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GENETICAL BEHAVIOUR OF SOME QUANTITATIVE CHARACTERS IN BREAD WHEAT (*Triticum aestivum* L.) USING SIX GENERATIONS MODEL

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ABSTRACT: ***Six common wheat varieties were used to establish the experimental materials for the biometrical tool used in this concern i.e., six populations analysis.***

The hybrid combination Sham 4 × Sids 1 was detected to be the only cross showed significant useful heterosis for grain yield per plant (18.5%)due to heterosis in number of grains per main culm ear and number of grains per spikelet. Additive gene effects (a) were found to be significant for plant height, number of grains per main culm ear, grains per ear, 1000-grain weight and grain yield per plant in the three crosses, heading date in the first and second crosses, number of productive tillers and number of grains per spikelet in the second and the third crosses, main culm ear length and main culm ear yield and number of spikelets per ear and ear yield in the first and the third crosses and number of spikelets per main culm ear in the first cross. Dominance gene effects (d) were found to be significant in the three crosses for main culm ear length, number of grains per main culm ear, main culm ear yield, number of grains per ear, ear yield and grain yield per plant and in the first and second cross for heading date and plant height and in the second and the third crosses for number of spikelets per main culm ear. The estimated value of dominance (d) was also significant for 1000-grain weight in the first and the third crosses and for number of productive tillers, number of spikelets per ear and number of grains per spikelet in the third cross only. The three epistatic types : additive × additive (aa), additive × dominance (ad) and dominance × dominance (dd) were found to be significant for heading date, main culm ear length, number of grains per main culm ear, ear yield and 1000-grain weight in different crosses. They also were found to be accompanied by significant estimates of both E_1 and E_2 epistatic scales in most traits studied.High heritability estimates In broad sense (h^2b) were detected for nearly all traits studied. High estimates of narrow sense heritability (h^2n) were found for heading date and number of productive tillers in the first and third cross, plant height, main culm ear length, number of grains per main culm ear, number of spikelets per ear and grain yield per plant in the first and second cross and number of spikelets per main culm ear, main culm ear length, number of grains per ear, number of grains per

spikelet, ear yield and 1000-grain weight in the first cross only. High genetic advance under selection was found to be associated with high (h^2n) estimates for number of productive tillers per plant in the first and third cross, plant height, main culm ear length, number of grains per main culm ear, number of spikelets per ear and grain yield per plant in the first and second crosses and number of spikelets per main culm ear, main culm ear yield, number of grains per ear, number of grains per spikelet, ear yield and 1000-grain weight in the first cross only.

***Key words:** Heterosis, Heritability, Additive, Dominance, Epistasis, Inbreeding depression, Genetic advance.*

INTRODUCTION

The estimation of the different variance components and the type of gene action which determining the inheritance of the agronomic traits has attracted the attention of most geneticists and plant breeders because of their implication in choosing the most efficient selection and procedures to be used for the improvement of these characters.

Most of the designs used in estimating the genetic components of variation assume the absence of epistasis. Most of the information on the genetic analysis is biased due to the presence of epistasis. However, epistatic interactions have frequently been reported by many scientists in wheat (Singh and Singh1976, Ketata *et al* 1976, Singh1981, Comber2001and others). Among all the designs available for estimation of gene action, the relationships illustrated by Gamble (1962) were considered one of the important models provide the different components of variation i.e additive, dominance and epistasis. In self-pollinated species like wheat, epistasis is perhaps more important to breeders than dominance, because the later is necessarily ephemeral in such species. Also, epistasis can also be partitioned into three components i.e., additive × additive, additive × dominance and dominance × dominance (Hayman and Mather 1955).

The objectives of the present study are to establish: (1) the potentiality of heterosis expression for grain yield and its contributory characters, heading date and plant height and (2) the genetical behaviour using six generations model (Gamble 1962), heritability and expected genetic advance under selection for grain yield and some agronomic traits in the three crosses, Gemmeiza 9 × Sakha 69, Giza 164 × Sakha 206 and Sham 4 × Sids 1.

MATERIALS AND METHODS

This experiment was carried out at the Experimental Farm, Faculty of Agriculture, Minufiya University at Shebin El-Kom during the three successive seasons 2001 / 2002, 2002 / 2003 and 2003 / 2004. Six common wheat varieties were used to establish the experimental materials for this investigation.The three intial crosses Gimmeiza 9 × Sakha 69, Giza 164 × Sakha 206 and Sham 4 × Sids 1, designated in the text as first, second and third cross respectively were made in 2001 / 2002 growing season. F_1 plants were self pollinated and backcrossed to both respective parents to obtain F_2 and backcross seeds in 2002 / 2003 growing season. The six populations P_1, P_2, F_1, F_2, Bc_1 and Bc_2 of each cross was sown in 2003 / 2004 using a randomized complete block design with three replicates. Each block comprised 15 rows of F_2, Bc_1 and Bc_2 and five rows of other three nonsegregating populations. The experimental units consisted of single row 3 meter long with 30 cm between rows, plants within rows were 10 cm apart allowing a total of 30 plants per row. Normal agricultural wheat practices were applied as usual for the ordinary wheat fields in the area. Heading date was recorded on individual plants of the six populations of each cross. At maturity, the guarded plants were selected from each row for subsequent measurements i.e. heading date (days) ,plant height (cm), number of productive tillers per plant, main culm ear length, number of spikelets per main culm ear, number of grains per main culm ear, main culm ear yield, number of spikelets per ear, number of grains per ear, number of grains per spikelet, ear yield (gm), 1000-grain weight (gm)and grain yield per plant (gm). The t-test was used to examine the existance of genetic variance between parental means. Statistical procedures used herein would only be computed if the F_2 genetic variance was found to be significant. A one tail "F" ratio was used to examine the existence of the genetic variance within the F_2 population.

Heterosis (H), was expressed as percent increase of the F_1 mean performance above the respective better parent. Inbreeding depression was measured as the average percent decrease of the $\overline{F_2}$ from the $\overline{F_1}$ .The F_2 – deviation (E_1) and backcross deviation (E_2) were calculated according to (Marani 1968). Nature of gene action was studied according to the relationships illustrated by Gamble (1962). Heritability was estimated in both broad and narrow senses for F_2 generation, according to Mather's procedures (1949). The predicted genetic advance under selection (ΔG) was computed according to Johnson and Aksel (1955).

RESULTS AND DISCUSSION

Varietal differences in response to their genetic background were found to be significant in all characters studied in each of the three crosses under investigation except number of productive tillers per plant, main culm ear yield, number of grains per ear, number of grains per spikelet and ear yield in the second cross (Giza 164 × Sakha 206) and grain yield per plant in the first cross (Gemmeiza 9 × Sakha 69) and number of grains per main culm ear and heading date in the third cross (Sham 4 × Sids 1). The genetic variances within F_2 populations were also found to be significant for all traits studied in the three crosses under investigation. Consequently, the various genetical parameters used in this investigation were estimated for all traits studied. The existence of the significant genetic variability in F_2 populations in spite of the insignificant differences between the parental cultivars for the characters previously mentioned, may suggest that the genes of like effects were not completely associated in the parental cultivars i.e., these genes are dispersed (Mather and Jinks1982). Means and variances of the six populations P_1, P_2, F_1, F_2, Bc_1 and Bc_2 for all traits studied in the three crosses are given in Table (1). Meanwhile the expression of heterotic effect values for all traits in the three crosses studied are presented in Table (2). High positive values of heterosis would be of interest in most traits under investigation, however, for heading date and plant height, high negative values would be useful from the wheat breeders point of view. As for heading date, highly significant negative useful heterosis was detected in the third cross (Sham 4 × Sids 1) where the F_1 hybrid combination flowered 3.61 days earlier than its better parent Sids 1. However, heterosis was found to be positive and highly significant in the other two crosses studied. Little or no heterosis for heading date was previously found by El-Sayed (1997) and Al-Gazar (1999). However, significant heterosis was previously detected by Hewezi (1996), Saad (1999), Seleem (2001), Hendawy (2003) and Bayoumi (2004). Concerning plant height, no useful heterosis toward shortness was found in the three crosses under investigation. Moreover, the second two crosses showed highly significant positive heterosis. Similar results were also found by El-Sayed (1997), Hendawy (1998), Seleem (2001) and Darwish and Ashoush (2003). As for number of productive tillers, the second cross Giza 164 × Sakha 206 was found to have significantly more tillers than its better parent Giza 164 and this useful heterosis was found to be 20.99% (Table 2). However, the first and third cross showed highly significant negative heterosis. Heterotic effects for number of headed tillers were also found by Hewezi (1996) and Seleem (2001). Highly significant negative heterosis for number of spikes per plant was detected by Esmail and Kattab (2002) and Bayoumi (2004). Concerning main culm ear length, significant positive heterotic effect was detected in the first cross only. However, the

Table 1: Means ($\overline{X}$) and variances (S^2) of P_1, P_2, F_1, F_2, BC_1 and BC_2 populations of the three crosses I [Gimmeiza 9 (P_1) × Sakha 69 (P_2)], II [Giza 164 (P_1) × Sakha 206 (P_2)] and III [Sham 4 (P_1) × Sids 1 (P_2)] for all traits studied.

Character	Statistics	Cross I						Cross II						Cross III					
		P_1	P_2	F_1	F_2	BC_1	BC_2	P_1	P_2	F_1	F_2	BC_1	BC_2	P_1	P_2	F_1	F_2	BC_1	BC_2
1) Heading date,day	$\overline{X}$	94.68	87.11	92.72	89.75	94.86	92.12	94.93	89.58	93.05	88.09	91.94	90.43	93.91	93.5	89.89	88.87	90.61	90.96
	S^2	7.77	9.38	11.57	36.17	23.16	23.0	12.99	35.009	25.51	67.4	50.48	61.12	16.86	12.12	17.98	50.57	31.22	39.31
2) Number of productive tillers	$\overline{X}$	8.23	11.0	9.68	8.74	8.45	8.48	8.05	7.83	9.74	9.38	9.95	8.27	14.15	9.26	11.94	10.62	12.7	12.47
	S^2	3.89	7.4	5.63	22.1	13.9	14.69	11.82	8.22	9.38	15.66	13.49	14.17	21.7	12.31	15.64	45.01	30.44	32.85
3) Plant height, cm	$\overline{X}$	119.36	117.18	118.11	122.24	115.65	118.95	121.36	117.44	124.55	133.51	125.76	130.2	97.26	124.49	114.31	114.08	106.76	121.59
	S^2	23.55	21.9	24.58	81.19	59.98	45.41	31.63	64.98	23.55	293.32	204.21	158.49	19.22	25.79	27.02	71.57	66.74	61.87
4) Main culm ear length ,cm	$\overline{X}$	13.22	12.62	13.46	13.27	14.38	13.49	13.42	16.74	15.11	14.49	15.35	15.67	11.79	15.38	13.98	13.31	13.08	15.22
	S^2	0.25	0.22	0.19	2.09	1.08	1.27	0.56	0.93	0.58	2.02	1.51	1.26	0.38	0.82	0.51	1.59	0.99	1.51
5) Number of spikelets per main culm ear	$\overline{X}$	24.1	23.3	24.3	24.1	24.9	23.6	23.47	24.55	24.1	23.9	24.9	24.93	21.64	22.68	22.56	21.9	22.31	22.66
	S^2	0.68	0.46	0.42	2.87	1.61	1.81	0.8	0.89	0.61	2.31	1.4	2.2	1.11	1.22	0.81	2.07	1.86	1.4
6) Number of grains per main culm ear	$\overline{X}$	75.29	68.04	64.3	68.43	75.26	72.03	75.6	83.38	76.36	74.49	86.36	79.57	67.27	67.73	74.33	69.12	71.55	82.06
	S^2	33.86	36.22	50.03	243.22	163.78	145.27	93.41	65.07	94.34	225.24	145.96	176.77	46.3	75.56	65.79	133.19	99.47	104.89
7) Main culm ear yield ,g	$\overline{X}$	3.76	2.82	3.62	3.24	3.85	3.33	3.41	3.29	3.77	3.33	3.92	3.74	2.26	3.36	3.52	2.93	3.05	3.78
	S^2	0.18	0.37	0.42	0.91	0.54	0.73	0.41	0.68	0.43	1.008	0.81	1.02	0.21	0.46	0.27	0.59	0.51	0.55

Table 1: Cont.

Character	Statistics	Cross I						Cross II						Cross III					
		P_1	P_2	F_1	F_2	BC_1	BC_2	P_1	P_2	F_1	F_2	BC_1	BC_2	P_1	P_2	F_1	F_2	BC_1	BC_2
8) Number of spikelets per ear	$\overline{X}$	20.67	19.64	20.59	20.08	21.16	19.54	20.67	22.25	20.62	20.36	21.41	20.93	17.75	20.4	19.87	19.18	18.85	19.98
	S^2	0.51	0.45	0.52	3.58	1.54	2.81	1.91	1.75	1.39	4.61	3.16	3.65	0.76	1.47	0.97	1.83	1.76	1.36
9) Number of grains per ear	$\overline{X}$	55.43	47.65	46.59	48.56	53.22	50.41	61.31	57.62	53.2	54.42	62.18	55.68	46.5	59.002	60.26	52.96	53.27	62.25
	S^2	38.07	54.78	47.89	131.79	95.08	95.19	116.14	115.79	84.45	174.24	141.2	153.98	31.15	73.59	63.85	96.88	74.37	86.55
10) Number of grain per spikelet	$\overline{X}$	2.68	2.44	2.3	2.39	2.53	2.56	2.59	2.5	2.45	2.64	2.87	2.61	2.63	2.33	3.06	2.74	2.8	3.1
	S^2	0.05	0.07	0.06	0.21	0.18	0.13	0.13	0.15	0.14	0.19	0.18	0.16	0.04	0.1	0.09	0.14	0.1	0.12
11) Ear yield ,g	$\overline{X}$	2.79	1.96	2.55	2.25	2.69	2.34	2.67	2.46	2.57	2.43	2.76	2.62	1.48	2.67	2.61	2.19	2.36	2.79
	S^2	0.16	0.15	0.08	0.46	0.34	0.31	0.33	0.22	0.37	0.67	0.44	0.59	0.09	0.22	0.16	0.35	0.36	0.26
12) 1000-grain weigh ,g	$\overline{X}$	50.53	41.21	56.37	46.17	50.36	46.41	51.9	45.9	49.6	44.72	45.32	47.54	33.19	46.37	44.76	41.19	42.45	44.74
	S^2	25.2	27.72	18.94	82.88	41.13	67.91	37.2	32.2	32.2	94.37	75.24	81.46	24.17	21.43	18.98	46.62	34.24	38.23
13) Grain yield per plant,g	$\overline{X}$	22.54	23.79	23.32	20.92	24.32	21.91	27.34	22.51	27.7	24.45	29.5	23.77	15.18	21.82	25.86	20.75	22.35	24.94
	S^2	27.79	43.03	44.35	92.33	95.95	41.31	44.61	52.84	44.05	139.3	108.99	84.51	21.78	31.28	28.8	89.09	61.57	72.91

other two crosses showed highly significant negative heterosis. Heterotic effects for main culm ear length were previously found by Hewezi (1996), El-Sayed (1997) and Seleem (2001). However, highly significant negative heterosis for main culm ear length was reported by Esmail and Kattab (2002). The three wheat crosses under investigation did not show any heterotic effects for number of spikelets per main culm ear. As for number of grains per main culm ear, the third cross only exhibited significant positive heterosis. Significant heterosis was also found by Hewezi (1996), Hendawy (1998), Al-Gazar (1999) and Darwish and Ashoush (2003). Concerning main culm ear yield, the second cross Giza 164 × Sakha 206 was found to be the only cross showed signficiant positive heterosis (10.55%). Heterosis for main culm ear yield was previously detected by Hewezi (1996), El-Sayed (1997), Hendawy (1998), Al-Gazar (1999) and Seleem (2001). Both number of spikelets per ear and number of grains per ear did not show useful heterosis in the three hybrid combinations under investigation. As for number of grains per spikelet, the third cross Sham 4 × Sids 1 was detected to be the only cross exhibited highly significant positive heterotic effect (8.12%). However, the first cross Gimmeiza 9 × Sakha 69 exhibited highly significant negative heterosis (-14.17%). These results are in harmony with those previously obtained by Hewezi (1996), El-Sayed (1997), Hendawy (1998), Al-Gazar (1999) and Comber (2001). Concerning ear yield, no useful heterotic effect was found in the three crosses studied, however, significant heterosis for yield was previously found by Hendawy (1998), Al-Gazar (1999), Comber (2001 and Seleem (2001).

As for 1000-grain weight, Gimmeiza 9 × Sakha 69 was detected to be the only cross showed highly significant heterosis (11.55%). Similar results were previously reported by Hendawy (1998), Al-Gazar (1999) and Comber (2001). The hybrid combination Sham 4 × Sids 1 was detected to be the only cross showed significant useful heterosis (18.5%). Heterosis for grain yield per plant was also found by Esmail and Kattab (2002), Darwish and Ashoush (2003) and Bayoumi (2004). It could be concluded that heterosis for grain yield per plant observed in Sham 4 × Sids 1 could be attributed to heterosis in number of grains per main culm ear and number of grains per spikelet.

The estimation of inbreeding depression values are presented in Table (2). Inbreeding depression values were found to be highly significant in most cases in the three crosses under investigation. Heterosis in F_1 generation should be followed by appreciable reduction in F_2 generation, since the two parameters are two sides of the same phenomena. The present results were found to agree with this expectation in most cases and that was previously obtained by Hendawy (1989). On the contrary, this expectation was not fulfilled in some cases, for instance in heading date, number of productive tillers and plant height where significant heterosis and insignificant

Table 2: Heterosis, inbreeding depression, and gene action parameters in the three crosses I (Gimmeiza 9 × Sakha 69), II (Giza 164 × Sakha 206) and III (Sham 4 × Sids 1) for all characters studied.

Character	Cross	Heterosis %	Inbreeding depression %	F_2 deviation E_1	Backcross deviation E_2	Gene action parameters					
						m	a	d	aa	ad	dd
1) Heading date	I	6.44**	3.2**	-2.055**	3.37**	89.75**	2.74**	16.79**	14.96**	-46.05**	-21.69**
	II	4.47**	5.38**	-4.53**	-3.18*	88.16**	1.62*	12.74**	11.76**	-1.39	-5.4
	III	-3.8**	1.13	-2.92**	-2.025	88.87**	-0.35	3.85	7.66*	-0.55	-3.61
2) Number of productive tillers	I	-12.0**	9.7*	-0.91**	-2.36**	8.74**	-0.03	-1.03	-1.1	1.36**	5.83*
	II	20.99**	3.5	0.67*	0.82	9.4**	1.74**	1.01	-1.04	1.86**	-0.6
	III	-15.61**	8.17	-0.89	0.45	11.01**	1.8*	5.57*	5.44*	-2.78**	-7.21*
3) Plant height	I	0.79	-3.49**	4.05**	-1.78	122.24**	-3.3**	-19.92**	-19.76**	-4.39**	23.32**
	II	6.05**	-7.19**	11.53**	12.01**	133.51**	-4.44*	-16.97**	-22.12**	-6.4**	-1.9
	III	17.53**	0.2	1.48*	3.165*	114.08**	-14.83**	3.815	0.38	-1.215	-6.71
4) Main culm ear length	I	1.8*	1.4	0.08	1.49**	13.27**	0.89**	3.2**	2.66**	0.59	-5.64**
	II	-9.73**	4.1**	-0.6**	0.83*	14.49**	-0.32	4.11**	4.08**	1.34**	-5.74**
	III	-9.1**	4.79**	-0.47**	0.74*	13.31**	-2.14**	3.75**	3.36**	-0.34	-4.83**
5) Number of spikelets per main culm ear	I	0.82	0.82	0.1	0.5	24.1**	1.3**	1.2	0.6	0.9**	-1.6
	II	-1.83	0.82	-0.155	1.72**	23.9**	-0.03	4.15**	4.06**	0.51	-7.5**
	III	-0.52	2.9**	-0.46**	0.25	21.9**	-0.35	2.74**	2.34**	0.17	-2.84
6) Number of grains per main culm ear	I	-14.5**	-6.42*	0.45	11.33**	68.43**	3.23*	13.5**	20.86**	-0.39	-43.51**
	II	-8.41*	2.44	-3.43*	10.08*	74.49**	6.79*	30.77**	33.9**	10.68**	-54.06**
	III	9.7*	7.01**	-1.79	11.78**	69.12**	-10.51**	37.58**	30.74**	-10.28**	-54.3**

Table 2: Cont.

Character	Cross	Heterosis %	Inbreeding depression %	F_2 deviation E_1	Backcross deviation E_2	Gene action parameters					
						m	a	d	aa	ad	dd
7) Main culm ear yield	I	-3.72	10.49**	-0.215	0.27	3.24**	0.52*	1.73**	-3.8**	0.05	-1.94*
	II	10.55*	11.67**	-0.23*	0.54	3.33**	0.18	2.42**	2.0**	0.12	-3.08**
	III	4.76	16.7**	-0.23*	0.5*	2.93**	-0.73**	2.65**	1.94**	-0.18	-2.94**
8) Number of spikelets per ear	I	-0.38	2.47**	-0.29	-0.04	20.08**	1.62**	1.52	1.08	1.11**	-0.99
	II	-7.32**	1.26	-0.68**	0.26	20.36**	0.48	1.27	3.24**	1.27*	-3.76
	III	-2.59	3.47**	-0.29	-0.11	19.18**	-1.13**	1.74*	0.94	0.20	-0.71
9) Number of grains per ear	I	-15.94**	-4.22	-0.505	4.2	48.56**	2.81*	8.08*	13.02*	-1.08	-24.02*
	II	-13.22**	-2.29	-1.91	5.2	54.42**	6.5**	11.78**	18.04*	4.66	-28.43*
	III	2.13	12.11**	-3.54**	0.509	52.69**	-8.98**	26.709**	19.2**	-2.729	-24.218*
10) Number of grains per spikelet	I	-14.17**	3.9	-0.04	0.23*	2.39*	-0.03	0.36	0.62**	-0.15	-1.08*
	II	-5.40	-7.75**	0.145**	0.49**	2.64**	0.26*	0.31	0.4	0.22*	-1.37**
	III	8.12**	10.45**	-0.155	0.11	2.74**	-0.3**	1.18**	0.84**	-0.2	-1.06*
11) Ear yield	I	-8.6**	11.76**	-0.21**	0.11	2.25*	0.35*	1.24**	1.06**	0.06	-1.27*
	II	-3.7	5.44	-0.13	0.25	2.43*	0.14	1.05*	1.04*	0.04	-1.53
	III	-2.2	16.09**	-0.15*	-0.465*	2.19*	-0.43**	2.08**	1.54**	0.16	-2.47**
12) 1000-grain weight	I	11.55**	-18.09**	-4.95**	-5.47*	46.17**	3.95*	19.36**	8.86**	-0.71	2.08
	II	-4.4	9.8**	-4.53**	-5.64*	44.72**	-2.22*	7.54	6.84**	-5.22*	4.44
	III	-3.4	7.9**	-1.18	2.65	41.19**	-2.29*	14.61**	9.62*	4.3*	-14.92*
13) Grain yield per plant	I	-1.97	10.29	-2.32*	-0.25	20.92**	2.41*	8.94**	8.78*	3.03	-8.27*
	II	1.31	11.73	-1.86	0.65	24.45**	5.73*	11.52**	8.74*	3.31	-10.03*
	III	18.5*	19.7**	-1.43	2.93	20.75**	-2.59*	18.94**	11.58*	0.73	-17.44*

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

inbreeding depression in the third cross Sham 4 × Sids 1. Also as for main culm ear yield in the first and third crosses, there was insignificant heterosis and significant inbreeding depression. Similar contradiction was also reported by Esmail and Kattab (2002). The contradiction between heterosis and inbreeding depression estimates could be due to the presence of linkage among genes in these materials (Van der Veen 1959).

F_2 mean performances for all traits studied in the three crosses under investigation are given in Table (1). F_2 mean performance was found to deviate significantly from the average of the F_1 and mid-parent value (E_1) for heading date and plant height in the three crosses, number of productive tillers and 1000-grain weight in the first and second crosses, main culm ear length and main culm ear yield in the second and third crosses, number of grains per main culm ear, spikelets number per ear and number of grains per spikelet in the second cross only, number of spikelets per main culm ear and number of grains per ear in the third cross only, ear yield in the first and third crosses and grain yield per plant in the first cross only (Table 2). The highly expressive F_2-deviation (E_1) would indicate the presence of epistasis in the inheritance of these traits.

Backcross performance for the thirteen traits studied in the three crosses under investigation are presented in Table (1). When no effects of epistasis are assumed, backcross performance would be expected to be near the average of F_1 and recurrent parent performance. Appreciable deviation from this expected value, however, will be observed if epistasis is found to be operated in the inheritance of the trait in view. Backcross deviation (E_2) was found to be significant for main culm ear length and number of grains per main culm ear in the three crosses studied, heading date, number of grains per spikelet and 1000-grain weight in the first and second cross, plant height in the second and third cross, number of productive tillers in the first cross, number of spikelets per main culm ear in the second cross and main culm ear yield and ear yield in the third cross. The F_2 deviation (E_1) was accompanied by backcross deviation (E_2) in thirteen cases (Table 2) and that would ascertained the presence of epistasis in such large magnitude as to warrant great deal of attention in wheat breeding programs.

Genetical analysis of generation means were calculated according to relationships illustrated by Gamble (1962) to give estimates of mean effect parameter (m), additive (a), dominance (d), the three epistatic types additive × additive (aa), additive × dominance (ad) and dominance × dominance (dd) The estimated values of the various types of gene effects are presented in Table (2). The estimated mean effects parameter (m), which reflects the contribution due to the over-all mean plus the locus effects and interaction of the fixed loci, were found to be highly significant for all traits in the three crosses. The additive gene effects (a) were found to be significant for plant height, number of grains per main culm ear, number of grains per ear, 1000-grain weight and grain yield per plant in the three crosses under investigation, heading date in the first and second cross, number of productive tillers and number of grains per spikelet in the second and third cross, main culm ear length, main culm ear yield, number of spikelets per ear and ear yield in the first and third cross and number of spikelets per main culm ear in the first cross, suggesting the potential for obtaining further improvements of these traits. Dominance gene effects (d) were found to be significant in the three crosses under investigation for main culm ear length, number of grains per main culm ear, main culm ear yield, number of grains per ear, ear yield and grain yield per plant and in the first and second cross for heading date and plant height and in the second and third cross for number of spikelets per main culm ear and in the first and third cross for 1000-grain weight and in the third cross only for number of productive tillers, number of spikelets per ear and number of grains per spikelet. Significant additive × additive epistatic types were detected for heading date, main culm ear length, number of grains per main culm ear, main culm ear yield, number of grains per ear, ear yield, 1000-grain weight and grain yield per plant in all crosses, plant height and number of grains per spikelet in the first cross, plant height, number of spikelets per main culm ear and number of spikelets per ear in the second cross and number of productive tillers, number of spikelets per main culm ear and number of grains per spikelet in the third cross. The estimated values of additive × dominance types of digenic epistasis were found to be significant for number of productive tillers in all crosses, heading date, number of spikelets per main culm ear and number of spikelets per ear in the first cross, plant height, main culm ear length, number of grains per main culm ear, number of spikelets per ear, number of grains per spikelet and 1000-grain weight in the second cross and plant height, number of grains per main culm ear and 1000-grain weight in the third cross. Dominance × dominance epistatic types were detected to be significant for main culm ear length, number of grains per main culm ear, main culm ear yield, number of grains per ear, number of grains per spikelet and grain yield per plant in the three crosses, heading date, number of productive tillers, plant height and ear yield in the first cross, number of spikelets per main culm ear in the second cross and number of productive tillers, ear yield and 1000-grain weight in the third cross. It is worth to mention that the three epistatic types(aa, ad and dd) were found to be accompanied by significant estimates of both E_1 and E_2 epistatic scales in most traits studied and that would ascertained the presence of epistasis in such large magnitude as to warrant great deal of attention in a wheat breeding programs. Also, the heterotic effects previously mentioned could be due to both dominance and epistasis. The presence of both additive and non-additive gene action in mostly all traits studied would indicate that selection procedures based on the accumulation of additive effects should be successful in improving all traits under investigation. However, to maximize selection advance, procedures which are known to be effective in shifting gene frequency when both additive and non-additive genetic variances are involved would be preferred. Similar results were previously reported by Hendawy (1989), Hewezi (1996), El-Sayed (1997), Hendawy (1998), Al-Gazar (1999), Comber (2001), Seleem (2001), Esmail and Kattab (2002), Darwish and Ashoush (2003) and Bayoumi (2004)

Heritability in both broad and narrow sense and genetic advance under selection were computed and the obtained results are illustrated in Table (3). High heritability estimates in broad sense were detected for nearly all traits studied. High estimates of narrow sense heritability were found for heading date and number of productive tillers in the first and third cross, plant height, main culm ear length, number of grains per main culm ear, number of spikelets per ear and grain yield per plant in the first and second crosses, and number of spikelets per main culm ear, main culm ear length, number of grains per ear, number of grains per spikelet, ear yield and 1000-grain weight in the first cross only. Similar results were obtained by Hassan and Abd El-Moniem (1991), Darwish and Ahsoush (2003) and Bayoumi (2004). Moderate estimates of narrow sense heritability were obtained for number of spikelets per main culm ear and ear yield in the second and third crosses and main culm ear length, number of grains per main culm ear, number of grains per spikelet, 1000-grain weight and grain yield per plant in the third cross. Low values of narrow sense heritability were observed for heading date, number of productive tillers, number of grains per spikelet and 1000-grain weight in the second cross, main culm ear length and number of grains per ear in the second and third cross and plant height and number of spikelets per ear in the third cross. The differences in magnitudes of both broad and narrow sense heritability estimates found for most traits under investigation would ascertain the presence of both additive and non-additive gene action in the inheritance of most traits in the three crosses studied as previously obtained from gene action parameters study Table (2). Genetic advance under selection given in Table (3) show the possible gain from selection as percent increase in the F_3 over the F_2 mean when the most desirable 5% of the F_2 plants were selected. Genetic advance under selection ($\Delta G\%$) was found to be high in magnitudes for number of productive tillers per plant, number of grains per main culm ear, main culm ear yield, number of grains per ear, ear yield, 1000-grain weight and grain yield per plant in the three crosses, plant height, main culm ear length and number of spikelets per ear in the first and second crosses, number of grains per spikelet in the first and

Table (3): Heritability estimates, genetic advance (Δg), and genetic advance expressed as a percent of the F2 mean ((Δg %) for all characters studied in the three crosses-under investigation.

Characters	Cross	Heritability %		Genetic advance	
		Broad sense	Narrow sense	Δg	Δg %
1) Heading date	I	73.54	72.38	8.96	9.99
	II	63.60	34.42	5.80	6.60
	III	69.05	60.52	8.86	9.90
2) Number of productive tillers	I	74.47	70.63	4.30	49.19
	II	37.35	23.37	1.90	20.20
	III	63.20	59.38	8.20	77.20
3) Plant height	I	71.25	70.19	13.02	10.65
	II	86.34	76.34	26.93	20.17
	III	66.45	20.30	3.53	3.10
4) Main culm ear length	I	89.40	87.50	2.59	19.50
	II	65.84	62.87	1.84	12.69
	III	64.15	42.76	1.11	8.30
5) Number of spikelets per main culm ear	I	81.80	80.80	2.81	11.65
	II	67.09	44.15	1.38	5.78
	III	49.75	42.51	1.25	5.70
6) Number of grains per main culm ear	I	83.50	72.90	23.42	34.22
	II	62.58	56.67	17.52	23.52
	III	53.03	46.56	11.06	16.00
7) Main culm ear yield	I	64.83	60.43	1.18	36.65
	II	50.39	18.45	0.38	11.41
	III	47.45	20.33	0.32	10.90
8) Number of spikelets per ear	I	86.31	78.49	3.05	15.23
	II	63.55	52.27	2.31	11.35
	III	42.07	29.51	0.82	4.27
9) Number of grains per ear	I	64.40	55.62	13.15	27.08
	II	39.47	30.58	8.31	15.27
	III	42.00	33.89	6.87	12.90
10) Number of grains per spikelet	I	71.42	52.38	0.49	20.50
	II	26.31	21.05	0.18	7.15
	III	50.00	42.85	0.33	12.04
11) Ear yield	I	71.73	58.69	0.81	36.44
	II	53.73	46.26	0.78	32.09
	III	57.14	42.85	0.52	23.80
12) 1000-grain weight	I	71.17	68.43	12.83	27.78
	II	64.11	33.95	6.79	15.18
	III	53.83	44.55	6.26	15.19
13) Grain yield per plant	I	58.42	51.33	10.16	48.56
	II	66.14	61.09	14.85	60.73
	III	69.37	49.05	9.53	45.96

third crosses and number of spikelets per main culm ear in the first cross only. Relatively moderate genetic gain were obtained for heading date in the three crosses, number of spikelets per main culm ear in the first and third crosses, number of grains per spikelet in the second cross and main culm ear length in the third cross. Low genetic gains were detected for plant height and number of spikelets per ear in the third cross only. Johnson *et al* (1955) reported that heritability estimates along with genetic gain upon selection were more valuable than the former alone in predicting the effect of selection. On the other hand, Dixit *et al* (1970) pointed out that high heritability is not always associated with high genetic advance, but in order to make effective selection, high heritability should be associated with high genetic gain. In the present investigation, high genetic gain was found to be associated with high narrow sense heritability estimates for number of productive tillers per plant in the first and third crosses, plant height, main culm ear length, number of grains per main culm ear, number of spikelets per ear and grain yield per plant in the first and second crosses and number of spikelets per main culm ear, main culm ear yield, number of grains per ear, number of grains per spikelet, ear yield and 1000-grain weight in the first cross only. Therefore, selection for these traits should be effective and satisfactory for successful breeding purposes. Moderate estimates of both narrow sense heritability and genetic advance were obtained for number of spikelets per main culm ear and ear yield in the second and third crosses and main culm ear length, number of grains per main culm ear, number of grains per spikelet, 1000-grain weight and grain yield per plant in the third cross. Consequently, selection for these traits would be effective, but probably of less success than in the former characters. Low genetic gain was associated with low narrow sense heritability values for plant height and number of spikelets per ear in the third cross only, hence selection for these two traits in this population would be of less effectiveness.

Generally, most of the genetic parameters resulting from the third cross Sham 4 × Sids 1 were found to be higher in magnitudes than those obtained from the other two crosses Gimmeiza 9 × Sakha 69 and Giza 164 × Sakha 206 and that, in general, illustrate that there is a considerable potentiality to improve these two wheat varieties.

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السلوك الوراثى لبعض الصفات الكمية فى قمح الخبز باستخدام موديل العشائر الستة

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الملخص العربى

أجرى هذا البحث فى مزرعة كلية الزراعة بشبين الكوم جامعة المنوفية وذلك فى الثلاثة مواسم المتتالية ٢٠٠١/٢٠٠٢ ، ٢٠٠٢/٢٠٠٣ ، ٢٠٠٣/٢٠٠٤ ، فقد تم التهجين فى الموسم الأول بين الآباء (شام ٤ × سدس ١) ، (جيزة ١٦٤ × سخا ٢٠٦) ، (سخا ٦٩ × جميزة ٩) وذلك للحصول على الجيل الأول لعمل موديل العشائر الست وفى الموسم الثانى تم عمل التهجينات الرجعية والحصول على الجيل الثانى للعشائر الست. وفى الموسم الثالث تم تقييم الستة اجيال فى نظام القطاعات الكاملة العشوائية فى ثلاث مكررات وذلك بهدف دراسة كلٍ من: قوة الهجين لصفات المحصول ومكوناته , السلوك الوراثى ، درجة التوريث التحسين الوراثى المتوقع بالانتخاب لصفات المحصول ومكوناته . وقد تم تحليل البيانات باستخدام طريقة جامبل عام ١٩٦٢ لتحليل العشائر الست وكانت الصفات المدروسة هى : ميعاد طرد السنابل – عدد الفروع المنتجة – ارتفاع النبات(سم) – طول السنبلة الرئيسية(سم) – عدد السنيبلات فى سنبلة الساق الرئيسى – عدد الحبوب فى سنبلة الساق الرئيسى – محصول سنبلة الساق الرئيسى – عدد السنيبلات فى السنبلة – عدد الحبوب فى السنبلة – عدد الحبوب بالسنيبلة – محصول السنبلة(جم) – وزن الألف حبة (جم) ومحصول النبات الفردى (جم) .

وقد اظهرت النتائج ما يلى :

وجد أن الهجين شام ٤ × سدس ١ هو الهجين الوحيد الذى أظهر قوة هجين معنوية لصفة المحصول (١٨,٥%) وتُعزى قوة الهجين هذه إلى قوة الهجين لكلٍ من صفتى عدد الحبوب فى سنبلة الساق الرئيسى وعدد الحبوب بالسنيبلة .

كان الفعل الجينى المضيف معنوياً لكلٍ من صفات ارتفاع النبات ، عدد الحبوب فى سنبلة الساق الرئيسى ، عدد الحبوب بالسنبلة ، وزن الألف حبة ومحصول النبات الفردى وذلك فى الثلاثة

هجن المدروسة، وكذلك لصفات ميعاد طرد السنابل فى الهجين الأول والثانى، وصفة عدد الأفرع المنتجة وعدد الحبوب فى السنيبلة وذلك فى الهجين الثانى والثالث، وكذلك طول سنبلة الساق الرئيسى ومحصول سنبلة الساق الرئيسى وعدد السنيبلات فى السنبلة ومحصول السنبلة وذلك فى الهجين الأول والثالث، وكذلك عدد السنيبلات فى سنبلة الساق الرئيسى فى الهجين الأول .

كان تأثير الجينات من النوع السيادى معنوياً فى الهجن الثلاثة لصفات طول سنبلة الساق الرئيسى – عدد الحبوب فى سنبلة الساق الرئيسى – محصول السنبلة الرئيسية – عدد الحبوب فى السنبلة ومحصول السنبلة ومحصول النبات الفردى ، وفى الهجين الأول والثانى لصفات ميعاد طرد السنابل وطول النبات ، وفى الهجين الثانى والثالث لصفة عدد السنيبلات فى سنبلة الساق الرئيسى .

كان فعل الجينات التفوقى بطرزه الثلاثة المضيف × المضيف، والمضيف × السيادى، والسيادى × السيادى معنوياً للصفات ميعاد طرد السنابل – طول سنبلة الساق الرئيسى – عدد الحبوب فى سنبلة الساق الرئيسى – محصول السنبلة ووزن الألف حبة وذلك للهجن المختلفة وكان فعل الجينات التفوقى بطرزه الثلاثة مصاحباً لمقاييس التفوق E1 ، E2 وذلك فى معظم الصفات المدروسة .

كانت قيمة درجة التوريث بمعناها العام عالية لجميع الصفات تحت الدراسة وكذلك أظهرت الكفاءة الوراثية بمعناها الدقيق قيماً عالية لكلٍ من صفات ميعاد طرد السنابل وعدد الفروع المنتجة وذلك فى الهجين الأول والثالث، ولصفات طول النبات وطول سنبلة الساق الرئيسية وعدد الحبوب فى سنبلة الساق الرئيسى وعدد السنيبلات فى السنبلة ومحصول النبات الفردى وذلك فى الهجين الأول والثانى، ولصفات عدد السنيبلات فى سنبلة الساق الرئيسى وطول سنبلة الساق الرئيسى وعدد الحبوب فى السنبلة وعدد الحبوب بالسنيبلة ومحصول السنبلة ووزن الألف حبة وذلك فى الهجين الأول فقط .

أظهرت النتائج أن القيم العالية للنسبة المئوية للتحسين الوراثى المتوقع بالانتخاب مصاحبة للقيم العالية لدرجة التوريث بالمعنى الدقيق لصفات عدد الفروع المنتجة بالنبات فى الهجين الأول والثالث ولصفات ارتفاع النبات وطول سنبلة الساق الرئيسى وعدد الحبوب فى سنبلة الساق الرئيسى وعدد السنيبلات بالسنبلة ومحصول النبات الفردى وذلك فى الهجين الأول والثانى، ولصفات عدد السنيبلات فى سنبلة الساق الرئيسى ومحصول السنبلة وعدد الحبوب فى السنبلة وعدد الحبوب بالسنبلة ومحصول السنبلة ووزن الألف حبة وذلك فى الهجين الأول فقط.