for transgressive segregants.

INTRODUCTION

Development of a new wheat cultivars required a considerable time and efforts. Therefore, it is desirable to estimate heterosis and combining ability as earlier time of the breeding program. Successful breeding programs should be initiated by a good understanding of the mode of inheritance of desirable traits. Combining ability analysis is used to identify the desirable parents in cross combinations and provides detailed informations about relative magnitude of additive and non additive types of gene action for studied traits.

In this respect, additive and non additive genetic variances as well as heterotic effects for earliness and yield components have been studied by several investigators in wheat. Non additive gene action was important than additive one in the expression of earliness (El-Hennawy, 1991; El-Sherbeny,1999 and Bayoumi, (2004) and yield components (Saad *et al*, 1997 and Hamada *et al*, 1997) . On the other hand, Eissa (1993); El-Shami *et al* (1996); Ageez and El-Sherbeny (1998); Ismail *et al* (2001) and El-Sherbeny (2004) reported that additive genetic variances played the major role in the inheritance of yield components traits. However, Darwish (2003), El-Seidy (2003), Abd El-Aty (2004) and Bayoumi (2004) stated that both additive and non additive gene action were involved in the inheritance of most yield component traits.

Heterosis values over the mid parents for earliness and yield components were estimated by Alkoddoussi and Hassan (1991); El-Borhamy (1995); EL-Hennawy (1996) and Esmail and Kattab (2002).

This investigation was conducted to detect the amounts of heterosis and types of gene action controlling the inheritance of earliness and yield components in a 7x7 diallel crosses mating design of wheat parental.

MATERIALS AND METHODS

The present study was carried out at the Experimental Research Farm of Sohag, Faculty of Agriculture, South Valley University during the two successive growing seasons of 2002/2003 and 2003/2004. Seven bread wheat cultivars (*Triticum aestivum L.*) representing a wide range of diversity were chosen as parents. Three of them are local cultivars [Giza 164 (P_1), Sakha 8 (P_2) and Gemmeiza 3 (P_3)]. While, the other four genotypes were introduced from Mexico [Tsi/vee \`S\`(P_4) and Bau\`S\` (P_7)] and Syria [Kara wan (P_5) and Kal/Bb (P_6)].

In 2002/2003 growing season, the seven parents were crossed according to a half diallel crosses mating design in all possible combinations excluding reciprocals to produce 21 F_1 hybrids. All parental cultivar were also self pollinated to increase seeds from each one.

In 2003/2004 growing season, the seven parental genotypes and their 21 F_1 hybrids were grown in a randomized complete blocks design with three replications. Each replicate contained 28 plots. Each plot consisted of one row with 3 m. long and 20 cm. apart between rows. Plants were spaced by 10 cm. within row. All recommended cultural practices were applied for wheat production at proper time.

Heading date was measured as the number of days from planting to the day when 50% of the heads were extruded from the flag leaf sheath. At maturity, data were recorded on 10 guarded plants chosen at random from the middle row of each plot in each replicate for spike length (SL), number of spikes per plant (S/P),100 grain weight (100 GW) and grain yield per plant (GY/P).

Data were subjected to the analysis of variance to test the significance of the differences among the 28 genotypes (seven parents and their 21 F_1 hybrids) according to Cochran and Cox (1957). General combining ability (GCA) and specific combining ability (SCA) variances were partitioned from total genotypic variance according to Griffing (1956) as method 2, model 1. The estimates of additive (σ^2_A), non-additive (σ^2_D) genetic variances including dominance were calculated according to Matzinger and Kempthorne (1956).

RESULTS AND DISCUSSION

Genotypic variations

The mean squares of genotypes (Table 1) were found to be highly significant for all studied traits. This provides evidence for presence of considerable amounts of genetic variation among studied genotypes. These results were in harmony with those previously obtained by Hamada et al (1997); Ageez and El-Sherbeny (1998); Ismail et al (2001); Abd El-Aty (2004) and El-Sherbeny (2004).

Table1: The results of the analysis of variance and the mean squares of the F_1 hybrids and their parents for all studied traits.

SV	DF	HD	SL	S/P	100GW	GY/P
Reps	2	1.28	0.28	2.91	0.01	7.22
Genotypes	27	53.63**	2.46**	16.12**	1.82**	155.1**
Error	54	1.37	0.27	0.81	0.03	2.01

** Significant at 1% level of probability.

Estimates of heterosis

The estimates of heterosis over mid parents for all studied traits are presented in Table 2. Earliness is an important aim in wheat, thus, the negative heterotic value for number of days to heading is desirable in breeding program. In this direction, seven out of 21 crosses were significantly flowered earlier than their mid parents with negative heterotic values ranged from –3.02% to –5.95%.

Concerning yield components, 20 out of 21 crosses exhibited significant positive heterosis values relative to The mid parents for spike length and ranged from 1.43% to 9.88%. Whereas, only one cross (P_2xP_4) showed negative significant heterosis value (-5.40%) for the same trait. Significant positive heterosis values were obtained for 16 out of 21 crosses for number of spikes per plant (3.06% to 22.29%). As for 100-grain weight, 17 out of 21 crosses were significantly heavier their mid parents with heterotic values ranged from 1.02 % to19.77%. Regarding to grain yield per plant, 11 out of 21 crosses were significant and better yielding than their mid parents and ranged from 4.13% to18.39%.

These results indicated that the majority of crosses were significantly earlier and high yielding than their mid parents. This finding suggested the important role of non-additive gene action in the inheritance of studied traits. These results were in agreement with those reported by Alkoddoussi and Hassan (1991); El-Borhamy (1995); El-Sayed et al (2000) and Abd El-Aaty (2004).

Table2: The estimates of heterosis over the mid parents for all studied traits.

Crosses	HD	SL	S/P	100GW	GY/P
P_1xP_2	-4.39**	4.14**	1.68	19.77**	18.39**
P_1xP_3	-2.28	3.19**	10.64**	17.02**	9.36**
P_1xP_4	-2.00	5.01**	-3.31**	6.42**	1.96
P_1xP_5	-2.04	9.88**	9.14**	8.96**	5.41**
P_1xP_6	-4.38**	8.60**	16.08**	4.47**	8.43**
P_1xP_7	-3.02*	6.17**	3.06**	6.20**	5.20**
P_2xP_3	0.65	6.86**	5.17**	8.06**	-5.43**
P_2xP_4	-5.95**	-5.40**	21.89**	-11.55**	-10.27**
P_2xP_5	-1.09	1.71**	5.63**	-6.15**	-7.31**
P_2xP_6	-1.81	6.60**	19.21**	7.61**	-7.36**
P_2xP_7	-2.17	4.08**	7.55**	2.29**	-9.00**
P_3xP_4	-1.94	4.50**	-12.22**	1.02**	9.21**
P_3xP_5	-2.36	1.94**	22.03**	6.08**	-10.26**
P_3xP_6	-3.37*	4.44**	-8.69**	5.96**	3.41
P_3xP_7	-3.70*	3.20**	0.63	1.40**	4.13*
P_4xP_5	-3.64*	8.33**	7.19**	9.68**	7.36**
P_4xP_6	-1.67	6.38**	12.50**	5.30**	8.72**
P_4xP_7	-1.32	9.09**	3.70**	7.81**	4.20*
P_5xP_6	-2.05	6.30**	22.29**	-2.29**	1.72
P_5xP_7	-0.66	3.88**	9.09**	5.88**	2.62
P_6xP_7	-2.67	1.43*	20.86**	-2.37**	5.11**
LSD 5%	2.86	1.28	2.20	0.42	3.48
1%	3.80	1.70	2.93	0.56	4.63

*,** Significant at 5% and 1% levels of probability, respectively.

Combining ability analysis

Combining ability analysis of variance for all studied traits are shown in Table 3. The results exhibited that the general combining ability (GCA) and specific combining ability (SCA) mean squares showed highly significance for all studied traits. In addition, the magnitudes of GCA was larger than those SCA one for earliness and yield components. The results also indicated that both GCA and SCA were important in the inheritance of these traits. It could be concluded that the obtained heterosis values mainly due to the Epistatic effect (A x A). Similar results were obtained by Hamada et al (1997); Ageez and El-Sherbeny (1998); Bayoumi (2004) and Abd El-Aty (2004).

Table 3: The results of the analysis of variance of half diallel crosses of for the F_1 hybrids and their parents for all studied traits.

SV	DF	HD	SL	S/P	100GW	GW/P
GCA	6	36.62**	2.29**	16.73**	2.01**	166.92**
SCA	21	12.52**	0.40**	2.13**	0.20**	18.77**
Error	54	0.46	0.09	0.27	0.01	0.67

*,** Significant at 1% level of probability.

GCA effects (g_i)

Estimates of general combining ability effects (g_i) of each parents for all studied traits are presented in Table 4. The results showed that Sakha 8 (P_2), Gemmeiza 3 (P_3) and Kal/Bb (P_6) were the best combiners for earliness and yield components traits. Therefore, these parents could be utilized in a breeding program for early high yielding cultivars. While, the other parents were found to be the poorest general combiners for earliness and yield components.

Table4: Estimates of general combining ability effects (g_i) of each parent for all studied traits.

Parents	HD	SL	S/P	100GW	GY/P
Giza 164 (P_1)	2.50**	-0.99**	-1.28**	-0.25**	-2.57**
Sakha 8 (P_2)	-6.83**	0.80**	1.87**	1.04**	6.09**
Gemmeiza 3 (P_3)	-0.65**	0.12	1.38**	0.10	1.70**
Tsi/vee`S` (P_4)	2.17**	-0.94**	-0.46**	-0.33**	-3.48**
Karawan (P_5)	0.22	-0.09	-0.05	-0.28**	-2.10**
Kal/Bb (P_6)	-1.06**	0.49**	0.61**	0.14**	1.52**
Bau`S` (P_7)	3.65**	0.61**	-2.07**	-0.42**	-1.17**
SE (gi)	0.21	0.09	0.16	0.03	0.25

*,** Significant at 5% and 1% levels of probability, respectively.

SCA effects (S_{ij})

Estimates of specific combining ability effects (S_{ij}) of each cross combination for all studied traits are cleared in Table 5. The results revealed that seven out of 21 crosses showed desirable SCA effects for earliness, among them only three crosses exhibited significant values which could give early genotypes in segregating generations. It could be also observed that the three desirable crosses (P_2xP_4), (P_3xP_7) and (P_4xP_5) were resulted from crossing (good x poor), (good x poor) and (poor x poor) general combiners, respectively.

With respect to yield component traits, four, seven, eight and 10 crosses showed significant positive SCA effect values for spike length (SL), number of spikes per plant (S/P), 100 grain weight (100 GW) and grain yield per plant (GY/P), respectively. Regarding to spike length, the four crosses were resulted of good x poor general combiners [(P_2 x P_3) and (P_4 x P_7)] and poor x poor general combiners [(P_1 x P_5) and (P_4 x P_5)]. As for number of spikes per plant, the seven crosses which revealed desirable SCA were resulted from crossing good x poor general combiners. Concerning 100 grain weight, one cross (P_2xP_6) was good x good general combiner, three crosses (P_1 X P_2),(P_2 x P_3) and (P_4xP_6) were good x poor general combiners and the four crosses (P_1 X P_3),(P_4 X P_5),(P_4 X P_7) and (P_5 X P_7) were poor x poor general combiners. For grain yield per plant, seven crosses were resulted from good x poor general combiners and three crosses (P_4 x P_5), (P_4 x P_7) and (P_5 x P_7) were poor x poor general combiners.

It could be noticed that the best cross combinations were obtained from crossing (good x good),(good x poor) and (poor x poor) general combiners. Therefore, it is not necessary that parents having estimates of high GCA effects would also give high estimates of SCA effects in their respective cross combinations. The previous promising crosses which gave desirable SCA effects could be used for wheat hybrids and segregating generations for transgressive segregants.

Table5:The estimates of Specific combining ability effects (S_{ij}) of each cross for all studied traits.

Crosses	HD	SL	S/P	100GW	GY/P
P_1xP_2	-0.48	0.12	-0.66	0.79**	16.00**
P_1xP_3	-1.00	-0.11	1.33**	0.37**	3.40**
P_1xP_4	1.85**	0.06	-0.73	-0.01	-4.16**
P_1xP_5	0.93	0.62*	0.09	-0.09	0.96
P_1xP_6	-0.70	0.40	0.94*	-0.11	1.55**
P_1xP_7	0.37	0.24	-0.15	-0.05	-0.54
P_2xP_3	-0.67	0.68*	0.22	0.28**	-3.07**
P_2xP_4	-2.48**	-0.99**	2.43**	-0.76**	-8.42**
P_2xP_5	0.93	-0.13	-0.66	0.46**	-3.66**
P_2xP_6	0.96	0.48	1.36**	0.37**	-5.91**
P_2xP_7	1.37*	0.25	0.04	-0.03	-6.63**
P_3xP_4	1.67**	0.18	-1.92**	0.12	6.31**
P_3xP_5	0.41	-0.19	2.50**	0.11	-9.17**
P_3xP_6	0.11	0.10	-2.15**	-0.11	1.41
P_3xP_7	-1.48*	0.03	-0.14	0.13	2.79**
P_4xP_5	-2.07**	0.54*	0.01	0.41**	5.61**
P_4xP_6	0.29	0.26	0.69	0.21*	4.83**
P_4xP_7	0.37	0.73**	0.03	0.30**	1.58*
P_5xP_6	1.04	0.22	1.27**	-0.20*	0.92
P_5xP_7	2.11**	0.02	-0.05	0.19*	2.46**
P_6xP_7	-1.19	-0.33	1.30**	-0.20*	2.68**
SE (s_{ij})	0.61	0.27	0.47	0.09	0.37

*,** Significant at 5% and 1% levels of probability, respectively.

Gene action

Estimates of all types of gene action for all studied traits are given in Table 6. The results indicated that the magnitudes of additive genetic variances (σ^2A) were positive and lower than those of non additive genetic variances including dominance (σ^2D) one for earliness. This finding could be verified by the ratio ($\sigma^2D/\ \sigma^2A)^{1/2}$ which was more than one, indicating that non additive gene action played a major role in the inheritance of earliness. Similar results were obtained by El-Hennawy (1991), El-Sherbeny (1999) and Bayoumi (2004) .In the contrary, the magnitudes of additive genetic variances (σ^2A) were positive and larger than those of non additive (σ^2D) ones for yield components. This fact could also verified by the ratio of ($\sigma^2D/\ \sigma^2A)^{1/2}$ which was less than one. This result suggested that the inheritance of yield component traits was mainly controlled by additive gene effects. The same trend was observed by El-Shami *et al* (1996); Ageez and El-Sherbeny (1998); Ismail *et al* (2001) and El-Sherbeny (2004)

Table6: Estimates of genetic parameters and heritability in broad (h^2_b%) and narrow (h^2_n%) sense for all studied traits.

Genetic parameters	HD	SL	S/P	100GW	GY/P
σ^2A	8.04	0.49	3.66	0.44	36.94
σ^2D	12.06	0.31	1.86	0.19	18.10
σ^2e	0.46	0.09	0.27	0.01	0.67
$(\sigma^2D/\sigma^2A)^{1/2}$	1.22	0.80	0.71	0.66	0.70
H^2_n%	39.11	55.06	63.21	68.75	66.31
H^2_b%	97.76	89.88	95.34	98.43	98.79

Estimates of heritability

The results in Table 6 showed that broad sense heritability estimates (h^2_b%) were more than 89% and larger than their corresponding narrow sense heritability (h^2_n%) for all studied traits. The estimates of narrow sense heritability were 39.11% for earliness and more than 50% for yield components. The estimates of narrow sense heritability presented additional evidence about the important of non additive gene action for earliness and additive gene action for yield components. The estimate of narrow sense heritability for earliness was relatively low (El-Sherbeny, 2004), while it was found to be moderately high (Hamada *et al*, 2002 and Darwish, 2003). Concerning yield components, narrow sense heritability estimates were moderately high for number of spikes per plant (Ismail *et al*, 2001), 1000 grain weight (El-Seidy, 2003 and Bayoumi, 2004) and grain yield per plant (El-Sherbeny, 2004).

It could be concluded that the cross combinations (P_1xP_3), (P_2xP_4), (P_4xP_5) and (P_4xP_7) showed desirable SCA effects and significant heterosis values. These promising crosses could be used for wheat hybrids and segregating generations for transgressive segregants. The estimates of nature of gene action and narrow sense heritability in this set of genetic materials emphasize that selection program in segregating generations could be possible for isolating new high yielding wheat cultivars.

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قوة الهجين وطبيعة فعل الجين لصفات التزهير ومكونات المحصول في قمح الخبز

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تم إجراء هذا البحث لدراسة قوة الهجين وطبيعة الفعل الجيني لصفات التزهير ومكونات المحصول وذلك باستخدام نظام التهجين النصف دائري بين سبعة أصناف من قمح الخبز تشمل ثلاث تراكيب وراثية مصرية و أربع تراكيب مستوردة.

ويمكن تلخيص أهم النتائج فيما يلي:

- أظهرت النتائج أن معظم الهجن أعطت قوة هجين عالية ومعنوية بالنسبة لمتوسط الأبوين وذلك لمعظم الصفات المدروسة.
- كانت تقديرات القدرة العامة والخاصة علي التآلف معنوية جدا لكل الصفات المدروسة مما يؤكد أهمية التباين الوراثي المضيف وغير المضيف في وراثة الصفات تحت الدراسة.
- اتضحت النتائج أن الأباء P_2, P_3, P_6 لها قدرة عامة عالية علي التآلف لكل الصفات المدروسة. كما كانت الهجن (P_1xP_3)،(P_2xP_4) ، (P_4xP_5)، (P_4xP_7) ذات قدرة خاصة عالية علي التآلف لصفة التزهير ومعظم صفات المحصول .
- كانت قيمة التباين الوراثي غير المضيف أكبر من التباين الوراثي المضيف لصفة التزهير، بينما كانت قيم التباين الوراثي المضيف أكبر من التباين الوراثي غير المضيف لصفة المحصول ومكوناته.
- كانت أعلي قيم لمعامل التوريث في المدى الواسع أكبر من ٨٩% وكانت أعلي من قيم معامل التوريث في المدى الضيق لكل الصفات المدروسة .و كانت قيم معامل التوريث في المدى الضيق (٤٣,٩١%) لصفة التزهير بينما كانت أعلي من(٥٠%) لصفات المحصول ومكوناته.
- طبقا لنتائج التحليل الوراثي للصفات تحت الدراسة فإن الانتخاب في الأجيال الانعزالية للهجن المبشرة قد يكون مجديا في الحصول علي تراكيب وراثية عالية المحصول..