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ESTIMATION OF SOME GENETIC PARAMETERS FOR SOME AGRONOMIC CHARACTERISTICS IN THREE CROSSES OF BREAD WHEAT

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ABSTRACT

Six populations; P_1, P_2, F_1, F_2, BC_1 and BC_2 were used in this study to determine quantitative genetic parameters. The means of the six generations were recorded for number of days to heading , days to physiological maturity, plant height, number of spikes per plant, number of kernels per spike, 100-kernel weight and grain yield per plant in three crosses namely; Giza 168 × Gemmiza 10, Giza 168 × Sakha 69 and Sakha 69 × Giza 163 generated from four diverse parents. The experiment was conducted in 2005/06, 2006/07 and 2007/08 wheat-growing seasons at Sakha Agric. Res. Station. Analyzed data revealed that sufficient genetic variations were found among generations for all the characters studied in all crosses. The results of the genetic analysis showed that the genetic variance among F_2 plants were genetically different for all studied characters in the three wheat crosses except for 100-kernel weight in the cross Giza 168 × Gemmiza 10. The additive, dominance and epistatic gene effects were important in controlling the inheritance of number of days to heading, number of spikes per plant, number of kernels per spike and grain yield. Heritability estimates in broad and narrow senses were generally moderate to high for most studied characters in the three crosses. The expected genetic advance estimates from selection in the F_2 were low for days to heading and days to physiological maturity, 100-kernel weight in crosses Giza 168 × Gemmiza 10 and Giza 168 × Sakha 69 and for plant height in cross Sakha 69 × Giza 163. Average degree of dominance was less than unity for days to physiological maturity in cross Giza 168 × Gemmiza 10, for plant height in cross Giza 168 × Sakha 69 and for grain yield per plant in the three crosses indicating the presence of partial dominance. Significant heterosis estimates were obtained for days to heading, days to physiological maturity, plant height and 100-kernel weight in most crosses.
Keywords: Bread wheat, Joint scaling test, Gene effects, Heritability

INTRODUCTION

Bread wheat (*Triticum aestivum* L.) is a major source of nourishment. Wheat requirements in Egypt are growing at an exorbitant rate due to rapid increases in population. Grain yield is a complex character made up of the interaction between different yield components under different environmental effects. Because of this complex interaction, yield components should also be investigated to improve grain yield (Novoselovic *et al.*, 2004). The importance of wheat is increasing day by day due to increased human population pressure in the country. An understanding of genetic factors determining of agronomic characters of yield components is a primary step for breeding studies. Generation mean analysis is a simple estimate but useful technique for estimating gene effects for a polygenic trait, its greatest merit laying in the ability to estimate epistatic gene effects such as additive × additive (aa), dominance × dominance (dd) and additive × dominance (ad) effects (Singh and Singh, 1992). Przulj and Mladenov (1999) indicated that additive genetic effect was predominent but epistatic dominance gene action was also important. In this respect, additive and dominance gene effects with additive x additive epistasis were found to control many traits (Menshawy 2000 and Abd El-Aty 2002). Also, additive and dominance gene effects were important in the inheritance of plant height, number of spikes/plant, number of kernels per spike and grain yield/plant (Awaad 2002) and Salem *et al*., 2000). In addition, moderate to high broad and narrow sense heritability estimates were obtained for days to heading, days to maturity, plant height, grain yield, spikes per plant, number of kernels per spike, 100-kernel weight (Abd El-Rahman, 2008).

This research was carried out to provide information about gene effects and available genetic variability for the most important quantitative characters of bread wheat, and to evaluate the variation and pattern of the transgressive segregation revealed in populations of bread wheat developed from backcrossing program for some economic characters. The effectiveness of backcross breeding programs can be improved by evaluating transgressive segregations for shelf life, and subsequently selecting for those with high yield and other related characters before crossing them back to the recurrent parents.

MATERIALS AND METHODS

The three crosses used in the present study were derived from the four wheat cultivars Giza 168, Gemmiza 10, Sakha 69 and Giza 163. The name and pedigree of parental genotypes are given in Table 1. These genotypes were used to obtain the following three crosses; cross 1 (Giza 168 × Gemmiza 10), cross 2 (Giza 168 × Sakha 69) and cross 3 (Sakha 69 × Giza 163) during the winter growing season 2005/06 at the Experimental Farm of Sakha Agricultural Research Station. During the 2006/07 season, the parental wheat genotypes and the obtained hybrid seeds were sown to produce F_2 seeds and to be backcrossed to their respective parents to produce BC_1 and BC_2 seeds. In 2007/08 season, six populations of each cross (P_1, P_2, F_1, F_2, BC_1, and BC_2) were sown using a randomized complete blocks design with three replications in a final experiment.

The rows were 4 m long, 30 cm apart and plants were spaced 20 cm within rows. For each cross, number of rows per replication were one for non segregating generations (P_1, P_2, and F_1), two for each backcross (BC_1 and BC_2) and six for F_2 generation. Wheat plants were subjected to the recommended cultural practices during the growing season. Estimated data for each cross were recorded on individual plant basis represented by 30 plants for each parent and F_1, 80 plants for each backcross, and 145 plants for each F_2 population. The characters assessed were; days to heading (DH), days to physiological maturity (DM), plant height (PH), number of spikes per plant (SP^{-1}), number of kernels per spike (KS^{-1}), 100-kernel weight (KW) and grain yield per plant (GYP^{-1}).

Table 1: Commercial name, cross name and pedigree of the four parental wheat genotypes.

Parent	Pedigree
Gemmiza 10	Maya74 "S" / On//1160 – 147/3/Bb/Gll/4/Chat "S" /5/Crow "S". CGM 5820 - 3GM - 1GM - 2GM – 0GM.
Giza 168	Mrl / Buc // Seri CM93046-8M-0Y-0M-2Y-0B- 0GZ
Giza 163	*T. aestivum* / Bon // Cno / 7c CM33009-F-15M-4Y-2M-1M-1M-1Y-0M
Sakha 69	Inia / RL 4220 // 7C /3/ YR"S" CM15430-2S-6S-0S-0S

The collected data were analyzed to test the differences among parental genotypes using "t" test before considering the biometrical analysis. Moreover, "F" ratio which was calculated to test the significance of genetic variance among F_2 plants according to Gamble's procedure (1962).

Scaling test and gene action parameters:

Simple scaling tests (A, B and C) were applied according to Mather and Jinks (1982) formula to test the presence of non- allelic interactions. According to the methodology of Gamble (1962), the following notation for gene effects have been used: additive (a), dominance (d), additive × additive (aa), additive × dominance (ad), dominance × dominance (dd) effect. The type of epistasis was determined only when dominance (d) and dominance × dominance (dd) effects were significant. For computing joint scaling test and six-parameter model values, Microsoft Excel Computer Software was used.

Genetic parameters:

The genetic components of variances; mean degree of dominance $(H/D)^{0.5}$, heritability in broad sense (h^2b) and narrow sense (h^2n), genetic advance (G.S), heterosis above better parent and genetic advance as percentage of the F_2 mean were estimated as follow:

Average degree of dominance = $(H/D)^{0.5}$, Heritability in broad and narrow senses, and heterosis compared to better parent were calculated according to Mather and Jinks (1982). The expected genetic gain resulting from selection in a character (GS %) was computed by the formula reported by Allard (1960).

RESULTS AND DISCUSSION

The mean values of the six populations, the t-test and F test are presented in Table 2. The data revealed that the parental means showed highly significant different for all studied characters except days to maturity, number of spike per plant, 100-kernel weight and grain yield per plant in the first cross. Also, the means of days to heading and grain yield per plant in the second cross and number of kernels per spike in the third one were nonsignificant different. F_1 generation values were high between the two parents for most characters in the three crosses (Table 2). On the other hand, the values were lower or higher than that of the two parents. These results indicated the presence of partial and over dominance, respectively.

The genetic variance among F_2 plants were genetically different for all studied characters in the three wheat crosses except for 100-kernel weight in cross 1 despite of insignificance of the mean values of the two parents. This could be attributed to the new recombinations resulted in the F_2 and the gene dispersion in the two parents (Kearsey, 1993). Thus, the genetic analysis was not completed for 100-kernel weight in cross 1. Data of backcrosses indicated that segregation was in the direction of their respective recurrent parents.

Table 2: Means, t test and F test in the three wheat crosses for studied agronomic traits.

Traits	Crosses	P_1	P_2	F_1	BC_1	BC_2	F_2	t test	F ratio
DH	C_1	109.50	103.45	104.90	106.94	102.74	106.21	**	**
	C_2	103.45	102.05	102.95	102.66	102.11	99.24	NS	**
	C_3	102.05	115.95	107.05	104.62	111.89	109.68	**	**
DM	C_1	152.35	152.05	150.60	150.05	149.05	149.51	NS	**
	C_2	152.05	150.05	148.35	148.76	148.47	146.06	**	**
	C_3	150.05	153.85	151.15	148.94	150.42	148.72	**	**
PH	C_1	94.25	109.00	103.50	99.82	103.06	102.31	**	**
	C_2	109.00	113.50	109.50	106.78	112.53	109.37	**	**
	C_3	113.50	120.00	124.00	115.29	118.18	118.72	**	**
SP^{-1}	C_1	23.40	23.05	24.60	21.61	21.39	24.39	NS	**
	C_2	23.05	27.35	23.15	22.24	26.15	28.41	*	**
	C_3	27.35	21.00	25.10	22.81	19.94	31.01	**	**
KS^{-1}	C_1	67.32	79.95	79.40	73.98	75.81	71.31	**	**
	C_2	79.95	64.22	72.74	80.55	70.78	70.14	**	**
	C_3	64.22	63.49	72.38	67.75	65.81	56.63	NS	**
KW	C_1	4.43	4.35	4.47	4.18	4.16	4.20	NS	**NS**
	C_2	4.35	5.06	4.43	4.15	4.63	4.31	**	**
	C_3	5.06	4.98	4.96	5.03	4.97	4.64	NS	**
GYP^{-1}	C_1	56.95	56.44	58.49	46.54	52.73	51.38	NS	**
	C_2	56.44	63.04	61.94	43.69	52.24	55.41	NS	**
	C_3	63.04	41.21	65.93	52.29	42.95	55.35	**	**

DH = Days to heading, DM = Days to physiological maturity, PH = Plant height and SP^{-1} = Number of spikes per plant, KS^{-1} = Number of kernels per spike, KW = 100-kernel weight, GYP^{-1} = Grain yield per plant.
C 1 = Giza 168 × Gemmiza 10, C 2 = Giza 168 × Sakha 69 and C 3 = Sakha 69 × Giza 163

Scaling tests and types of gene action:

Scaling test data of the studied traits in the three wheat crosses are presented in Table 3. A and B scaling tests provide an evidence for the presence of aa (additive × additive), ad (additive × dominance) and dd (dominance × dominance) gene interaction. The C scaling test provides test for (dominance × dominance) epistasis.

The calculated values of A, B and C scaling tests for all studied characters in the three crosses were significant except for plant height in the first and second crosses .These findings indicated that the six parameter model is valid to explain the nature of gene action for these characters. Meanwhile, non of A, B or C scaling tests were significant, indicating the adequacy of the three parameter model to explain the type of gene action in the first and second crosses for plant height.

Table 3: Scaling test of the studied traits in the three wheat crosses

Traits	Crosses	Scaling test		
		A	B	C
DH	C_1	-8.52**	5.13**	2.08
	C_2	-1.08	-0.79	-14.43**
	C_3	0.15	0.79	6.60**
DM	C_1	-2.86**	-4.56**	-7.56**
	C_2	-2.87**	-1.46	-14.55**
	C_3	-3.32**	-4.15**	-11.33**
PH	C_1	-4.85	0.37	-1.01
	C_2	2.55	-5.44	-4.04
	C_3	-13.41**	-1.15	-6.60*
SP^{-1}	C_1	-4.78*	-4.87*	1.92
	C_2	6.27*	-6.19**	16.93**
	C_3	-6.83**	-6.22**	25.48**
KS^{-1}	C_1	5.23	-11.73**	-20.83**
	C_2	-11.58**	24.59**	-9.10
	C_3	-1.09	-4.24	-45.96**
KW	C_2	-0.20	-0.52**	-1.02**
	C_3	0.11	-0.07	-1.39**
GYP^{-1}	C_1	-21.85**	-35.98**	-24.86*
	C_2	-20.50**	-31.01**	-21.72*
	C_3	-2.57	-43.07**	-14.69

DH = Days to heading, DM = Days to physiological maturity, PH = Plant height and SP^{-1} = Number of spikes per plant, KS^{-1} = Number of kernels per spike, KW = 100-kernel weight, GYP^{-1} = Grain yield per plant.
C 1 = Giza 168 × Gemmiza 10, C 2 = Giza 168 × Sakha 69 and C 3 = Sakha 69 × Giza 163
***, ** = significant at 0.05 and 0.01 levels of probability, respectively.**

Types of gene action for the studied characters in the three crosses are presented in Table 4. The results indicated that the differences among the values of F_2 mean (m) were significant for all studied characters in the three wheat crosses.

Additive gene effects (a) were positive and significant in the first two crosses for plant height, in the second and third crosses for number of spikes per plant, in the second cross for 100-kernel weight and in the three crosses for grain yield per plant. The obtained results indicate that selection could be effective for these characters in early generations. Meanwhile, negative and significant values were detected for days to heading in cross 1 and cross 3, for days to maturity and plant height in cross 3 and number of kernels per spike in cross 2. These results indicate that the materials used in this study have decreasing alleles for these characters and selection to improve it could not be effective except for plant height if shorter cultivars are desired.

Table 4: Gene action parameter of the studied traits in the three wheat crosses.

Traits	Crosses	Gene action parameter					
		m	a	d	aa	ad	dd
DH	C_1	106.21**	-3.80**	-7.04**	-5.46**	-6.83**	8.85**
	C_2	99.24**	0.55	12.76**	12.56**	-0.15	-10.69**
	C_3	109.68**	-7.27**	-7.62**	-5.67**	-0.32	4.73
DM	C_1	149.51**	1.00	-1.45	0.15	0.85	7.26 **
	C_2	146.06**	0.29	7.52**	10.22**	-0.71	-5.89
	C_3	148.72**	-1.48**	3.06	3.86	0.42	3.61
PH	C_1	102.31**	4.76*	-1.60	-	-	-
	C_2	109.37**	6.25*	-0.60	-	-	-
	C_3	118.72**	-2.88**	-0.71	-7.96*	0.37	22.51**
SP^{-1}	C_1	24.39**	0.22	-10.20**	-11.57**	0.05	21.22**
	C_2	28.41**	4.08**	-18.90**	-16.85**	6.23**	16.77*
	C_3	31.01**	2.87**	-37.60**	-38.52**	-0.30	51.57**
KS^{-1}	C_1	71.31**	2.16	20.10**	14.34**	8.48**	-7.84
	C_2	70.14**	-10.22**	22.76**	22.11**	-18.09**	-35.12**
	C_3	56.63**	1.94	49.15**	40.62**	1.57	-35.28**
KW	C_2	4.31**	0.52**	0.03	0.30	0.87**	0.42
	C_3	4.64**	0.05	1.37**	1.43**	0.02	-1.47**
GYP^{-1}	C_1	51.38**	6.81*	-31.17**	-32.96**	6.56*	90.78 **
	C_2	55.41**	8.55**	-27.58**	-29.78**	11.85**	81.29**
	C_3	55.35**	9.34**	-17.13	-30.94**	-1.57	76.58**

DH = Days to heading, DM = Days to physiological maturity, PH = Plant height and SP^{-1} = Number of spikes per plant, KS^{-1} = Number of kernels per spike, KW = 100-kernel weight, GYP^{-1} = Grain yield per plant.
C 1 = Giza 168 × Gemmiza 10, C 2 = Giza 168 × Sakha 69 and C 3 = Sakha 69 × Giza 163
***, ** = significant at 0.05 and 0.01 levels of probability, respectively.**
m = Mean effects, a = additive effects, d = dominance effects

On the other hand, additive × nonadditive gene effects (ad) were positively significant for number of kernels per spike, 100-kernel weight and grain yield in cross 1 and number of spikes per plant and grain yield in cross 2. However, negatively significant estimates were obtained for heading date in cross 1 and number of kernels per spike in cross 2. In this regard, Ragab (2005) and El-Hag (2006) reported the presence of epistasis for earliness and yield and its component traits in most cases.

Additive × additive gene effects (aa) were significant for all studied characters except for days to maturity in cross 1 and cross 3, 100-kernel weight in the second cross. So, early generation selection for these characters might be effective for wheat breeding programs.

Dominance gene effects (d) were highly significant for all characters except for plant height in the three crosses for days to maturity in first and third crosses; for 100-kernel weight in the third cross and grain yield per plant in the third cross. These results indicated the presence of dominance gene effect in the inheritance of these characters. Accordingly, selection for these traits could be delayed to the later generations.

The dominance × dominance (dd) gene effects were positively significant for number of spikes per plant and grain yield in the three crosses, days to heading and days to maturity in cross 1 and plant height in cross 3.

The results of heritability, expected genetic advance, degree of dominance and heterosis are included in Table 5 Estimates of heritability in broad and narrow senses were the same because non-additive components were negative (an estimate to zero) indicating the importance of the additive genetic effects in the genetic control for most studied characters. Similar results have been reported by Hammad (2003) and El-diasty *et al.* (2008).

The heritability estimates in broad and narrow senses were high and nearly of similar magnitudes for each traits in the three crosses except for days to maturity in crosses 1 and 2, plant height in cross 3, 100-kernel weight in cross 2 and grain yield in cross 3, where the h^2 b % was smaller revealing that genetic variance in this case was mostly attributed to the additive effects. Therefore, it could be concluded that selection for studied characters would be effective in early generations (Sharma and Sharma, 2007 and Iqbal *et al.*, 2007). The estimates of heritability in broad and narrow sense indicated the importance of the non-additive variance components in the inheritance of the days to maturity in cross 2, plant height in cross 3 and 100-kernel weight in cross 1 suggesting that selection for these characters should be delayed to later generations.

Table 5: Heritability estimates, degree of dominance, expected genetic advance (GS) and heterosis based on better parents for some studied characters in the three wheat crosses.

Traits	Crosses	Heritability		(GS%)	$(H/D)^{0.5}$	Heterosis BP
		h^2_b %	h^2_n %			
DH	C_1	68.15	68.15	9.24	-	-4.20*
	C_2	56.69	56.69	10.77	-	-0.48*
	C_3	88.13	88.13	17.63	-	4.90**
DM	C_1	91.00	78.10	7.10	0.57	-1.1 5**
	C_2	78.08	21.93	1.65	2.26	-2.43**
	C_3	99.22	99.22	53.37	-	0.73**
PH	C_1	96.80	96.80	43.44	-	-5.0 5*
	C_2	96.89	95.16	47.28	0.19	-3.52
	C_3	87.04	43.43	7.07	1.42	3.33**
SP^{-1}	C_1	72.27	72.27	18.15	-	5.13
	C_2	68.64	68.64	27.84	-	0.43
	C_3	84.54	84.54	48.14	-	-8.23
KS^{-1}	C_1	74.45	74.45	26.31	-	17.94
	C_2	82.94	82.94	28.53	-	-9.02
	C_3	84.60	84.60	35.76	-	12.70
KW	C_2	71.66	31.67	0.40	1.59	-12.41**
	C_3	60.92	60.92	1.65	-	-0.33**
GYP^{-1}	C_1	74.36	74.36	44.36	-	3.63
	C_2	77.41	77.41	42.54	-	-1.74
	C_3	79.30	72.80	36.10	0.42	59.99

DH = Days to heading, DM = Days to physiological maturity, PH = Plant height and SP^{-1} = Number of spikes per plant, KS^{-1} = Number of kernels per spike, KW = 100-kernel weight, GYP^{-1} = Grain yield per plant.
C 1 = Giza 168 × Gemmiza 10, C 2 = Giza 168 × Sakha 69 and C 3 = Sakha 69 × Giza 163
***, ** = significant at 0.05 and 0.01 levels of probability, respectively.**

The expected genetic advance estimates (G.S) from selection in the F_2 (Table 5) were low for days to heading and maturity in crosses 1 and 2, 100-kernel weight in crosses 2 and 3 and plant height in cross 3. The expected genetic advances calculated for the remaining characters were high, and hence, it could be concluded that selection for these characters would be effective in early generations.

The average degree of dominance was less than unit in the first cross for days to maturity, in the second cross for plant height and in the third cross for grain yield per plant. These results indicate the role of partial dominance in controlling these characters. On the contrary, over dominance was pronounced in the second cross for days to maturity, in the third cross for plant height and the second cross for 100-kernel weight. On the other hand, for the remaining characters, non-additive component was negative (an estimate to zero), therefore, the average degree of dominance was not calculated.

Estimates of heterosis over better parent are presented in Table 5. Only three undesired significant heterotic effects were obtained for days to heading, days to maturity and plant height were obtained. On the other hand, desired (negatively significant) heterotic effects were found in crosses 1 and 2 for earliness and for short statuse plant in cross 1. Negative heterosis was obtained for 100-kernel weight in crosses 2 and 3. The significant heterotic effect might be due to the dominance and/or dominance × dominance effects. These results are in accordance with those obtained by Mahgoub and Hammad (2006) for days to maturity and plant height.

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تقدير بعض الثوابت الوراثية لبعض الصفات المحصولية في ثلاثة هجن من قمح الخبز

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تم استخدام ستة عشائر لتحديد الثوابت الوراثية وقد تم قياس متوسطات تلك العشائر بالنسبة لعدد الأيام حتى طرد السنابل وحتى النضج الفسيولوجي وارتفاع النبات وعدد السنابل لكل نبات وعدد حبوب السنبلة ووزن المائة حبة ومحصول الحبوب للنبات وذلك لثلاثة هجن من قمح الخبز ناتجة من أربعة آباء وهي جيزة ١٦٨ × جميزة ١٠، جيزة ١٦٨ × سخا ٦٩ ، وسخا ٦٩ × جيزة ١٦٣ وقد تم قياس التباين للستة عشائر للهجن لكل الصفات، وأجريت التجربة في ثلاثة مواسم زراعية وهي ٢٠٠٦/٠٥ ، ٢٠٠٧/٠٦، ٢٠٠٨/٠٧ م في محطة البحوث الزراعية بسخا. وقد أظهرت النتائج المتحصل عليها أن التباين الوراثي بين نباتات الجيل الثاني كان مختلفاً لكل الصفات تحت الدراسة للثلاثة هجن من القمح ماعدا صفة وزن المائة حبة للهجين جيزة ١٦٨ × جميزة ١٠. كانت التأثيرات الجينية المضيفة والسيادية والتفوقية مهمة في توارث صفتي عدد الأيام حتى طرد السنابل وعدد السنابل لكل نبات وعدد حبوب السنبلة ومحصول الحبوب للنبات. بينما كانت تقديرات المكافئ الوراثي بالمعنى الواسع والضيق متوسطة إلى مرتفعة لمعظم الصفات المدروسة في الهجن الثلاثة ، وكانت تقديرات العائد الوراثي المتوقع من الانتخاب في الجيل الثاني منخفضة لكل من عدد الأيام حتى طرد السنابل والنضج الفسيولوجي وزن المائة حبة في كل من الهجينين جيزة ١٦٨ × جميزة ١٠ و جيزة ١٦٨ × سخا ٦٩ وصفة ارتفاع النبات في الهجين سخا ٦٩ × جيزة ١٦٣. وكان متوسط درجة السيادة أصغر من الوحدة كما أظهرت النتائج وجود سيادة جزئية لصفات عدد الأيام حتى النضج الفسيولوجي في الهجين جيزة ١٦٨ × جميزة ١٠، وارتفاع النبات في الهجين جيزة ١٦٨ × سخا ٦٩ ، ومحصول الحبوب للنبات في الثلاثة هجن. في حين كانت تقديرات قوة الهجين معنوية سالبة أو موجبة لكل من صفة عدد الأيام حتى طرد السنابل وعدد الأيام حتى النضج الفسيولوجي وارتفاع النبات.