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USING SIX POPULATIONS MODEL FOR ESTIMATING EPISTATIC, ADDITIVE AND DOMINANCE GENETIC VARIANCE IN BREAD WHEAT [Triticum aestivum L.]

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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 Giza168 × Sids 9 was detected to be the only cross showed significant useful heterosis for grain yield per plant (83.93%). The potence ratio values indicated the existence of overdominance toward the better parent for number of grains per ear in the second cross and 1000-grain weight and grain yield per plant in the first cross and main culm ear length and number of grains per main culm ear in the third cross and number of productive tillers in the fourth cross.The additive gene effects (a) were found to be significant for heading date, number of productive tillers and ear yield in the first, third and fourth crosses and plant height in all crosses studied and main culm ear length and main culm ear yield in the first and second crosses and number of spikelets per main culm ear and number of grains per main culm ear in the first , second and fourth crosses and number of grains per ear in the first and fourth crosses and 1000-grain weight in the second and fourth crosses and grain yield per plant in the third and fourth crosses. Dominance gene effects (d) were found to be significant in the four crosses for number of spikelets per ear, number of grains per ear, 1000-grain weight and grain yield per plant and in the last three crosses for heading date and number of productive tillers and in the first , second and fourth crosses for plant height and in the first cross for main culm ear length and in the first and second crosses for number of spikelets per main culm ear and number of grains per main culm ear and in the first , second and third crosses for main culm ear yield and in the second and third crosses for number of grains per spikelet and ear yield. The three epistatic types additive × additive, additive × dominance and dominance × dominance were found to be significant for heading date, number of productive tillers and main culm ear length in the second cross and main culm ear yield and number of spikelets per ear in the second and third cross and number of grains per main culm ear and 1000-grain weight in the first and second crosses and number of grains per ear and grain yield per plant in the third cross. 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. High heritability estimates in broad sense were detected for nearly all traits studied. High estimates of narrow sense heritability were found for plant height , number of grains per spikelet , ear yield and grain yield per plant in the all crosses studied and heading date in the second and fourth crosses and main culm ear length , number of spikelets per main culm ear , main culm ear yield and number of grains per ear in the first cross only. High genetic advance under selection was found to be associated with high narrow sense heritability estimates for number of productive tillers per plant and heading date in the fourth cross only and plant height, main culm ear yield and number of grains per ear in the first cross and main culm ear length and number of spikelets per main culm ear in the first and fourth crosses and number of grains per ear, ear yield and grain yield per plant in all crosses studied. Moderate estimates of narrow sense heritability and high or moderate genetic advance were obtained for number of productive tillers in the first, second and third crosses and main culm ear length and main culm ear yield in the third cross only and number of grains per main culm ear in the first and second crosses and number of spikelets per ear in the first, second and fourth crosses and number of grains per ear in the first and fourth crosses and 1000-grain weight in the first cross.

***Keywords:** Heterosis, Heritability, Additive, Dominance, Epistasis, Inbreeding depression, Genetic advance, Potence ratio.*

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 (Ketata et al 1976, Comber 2001 and 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 four crosses, Giza168 × Sids9, Gimmiza7 × Sakha 94, Gimmiza7 × Sakha 69 and Giza170 × Sakha 94.

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 2005 / 2006, 2006 / 2007 and 2008 / 2009. Six common wheat varieties were used to establish the experimental materials for this investigation.The three intial crosses Giza168 × Sids9, Gimmiza7 × Sakha 94, Gimmiza7 × Sakha 69 and Giza170 × Sakha 94, designated in the text as first, second, third and fourth cross respectively were made in 2005 / 2006 growing season. F1 plants were self pollinated and backcrossed to both respective parents to obtain F2 and backcross seeds in 2006 / 2007 growing season. The six populations P1, P2, F1, F2, Bc1 and Bc2 of each cross was sown in 2008 / 2009 using a randomized complete block design with three replicates. Each block comprised 15 rows of F2, Bc1 and Bc2 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 an individual plant of the six populations of each cross. Data were recorded on individual guarded plants for the studied characters 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 existence of genetic variance between parental means. Statistical procedures used herein would only be computed if the F2 genetic variance was found to be significant. A one tail “F” ratio was used to examine the existence of the genetic variance within the F2 population.

Heterosis (H), was expressed as percent increase of the F1 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 F2 – deviation (E1) and backcross deviation (E2) were calculated according to (Marani 1968). Nature of gene action was studied according to the relationships illustrated by Gamble (1962). Nature and degree of dominance were determined by means of potence ratio method (P) which can be defined

as the average dominance of the whole gene set of one parent or the other (Petr and Frey, 1966). Heritability was estimated in both broad and narrow senses for F2 generation, according to Mather's procedures (1949). The predicted genetic advance under selection (∆G) was computed according to Johnson *et al*. (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 four crosses i.e (Giza 168 x Sids 9 I, Gemmiza 7 x Sakha 94 II, Gemmiza 7 x Sakha 69 III and Giza 170 x Sakha 94 IV) under investigation except grain yield per plant in the first cross and number of grains per ear in the second cross and heading date and grain yield per plant in the third cross and number of spikelets per main culm ear , number of grains per spikelet and 1000- grain weight in the fourth cross. 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 Jinks, 1982). 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 four crosses are given in Table (1). Meanwhile the expression of heterotic effect values for all traits in the four 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 (Giza 170 × Sakha 94) where the F_1 hybrid combination flowered 5.69 days earlier than its better parent Giza170, however, heterosis was found to be positive and highly significant in the first and third crosses studied and there was no heterosis in the second cross . 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 Seleem (2001), Bayoumi (2004), and El Massry (2009) . Concerning plant height, useful heterosis toward shortness were found to be significant in the third cross (Gemmiza 7 x Sakha 69), the other crosses showed highly significant positive heterosis. Similar results were also found by Hendawy (1998), Darwish and Ashoush (2003) and Dawwam *et al* (2007). As for number of productive tillers, the first cross Giza 168 × Sids 9 was found to have significantly more tillers than its better parent Giza 168 and this useful heterosis was found to be 11.11% (Table4). However, the second and fourth cross showed highly significant negative heterosis. No useful heterosis was found in the third cross. Heterotic effects for number of headed tillers were also found by Hewezi (1996) and Seleem (2001).

Table (1): Means ($\bar{X}$) and variances (S^2) of P_1, P_2, F_1, F_2, BC_1 and BC_2 populations of the four crosses I [Giza168 (P_1) x Sids9 (P_2)], II [Gemmiza 7(P_1) x Sakha 94 (P_2)] , III [Gemmiza7(P_1) x Sakha69 (P_2)] and IV [Giza170(P_1) x Sakha 94(P_2)] for all traits studied.

Character		Heading date		No. of productive tillers, cm		Plant height, cm		Main culm ear length, cm	
Cross no.	generation	$\bar{X}$	S^2	$\bar{X}$	S^2	$\bar{X}$	S^2	$\bar{X}$	S^2
I	P1	85.533	9.430	11.73	9.720	95.50	10.22	16.84	1.062
	P2	90.667	6.092	13.90	8.852	107.7	9.320	17.64	1.025
	F1	80.667	10.250	10.43	7.220	99.70	11.21	16.51	1.137
	F2	85.36	50.00	13.32	38.76	104.8	112.3	17.17	5.000
	BC1	80.944	30.250	11.48	35.64	99.78	80.00	16.90	16.90
	BC2	87.356	34.260	13.30	66.23	103.51	66.23	17.17	3.21
II	P1	79.967	8.378	6.967	3.360	118.43	8.461	15.51	1.186
	P2	90.667	6.092	13.90	5.260	107.70	9.320	17.64	1.025
	F1	79.800	3.545	7.733	5.582	116.83	11.24	17.00	1.650
	F2	89.394	36.891	9.218	9.150	120.71	50.36	13.06	2.288
	BC1	79.158	20.360	7.975	8.150	114.70	27.91	17.22	1.950
	BC2	79.333	30.690	7.717	6.360	110.27	39.36	16.46	1.780
III	P1	79.96	8.378	6.967	3.360	118.4	8.461	15.51	1.186
	P2	82.56	6.599	9.833	7.523	114.5	13.25	12.62	1.240
	F1	81.43	9.000	10.06	5.240	108.9	15.25	16.55	1.110
	F2	83.68	10.41	11.64	17.24	109.1	75.69	17.26	2.370
	BC1	83.95	8.950	7.138	14.24	112.6	52.39	16.35	1.950
	BC2	80.53	9.948	8.550	12.21	109.9	39.83	16.73	1.680
IV	P1	85.53	9.430	11.73	9.720	95.5	10.22	16.84	1.062
	P2	90.66	6.092	13.90	8.852	107.7	9.320	17.64	1.025
	F1	80.66	10.25	10.43	7.220	99.70	11.21	16.51	1.137
	F2	85.36	50.00	13.32	38.76	104.8	112.3	17.17	5.000
	BC1	80.94	30.25	11.48	35.64	99.78	80.00	16.90	4.100
	BC2	87.35	34.26	13.30	19.65	103.5	66.23	17.17	3.210

Table (1): Cont.

Character		No.of spikelets per main culm ear		No. of grains per main culm ear		Main culm ear yield ,g	
Cross no.	generation	$\bar{X}$	S^2	$\bar{X}$	S^2	$\bar{X}$	S^2
I	P1	22.70	2.300	76.20	65.20	3.481	0.345
	P2	23.26	3.210	83.03	52.72	4.295	0.423
	F1	22.93	1.900	76.70	56.24	3.748	0.707
	F2	22.77	10.00	85.85	164.4	4.367	1.004
	BC1	22.55	7.680	85.88	168.0	4.266	0.931
	BC2	22.86	5.640	89.54	110.6	4.441	0.716
II	P1	25.20	1.683	75.16	89.38	4.668	0.568
	P2	23.26	2.100	83.03	70.26	4.295	0.423
	F1	23.60	1.900	79.33	77.33	4.800	0.437
	F2	24.04	4.120	70.91	190.25	3.279	1.230
	BC1	24.46	2.923	92.00	139.6	4.661	0.860
	BC2	23.00	3.600	80.12	150.36	4.170	0.950
III	P1	25.20	1.683	75.16	89.38	4.668	0.568
	P2	23.43	1.289	66.66	85.60	2.669	0.422
	F1	23.23	0.599	79.60	59.36	3.663	0.407
	F2	22.95	2.390	83.02	172.6	4.352	1.236
	BC1	23.07	1.880	76.88	124.3	3.760	0.980
	BC2	23.13	1.780	80.08	134.5	3.839	0.880
IV	P1	22.70	2.300	76.20	65.20	3.481	0.345
	P2	23.26	3.210	83.03	52.72	4.295	0.423
	F1	22.93	1.900	76.70	56.24	3.748	0.707
	F2	22.77	10.00	85.85	164.4	4.367	1.004
	BC1	22.55	7.680	85.88	168.0	4.266	0.931
	BC2	22.86	5.640	89.54	110.6	4.441	0.716

Table (1): Cont.

Character		No.of spikelets per ear		No. of grains per ear		No. of grains per spikelet	
Cross no.	generation	$\bar{X}$	S^2	$\bar{X}$	S^2	$\bar{X}$	S^2
I	P1	17.85	0.620	42.99	50.00	2.740	0.950
	P2	18.48	1.127	56.05	45.00	3.184	0.680
	F1	17.72	1.413	50.38	52.36	2.913	0.870
	F2	17.12	3.240	50.07	100.0	2.791	3.210
	BC1	18.00	2.736	52.25	80.00	2.943	1.980
	BC2	18.38	2.350	58.55	73.36	3.330	2.210
II	P1	21.89	1.548	58.08	85.99	2.640	0.175
	P2	18.48	1.127	56.05	70.36	3.184	0.680
	F1	17.72	1.092	53.91	90.23	2.878	0.428
	F2	20.71	3.980	48.26	170.3	2.412	1.360
	BC1	18.45	3.110	45.70	150.0	2.883	1.110
	BC2	17.52	2.880	46.48	120.3	3.153	0.779
III	P1	21.89	1.548	58.08	85.99	2.640	0.175
	P2	19.10	1.744	46.05	72.75	2.371	0.091
	F1	18.89	1.086	43.67	90.00	2.685	0.430
	F2	18.67	4.230	57.46	150.3	3.162	3.210
	BC1	17.60	3.230	46.79	130.3	2.572	2.110
	BC2	18.12	2.980	49.21	123.3	3.000	2.000
IV	P1	17.85	0.620	42.99	50.00	2.740	0.950
	P2	18.48	1.127	56.05	45.00	3.184	0.680
	F1	17.72	1.413	50.38	52.36	2.913	0.870
	F2	17.12	3.240	50.07	100.0	2.791	3.210
	BC1	18.00	2.736	52.25	80.00	2.943	1.980
	BC2	18.38	2.350	58.55	73.36	3.330	2.210

Table (1): Cont.

Character		Ear yield ,g		1000-grain weight ,g		Grain yield per plant,g	
Cross no.	generation	$\overline{X}$	s^2	$\overline{X}$	s^2	$\overline{X}$	s^2
I	P1	2.137	0.305	49.54	24.69	27.20	51.34
	P2	2.894	0.209	49.75	27.00	43.35	80.00
	F1	2.516	0.552	48.49	30.25	26.31	85.00
	F2	2.715	1.700	51.85	50.00	43.97	300.0
	BC1	2.628	1.050	47.97	36.25	38.54	239.6
	BC2	3.130	1.400	50.02	45.23	44.40	200.0
II	P1	3.394	0.326	57.01	24.25	23.60	60.35
	P2	2.894	0.209	49.75	27.00	43.35	80.00
	F1	3.620	0.669	52.32	23.97	27.71	80.10
	F2	2.268	1.360	45.85	89.99	21.59	170.3
	BC1	3.208	0.823	51.53	69.36	26.21	115.34
	BC2	3.063	0.980	53.76	50.36	25.58	139.44
III	P1	3.394	0.326	57.015	24.25	23.60	60.35
	P2	1.880	0.233	40.949	30.24	22.12	56.36
	F1	2.687	0.319	54.133	22.21	25.51	50.92
	F2	3.113	1.110	53.814	70.250	46.08	241.62
	BC1	2.568	0.880	55.132	60.35	18.73	195.25
	BC2	3.041	0.750	55.036	58.24	28.70	149.57
IV	P1	2.137	0.305	49.54	24.69	27.20	51.34
	P2	2.894	0.209	49.757	27.00	43.35	80.00
	F1	2.516	0.552	48.493	30.250	26.32	85.00
	F2	2.715	1.70	51.858	50.00	43.97	300.00
	BC1	2.628	1.05	47.97	36.25	38.55	239.66
	BC2	3.130	1.40	50.03	45.23	44.41	200.00

Highly significant negative heterosis for number of spikes per plant was detected by Bayoumi (2004) and Dawwam *et al* (2007). Concerning main culm ear length, significant positive heterotic effect was detected in the first and third crosses, however, the other two crosses showed highly significant negative heterosis. Heterotic effects for main culm ear length were previously found by El-Sayed (1997) and Seleem (2001). However, highly significant negative heterosis for main culm ear length was reported by Esmail and Kattab (2002) and Ghanem (2008). Concerning number of spikelets per main culm ear, significant negative heterotic effect was detected in the first, second and third crosses. However, there was no heterosis in the fourth cross. Significant heterosis was also found by El-Sayed (1997) and Ghanem (2008). As for number of grains per main culm ear, the third cross only exhibited significant positive heterosis among all crosses. Significant heterosis was also found by Darwish and Ashoush (2003) and Dawwam *et al* (2007). Concerning main culm ear yield, the third and the fourth crosses were found significant negative heterosis (-21.51 %) and (-12.75 %), respectively. Heterosis for main culm ear yield was previously detected by El-Sayed (1997), Hendawy (1998), Seleem (2001) and Dawwam *et al* (2007). The four wheat crosses under investigation did not show any useful heterotic effects for number of spikelets per ear, number of grains per ear and number of grains per spikelet. Concern in ear yield, no useful heterotic effect was found in the four crosses studied; however, significant heterosis for yield was previously found by, Al Gazar (1999), Comber (2001) and Seleem (2001). As for 1000 grain weight, Giza 168 x Sids 9 was detected to be the only cross showed highly significant heterosis 22.15 %. Similarresults were previously reported by Hendawy (1998), Al-Gazar (1999) and Dawwam *et al* (2007). The hybrid combination Giza 168 x Sids 9 was detected to be the only cross showed significant useful heterosis (83.93 %). Heterosis for grain yield per plant was also found by Esmail and Kattab (2002), Darwish and Ashoush (2003), Bayoumi (2004), Dawwam *et al* (2007) and Ghanem (2008). It could be concluded that heterosis for grain yield per plant observed in Giza 168 x Sids 9 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 four crosses under investigation. Heterosis in F_1 generation should be followed by appreciable reduction in F_1 generation, since the two parameters are two sides of the same phenomoena. The present results were found to agree with this expectation in most cases and that was previously obtained by Esmail and Kattab (2002), Dawwam *et al* (2007) and El-Massry (2009). On the contrary, this expectation was not fulfilled in some cases, for instance in heading date, number of grains per main culm ear, main culm ear yield, number of grains per ear, number of grains per spikelet and ear yield where insignificant heterosis and significant inbreeding depression in the

Table 2

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second cross Gemmiza 7 x Sakha 94. Also as for plant height, main culm ear length and 1000 grain weight in the first cross there were significant heterosis and insignificant inbreeding depression. Similar contradiction was also reported by Esmail and Kattab (2002) and El-Massry (2009). The contradiction between heterosis and inbreeding depression estimates could be due to the presence of linkage between genes in these materials Vander Veen (1959).

Potence ratio for all traits studied in the four crosses under investigation are given in Table (2). The average degree of dominance as indicated by potence ratio revealed the existence of over dominance towards the high parent for heading date in the second and fourth crosses and number of productive tillers, main culm ear length and grain yield per plant in the first and third crosses and plant height in the third crosses and number of grains per main culm ear and number of grains per spikelet in the third cross , ear yield in the second cross and 1000-grain weight in the first cross, while it was towards the lower parent for number of productive tillers, main culm ear length, 1000- grain weight and grain yield per plant in the fourth cross only and number of spikelets per main culm ear in the first and third crosses and number of spikelets per ear in all crosses studied and number of grains per ear in the second and third crosses and there is no dominance in ear yield in the fourth cross. Partial dominance towards the higher parent was found for heading date in the first cross , plant height in the first and fourth crosses , main culm ear length and number of grains per main culm ear in the second cross , main culm ear yield in the first and second crosses , number of grains per ear in the fourth cross , ear yield in the first and third crosses , 1000 grain weight in the third cross only. However, partial dominance towards the lower parent were found for heading date in the third cross , number of productive tillers and plant height in the second cross , number of spikelets per main culm ear and number of grains per spikelet in the second and fourth crosses and number of grains per main culm ear in the first and fourth crosses , main culm ear yield in the third and fourth crosses , number of grains per ear in the first cross , 1000 grain weight and grain yield per plant in the second cross only. Similar results were also found by Comber (2001) and Ghanem (2008).

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

would indicate the presence of epistasis in the inheritance of these traits these result was found also by Esmail and Kattab (2002), Dawwam et al (2007), Ghanem(2008) and El-Massry (2009).

Backcross performance for the thirteen traits studied in the four crosses under investigation are presented in Table (2). 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 yield. Backcross deviation (E_2) was also found to be significant for heading date, number of productive tillers, plant height and number of spikelets per ear in the first, second and third crosses, number of grains per main culm ear in all crosses, main culm ear length, number of spikelets per main culm ear and 1000 grain weight in the first and third crosses, main culm ear yield in the second and fourth crosses, number of grains per spikelet in the first cross only. 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. Also, a great deal of attention of epistasis was reported in wheat by Darwish and Ashoush (2003), Dawwam *et al* (2007), Ghanem (2008) and El-Massry(2009).

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 four crosses. The additive gene effects (a) were found to be significant for plant height in the four crosses under investigation, heading date, number of productive tillers and number of grains per main culm ear in the first, second and fourth crosses, main culm ear length and main culm ear yield in the first and second crosses, number of spikelets per main culm ear, number of spikelets per ear and number of grains per spikelet in the second cross only, number of grains per ear in the first and fourth crosses, ear yield in the first, third and fourth crosses, 1000-grain weight in the second and fourth crosses, grain yield per plant in the third and fourth crosses, suggesting the potential for obtaining further improvements of these traits. Dominance gene effects (d) were found to be significant in the four crosses under investigation for number of spikelets per ear, number of grains per ear, 1000- grain weight and grain yield per plant in the four crosses under investigation, heading date and number of productive tillers in the second, third and fourth crosses, plant height in the first, second and fourth crosses, number of spikelets per main culm ear and number of grains per main culm ear in the first and

second crosses, main culm ear length in the second cross, main culm ear yield in the first, second and fourth crosses, number of grains per spikelet and ear yield in the second and third crosses , suggesting that the dominance factors play a great role in the inheritance of these traits. Significant additive x additive (aa) epistasic types were detected for plant height in all crosses under investigation, heading date, number of productive tillers, number of grains per main culm ear, main culm ear yield and grain yield per plant in the first, second and third crosses, main culm ear length and ear yield in the second and third crosses, number of spikelets per ear in the second, third and fourth crosses, number of grains per ear in the third and fourth crosses, number of grains per spikelet in the second cross only, number of spikelets per main culm ear showed no significant in all crosses under investigation. This would be indicated by Hendawy *et al.* (2007), Ghanem (2008) and El-Massry(2009). The estimated values of additive x dominance (ad) types of digenic epistasis were found to be significant for heading date in all crosses studied, number of productive tillers in the second cross only, main culm ear length, number of grains per main culm ear, number of spikelets per ear and 1000-grain weight in the first, second and third crosses, number of spikelets per main culm ear and ear yield in the third cross only, main culm ear yield and grain yield per plant in the second and third crosses, number of grains per ear and number of grains per spikelet in the first and third crosses.While plant height show no significant in four crosses studied .This would be indicated by Dawwam *et al* (2007), Ghanem (2008) and El-Massry(2009). Dominance x dominance (dd) epistatic types were detected to be significant for number of spikelets per ear, number of grains per ear, main culm ear yield and 1000-grain weight in all crosses under investigation, heading date and main culm ear length in the second cross only, number of productive tillers in the first, second and third crossesplant height and number of grains per spikelet in the first and second crosses, number of spikelets per main culm ear in the first cross only, number of grains per main culm ear and ear yield in first, second and fourth crosses, grain yield per plant in the first, third and fourth crosses . This would be indicated by Darwish and Ashoush (2003), Hendawy *et al.* (2007) and El-Massry(2009). 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 Esmail and Kattab (2002), Darwish and Ashoush (2003), Bayoumi (2004), Hendawy *et al.* (2007), Ghanem (2008) and El-Massry(2009).

Heritability in both broad and narrow sense and genetic and 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 fourth cross, plant height , number of grains per spikelet, ear yield and grain yield per plant in all crosses under investigation, and main culm ear length and number of spikelets per main culm ear in the first and fourth crosses, number of grains per main culm ear and number of spikelets per ear in the third cross, main culm ear yield in the first and second crosses , number of grains per ear in the first cross only and 1000-grain weight in the second cross only. Similar results were obtained by Hendawy *et al.* (2007), Ghanem (2008) and El-Massry (2009).

Moderate estimates of narrow sense heritability were obtained for heading date and 1000 grain weight in the first cross only, and number of productive tillers in the first, second and third crosses and main culm ear length and main culm ear yield in the third cross, number of spikelets per main culm ear in the second and third crosses, and number of grains per main culm ear in the first and second crosses, and number of spikelets per ear in the first, second and fourth crosses, and number of grains per ear in the second and fourth crosses. Low values of narrow sense heritability were observed for heading date and number of grains per ear in the third cross and main culm ear length in the second cross and number of grains per main culm ear and main culm ear yield in the fourth cross and 1000-grain weight in the third and fourth crosses. The differences in magnitudes of both broad and narrow sense heritability estimates which were found for most traits under investigation would ascertained the presence of both additive and non additive gene action in the inheritance of most traits in the fourth crosses studied as previously obtained from gene action parameters study Table (2). Similar results were obtained by Hendawy *et al.* (2007), Ghanem (2008) and El-Massry (2009).

Genetic advance under selection which are given in Table (3) show the possible gain from selection as percent increase in the F3 over the F2 mean when the most desirable 5 % of the F2 plants are selected. Genetic advance under selection (AG %) was found to be high in magnitudes for number of productive tillers, main culm ear yield, number of grains per ear, number of spikelet per ear, ear yield, 1000- grain weight and grain yield per plant in all crosses studied and heading date in the fourth cross and plant height in the first cross and main culm ear length and number of spikelets per main culm ear in the first and fourth crosses and number of grains per main culm ear in

Table (3): Heritability estimates, genetic advance (∆g), and genetic advance expressed as a percent of the F_2 mean ((∆g %) for all characters studied in the four crosses-under investigation.

Characters	Cross	Heritability %		Genetic advance	
		Broad sense	Narrow sense	∆g	∆g %
1) Heading date	I	53.919	44.455	3.776	5.245
	II	83.722	61.620	7.710	8.625
	III	23.291	18.620	1.238	1.479
	IV	82.819	70.980	10.339	12.113
2) Number of productive tillers	I	82.564	48.800	4.496	56.765
	II	48.264	41.421	2.581	28.001
	III	68.826	46.578	3.984	34.213
	IV	77.823	57.372	7.359	55.244
3) Plant height	I	90.825	74.695	16.879	17.413
	II	80.786	66.430	9.711	2.608
	III	83.723	78.154	14.007	2.737
	IV	90.878	69.856	15.254	3.142
4) Main culm ear length	I	85.154	59.501	2.798	15.487
	II	43.745	36.980	1.152	8.822
	III	50.261	46.835	1.485	8.601
	IV	78.504	53.800	2.478	14.432
5) Number of spikelets per main culm ear	I	91.430	80.321	5.290	22.461
	II	54.023	41.669	1.742	7.245
	III	50.208	46.862	1.492	6.501
	IV	75.300	66.800	4.352	19.111
6) Number of grains per main culm ear	I	47.204	42.550	13.730	14.809
	II	58.479	47.548	13.510	19.051
	III	54.760	50.070	13.554	16.325
	IV	64.690	30.494	8.055	9.382
7) Main culm ear yield	I	84.049	66.667	4.120	114.802
	II	61.296	52.846	1.207	36.819
	III	62.330	49.515	1.134	26.057
	IV	51.039	35.972	0.743	17.003

Table (3): Cont.

Characters	Cross	Heritability %		Genetic advance	
		Broad sense	Narrow sense	∆g	∆g %
8) Number of spikelets per ear	I	70.447	42.859	1.930	11.344
	II	68.447	49.497	2.034	9.818
	III	65.501	53.191	2.254	12.066
	IV	67.488	43.022	1.595	9.315
9) Number of grains per ear	I	59.372	53.250	16.691	27.940
	II	51.741	41.269	11.095	22.988
	III	44.841	31.213	7.883	13.718
	IV	50.880	46.640	9.608	19.185
10) Number of grains per spikelet	I	70.840	62.000	2.212	61.361
	II	68.560	61.099	1.468	60.843
	III	92.778	71.963	2.656	83.985
	IV	74.039	69.470	2.564	91.867
11) Ear yield	I	69.164	67.000	2.760	73.569
	II	70.491	67.460	1.621	71.468
	III	73.618	53.153	1.154	37.058
	IV	79.091	55.882	1.501	55.286
12) 1000-grain weight	I	55.112	46.154	8.397	14.326
	II	72.135	66.963	13.086	28.536
	III	63.606	31.189	5.385	10.007
	IV	45.369	37.040	5.395	10.404
13) Grain yield per plant	I	68.009	50.000	11.744	39.026
	II	56.872	50.472	13.572	62.838
	III	76.873	57.293	18.346	39.813
	IV	75.961	53.445	19.069	43.359

the first, second and third crosses and number of spikelets per ear in the first and third crosses. Johnson *et al.* (1955) reported that heritability estimates a long with genetic gain upon selection were more valuable than the former a lone 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, number of grains per spikelet, ear yield and grain yield per plant in all crosses studied and heading date in the fourth cross and plant height and number of grains per ear in the first cross only and main culm ear length and number of spikelets per main culm ear in the first and fourth crosses and number of grains per main culm ear and number of spikelets per ear in the third cross and main culm ear yield in the first and second crosses. Therefore, selection for these traits should be effective and satisfactory for successful breeding proposes. Moderate estimates of narrow sense heritability and high or moderate genetic advance were obtained for number of productive tillers in the first, second and third crosses and main culm ear length and main culm ear yield in the third cross only and number of grains per main culm ear in the first and second crosses and number of spikelets per ear in the first, second and fourth crosses and number of grains per ear in the first and fourth crosses and 1000 grain weight in the first cross. Consequently, selection for these traits would be effective, but probably of less success than in the former characters. Relatively low narrow sense heritability was associated with moderate or low estimates of genetic gain for heading date and number of grains per ear in the third cross and main culm ear length in the second cross and number of grains per main culm ear and main culm ear yield in the fourth cross and 1000-grain weight in the third and fourth crosses, hence selection procedures for these traits would be of less effectiveness. Similar results were obtained by Bayoumi (2004), Hendawy *et al.* (2007), Dawwam *et al* (2007) and El-Massry (2009).

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استخدام موديل العشائر الستة لتقدير التباين الوراثى التفوقى والمضيف والسيادى فى قمح الخبز

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الملخص العربى

أُجرى هذا البحث فى مزرعة كلية الزراعة بشبين الكوم جامعة المنوفية وذلك فى ثلاثة مواسم هى ٢٠٠٥/٢٠٠٦ ، ٢٠٠٦/٢٠٠٧ ، ٢٠٠٨/٢٠٠٩ ، فقد تم التهجين فى الموسم الأول بين الآباء (جيزة ١٦٨ × سدس ٩) ، (جميزة ٧ × سخا ٩٤) ، (جميزة ٧ × سخا ٦٩)، (جيزة ١٧٠× سخا ٩٤) وذلك للحصول على الجيل الأول لعمل موديل العشائر الستة وفى الموسم الثانى تم عمل التهجينات الرجعية والحصول على الجيل الثانى للعشائر الستة. 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 الستة 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(جم) – 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 جيزة ١٦٨ × سدس ٩ هو الهجين الوحيد الذى أظهر قوة هجين معنوية لصفة المحصول (٨٣,٩٣%) .

وجدت سيادة فائقة تجاه الأب الأفضل بإستخدام دليل السيادة لصفات عدد حبوب السنبلة فى الهجين الثانى ووزن الألف حبة ومحصول النبات الفردى فى الهجين الأول وطول السنبلة الرئيسية وعدد حبوبها فى الهجين الثالث وعدد الأفرع المنتجة فى الهجين الرابع .

كان الفعل الجينى المضيف معنوياً لكلٍ من صفات ميعاد طرد السنابل ، عدد الأفرع المنتجة ومحصول السنبلة فى الهجين الأول والثالث والرابع وصفة طول النبات فى الأربعة هجن المدروسة وطول السنبلة الرئيسية ومحصولها فى كلا الهجينين الأول والثانى وعدد سنيبلات السنبلة الرئيسية وعدد حبوبها فى الهجين الأول والثانى والرابع وعدد حبوب السنبلة فى الهجين الأول والرابع ووزن الألف حبة فى الهجين الثانى والرابع ومحصول النبات الفردى فى الهجين الثالث والرابع.

كان تأثير الجينات من النوع السيادى معنوياً فى الهجن الأربعة لصفات عدد سنيبلات السنبلة ،عدد حبوبها ،وزن الألف حبة ومحصول النبات الفردى وصفة ميعاد طرد السنابل وعدد الأفرع المنتجة فى الثلاثة هجن الأخيرة وصفة طول النبات فى الهجين الأول والثانى والرابع وطول السنبلة الرئيسية فى الهجين الأول فقط وصفتى عدد سنيبلات السنبلة الرئيسية وعدد حبوبها فى الهجينين الأول والثانى وصفة محصول السنبلة الرئيسية فى الثلاثة هجن الأولى وصفتى عدد حبوب السنيبلة ومحصول السنبلة فى الهجينين الثانى والثالث.

كان فعل الجينات التفوقى بطرزه الثلاثة المضيف × المضيف والمضيف × السيادى والسيادى × السيادى معنوياً لصفات ميعاد طرد السنابل ،عدد الأفرع المنتجة وطول السنبلة الرئيسية فى الهجين الثانى ومحصول السنبلة الرئيسية وعدد سنيبلات السنبلة فى الهجينين الثانى والثالث وعدد حبوب السنبلة الرئيسية ووزن الألف حبة فى الهجينين الأول والثانى وعدد حبوب السنبلة ومحصول النبات الفردى فى الهجين الثالث وكان فعل الجينات التفوقى بطرزه الثلاثة مصاحباً لمقاييس التفوق E_1 ، E_2 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 طول النبات ،عدد حبوب السنيبلة ، محصول السنبلة ومحصول النبات الفردى فى الأربعة هجن المدروسة وصفة ميعاد طرد السنابل فى الهجينين الثانى والرابع وطول السنبلة الرئيسية ،عدد سنيبلاتها ،محصولها وعدد حبوب

السنبلة 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 وميعاد طرد السنابل فى الهجين الرابع فقط وطول النبات ،محصول السنبلة الرئيسية وعدد حبوب السنبلة فى الهجين الأول وطول السنبلة الرئيسية وعدد سنيبلاتها فى الهجينين الأول والرابع وعدد حبوب السنبلة ، محصول السنبلة ومحصول النبات الفردى فى الأربعة هجن المدروسة ، وكذلك وجد أن القيم المتوسطة والمنخفضة للتحسين الوراثى مرتبطة مع القيم المتوسطة والمنخفضة للكفاءة الوراثية بالمعنى الدقيق وذلك فى بعض الصفات المدروسة .

Table (2): Heterosis, inbreeding depression, and gene action parameters in the four crosses I (Giza168 x sids9), II (Gemmiza 7 x sakha 94) , III (Gemmiza7 x sakha69) and IV (Giza170 x sakha 94) for all characters studied.

Character	Cross	Heterosis %	Inbreeding depression %	Potence ratio	F_2 deviation E_1	Backcross deviation E_2	Gene action parameters					
							m	a	d	aa	ad	dd
1) Heading date	I	7.075**	-0.498	0.545	-2.485**	-2.472**	71.990**	3.544**	-0.688	4.996*	-6.872**	-0.051
	II	-0.208	-12.023**	1.031	6.836**	-6.625**	89.394**	-0.175	-46.11**	-40.59**	5.175**	53.84**
	III	1.834*	-2.770**	-0.127	2.339**	1.788*	83.689**	3.413**	-5.61**	-5.78**	4.713**	2.206
	IV	-5.690**	-5.818**	2.89	0.977	-0.467	85.360**	-6.411**	-12.27**	-4.840	-3.844**	5.773
2) Number of productive tillers	I	11.111*	20.80**	1.41	-0.355	-3.706**	7.920**	1.756**	-2.541	-5.99**	-0.694	13.40**
	II	-44.36**	-19.19**	-0.91	0.134	-2.475**	9.218**	0.258	-8.187**	-5.48**	3.725**	10.43**
	III	2.373	-15.67**	1.16	2.411**	-2.779**	11.644**	-1.413*	-13.53**	-15.20**	0.021	20.76**
	IV	-24.94**	-27.66**	-2.201	1.695*	1.539	13.320**	-1.811*	-6.086*	-3.702	-0.728	0.624
3) Plant height	I	3.327**	-1.782	0.519	0.038	-8.361**	96.930**	6.356**	-20.19**	-16.87**	-0.028	33.59**
	II	8.480**	-3.325**	-0.702	5.76**	-4.917**	120.718**	4.433**	-29.14**	-32.90**	-0.933	42.73**
	III	-4.891**	-0.214	3.85	-3.55**	-2.767*	109.133**	2.625*	1.100	8.667*	0.658	-3.133
	IV	4.398**	-5.155**	0.311	4.19**	2.000	104.840**	-3.722**	-14.66**	-12.76**	2.378	8.760

Table (2): Cont.

Character	Cross	Heterosis %	Inbreeding depression %	Potence ratio	F_2 deviation E_1	Backcross deviation E_2	Gene action parameters					
							m	a	d	aa	ad	dd
Main culm ear length	I	5.597**	1.284	1.64	1.013**	1.101**	18.065**	-0.328*	0.646	-1.849	1.197**	-0.352
	II	-3.609*	23.196**	0.403	-3.730**	0.108	13.062**	0.764**	15.56**	15.13**	1.831**	-15.35**
	III	6.748**	-4.302**	1.73	1.956**	2.465**	17.269**	-0.378	-0.407	-2.89**	-1.819**	-2.034
	IV	-6.424**	-4.010*	-1.85	0.294	0.316	17.172**	-0.271	-1.281	-0.546	0.127	-0.086
Number of spikelets per main culm ear	I	-3.830**	-0.498	-1.95	-0.192	-1.494**	23.550**	-0.211	-2.839*	-2.222	0.106	5.211**
	II	-6.349**	-1.894	-0.65	0.130	-0.367	24.047**	1.467**	-1.888*	-1.255	0.500	1.988
	III	-7.804**	1.196	-1.23	-0.819**	-1.338**	22.956**	-0.063	-0.481	0.603	-0.946**	2.072
	IV	-1.433	0.712	-0.176	-0.188	-0.494	22.770**	-0.311	-0.286	-0.236	-0.028	1.224
Number of grains per main culm ear	I	-19.57**	1.021	-0.231	-3.098	-18.75**	92.710**	-11.15**	-29.39**	-25.11**	7.361**	62.61**
	II	-4.456	10.608**	0.059	-8.299**	13.69**	70.918**	11.87**	60.81**	60.57**	15.81**	-87.96**
	III	5.898*	-4.299	2.04	7.764**	6.458*	83.022**	-3.200	-9.456	-18.13**	-7.45**	5.222
	IV	-7.627**	-11.93**	-0.854	7.692**	19.12**	85.850**	-3.65*	4.550	7.467	-0.239	-45.70**
Main culm ear yield	I	-4.002	33.504**	0.801	-1.356**	-0.408	3.589**	-1.010**	5.514**	4.610**	0.118	-3.795*

	II	2.835	31.685**	0.132	-1.362**	-0.450*	3.279**	0.490**	4.865**	4.546**	0.304*	-3.64**
	III	-21.51**	-18.792**	-0.006	0.686**	0.268	4.352**	-0.079	-2.213**	-2.208**	-1.078**	1.673*
	IV	-12.75**	-16.537**	-0.344	0.549**	1.070**	4.367**	-0.175	-0.198	-0.057	0.232	-2.084**

Table (2): Cont.

Character	Cross	Heterosis %	Inbreeding depression %	Potence ratio	F_2 deviation E_1	Backcross deviation E_2	Gene action parameters					
							m	a	d	aa	ad	dd
Number of spikelets per ear	I	-23.841**	3.627*	-4.02	-2.853**	-6.458**	17.013**	0.206	-5.930**	-1.505	1.308**	14.42**
	II	-19.078**	-16.924**	-1.45	1.763**	-1.924**	20.719**	0.930**	-13.37**	-10.89**	-0.776**	14.74**
	III	-13.729**	1.133	-1.15	-1.018**	-3.659**	18.677**	-0.520	-4.853**	-3.245**	-1.918**	10.56**
	IV	-4.109**	3.398*	-1.39	-0.823**	0.494	17.125**	-0.385	3.84**	4.281**	-0.067	-5.27**
Number of grains per ear	I	-35.379**	10.362**	-0.683	-14.30**	-31.29**	59.739**	-16.94**	-20.15**	-5.349	4.738*	67.92**
	II	-7.175	10.483**	-3.11	-7.229**	-18.807**	48.265**	-0.780	-11.85*	-8.698	-1.794	46.31**
	III	-24.810**	-31.582**	-1.39	9.596**	0.268	57.467**	-2.424	-46.24**	-37.84**	-8.44**	37.31**
	IV	-10.112**	0.613	0.132	0.123	10.902**	50.079**	-		21.312**	0.235	-43.11**

Character	Cross	Heterosis %	Inbreeding depression %	Potence ratio	F_2 deviation E_1	Backcross deviation E_2	m	a	d	aa	ad	dd
								6.297**	22.17**			
Number of grains per spikelet	I	-6.006	13.607*	0.665	-0.302	-0.957**	3.605**	-0.234	-0.174	-0.706	0.564*	2.620*
	II	-9.621	16.166**	-0.125	-0.482**	0.246	2.412**	-0.270*	2.388**	2.423**	0.002	-2.916**
	III	1.692	-17.78*	1.34	0.567**	0.382	3.162**	-0.428	-1.326**	-1.505	-0.563*	0.742
	IV	-8.501	4.199	-0.22	-0.147	0.398	2.791**	-0.386	1.334	1.382	-0.164	-2.178

Table (2): Cont.

Character	Cross	Heterosis %	Inbreeding depression %	Potence ratio	F_2 deviation E_1	Backcross deviation E_2	Gene action parameters					
							m	a	d	aa	ad	dd
Ear yield	I	-19.765**	1.983	0.202	0.043	-0.771*	3.752**	-0.974**	-1.476	-1.715	0.208	3.256*
	II	6.658	37.364**	1.904	-1.115**	-0.494*	2.268**	0.145	3.947**	3.471**	-0.106	-2.484**
	III	-20.829**	-15.84**	0.066	0.451**	0.285	3.113**	-0.473**	-1.183*	-1.233*	-1.230**	0.662
	IV	-13.063*	-7.920	0	0.199	0.727**	2.715**	-0.502**	0.656	0.656	-0.124	-2.110*

1000-grain weight	I	22.15**	-3.421	4.86	8.407**	4.829**	58.612**	0.368	-11.03**	-23.97**	3.027*	14.31*
	II	-8.223**	12.36**	-0.292	-6.999**	-0.411	45.857**	-2.225*	26.11**	27.17**	-5.854**	-26.35**
	III	-5.055*	0.589	0.641	2.256*	7.054**	53.814**	0.096	10.23*	5.083	-7.937**	-19.19**
	IV	-2.539	-6.938**	-10.81	2.786**	-0.144	51.858**	-2.058*	-12.58**	-11.43**	-1.951	11.72*
Grain yield per plant	I	83.93**	25.125**	15.79	-0.307	-21.25**	30.092**	-0.757	-21.69**	-41.27**	-1.997	83.76**
	II	-36.05**	22.081**	-0.584	-9.001**	-9.401**	21.598**	0.631	11.44*	17.20**	10.50**	1.602
	III	8.099	-80.57**	3.58	21.88**	-0.944	46.080**	-9.970**	-86.78**	-89.43**	-10.71**	91.32**
	IV	-39.29**	-67.127**	-1.11	13.18**	21.36**	43.979**	-5.861**	-18.97*	-10.008	2.209	-32.71**

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

Table(2): Heterosis, inbreeding depression, and gene action parameters in the four crosses I (Giza168 x sids9), II (Gemmiza 7 x sakha 94) , III (Gemmiza7 x sakha69) and IV (Giza170 x sakha 94) for all characters studied.

Character	Cross	Heterosis %	Inbreeding depression %	Potence ratio	F_2 deviation E_1	Backcross deviation E_2	Gene action parameters					
							m	a	d	aa	ad	dd
1) Heading date	I	7.075**	-0.498	0.545	-2.485**	-2.472**	71.990**	3.544**	-0.688	4.996*	-6.872**	-0.051
	II	-0.208	-12.023**	1.031	6.836**	-6.625**	89.394**	-0.175	-46.11**	-40.59**	5.175**	53.84**
	III	1.834*	-2.770**	-0.127	2.339**	1.788*	83.689**	3.413**	-5.61**	-5.78**	4.713**	2.206
	IV	-5.690**	-5.818**	2.89	0.977	-0.467	85.360**	-6.411**	-12.27**	-4.840	-3.844**	5.773
2) Number of productive tillers	I	11.111*	20.80**	1.41	-0.355	-3.706**	7.920**	1.756**	-2.541	-5.99**	-0.694	13.40**
	II	-44.36**	-19.19**	-0.91	0.134	-2.475**	9.218**	0.258	-8.187**	-5.48**	3.725**	10.43**
	III	2.373	-15.67**	1.16	2.411**	-2.779**	11.644**	-1.413*	-13.53**	-15.20**	0.021	20.76**
	IV	-24.94**	-27.66**	-2.201	1.695*	1.539	13.320**	-1.811*	-6.086*	-3.702	-0.728	0.624
3) Plant height	I	3.327**	-1.782	0.519	0.038	-8.361**	96.930**	6.356**	-20.19**	-16.87**	-0.028	33.59**
	II	8.480**	-3.325**	-0.702	5.76**	-4.917**	120.718**	4.433**	-29.14**	-32.90**	-0.933	42.73**
	III	-4.891**	-0.214	3.85	-3.55**	-2.767*	109.133**	2.625*	1.100	8.667*	0.658	-3.133
	IV	4.398**	-5.155**	0.311	4.19**	2.000	104.840**	-3.722**	-14.66**	-12.76**	2.378	8.760

Table (2): Cont.

Character	Cross	Heterosis %	Inbreeding depression %	Potence ratio	F_2 deviation E_1	Backcross deviation E_2	Gene action parameters					
							m	a	d	aa	ad	dd
4) Main culm ear length	I	5.597**	1.284	1.64	1.013**	1.101**	18.065**	-0.328*	0.646	-1.849	1.197**	-0.352
	II	-3.609*	23.196**	0.403	-3.730**	0.108	13.062**	0.764**	15.56**	15.13**	1.831**	-15.35**
	III	6.748**	-4.302**	1.73	1.956**	2.465**	17.269**	-0.378	-0.407	-2.89**	-1.819**	-2.034
	IV	-6.424**	-4.010*	-1.85	0.294	0.316	17.172**	-0.271	-1.281	-0.546	0.127	-0.086
5) Number of spikelets per main culm ear	I	-3.830**	-0.498	-1.95	-0.192	-1.494**	23.550**	-0.211	-2.839*	-2.222	0.106	5.211**
	II	-6.349**	-1.894	-0.65	0.130	-0.367	24.047**	1.467**	-1.888*	-1.255	0.500	1.988
	III	-7.804**	1.196	-1.23	-0.819**	-1.338**	22.956**	-0.063	-0.481	0.603	-0.946**	2.072
	IV	-1.433	0.712	-0.176	-0.188	-0.494	22.770**	-0.311	-0.286	-0.236	-0.028	1.224
6) Number of grains per main culm ear	I	-19.57**	1.021	-0.231	-3.098	-18.75**	92.710**	-11.15**	-29.39**	-25.11**	7.361**	62.61**
	II	-4.456	10.608**	0.059	-8.299**	13.69**	70.918**	11.87**	60.81**	60.57**	15.81**	-87.96**
	III	5.898*	-4.299	2.04	7.764**	6.458*	83.022**	-3.200	-9.456	-18.13**	-7.45**	5.222
	IV	-7.627**	-11.93**	-0.854	7.692**	19.12**	85.850**	-3.65*	4.550	7.467	-0.239	-45.70**
7) Main culm ear yield	I	-4.002	33.504**	0.801	-1.356**	-0.408	3.589**	-1.010**	5.514**	4.610**	0.118	-3.795*
	II	2.835	31.685**	0.132	-1.362**	-0.450*	3.279**	0.490**	4.865**	4.546**	0.304*	-3.64**
	III	-21.51**	-18.792**	-0.006	0.686**	0.268	4.352**	-0.079	-2.213**	-2.208**	-1.078**	1.673*
	IV	-12.75**	-16.537**	-0.344	0.549**	1.070**	4.367**	-0.175	-0.198	-0.057	0.232	-2.084**

Table (2): Cont.

Character	Cross	Heterosis %	Inbreeding depression %	Potence ratio	F_2 deviation E_1	Backcross deviation E_2	Gene action parameters					
							m	a	d	aa	ad	dd
8) Number of spikelets per ear	I	-23.841**	3.627*	-4.02	-2.853**	-6.458**	17.013**	0.206	-5.930**	-1.505	1.308**	14.42**
	II	-19.078**	-16.924**	-1.45	1.763**	-1.924**	20.719**	0.930**	-13.37**	-10.89**	-0.776**	14.74**
	III	-13.729**	1.133	-1.15	-1.018**	-3.659**	18.677**	-0.520	-4.853**	-3.245**	-1.918**	10.56**
	IV	-4.109**	3.398*	-1.39	-0.823**	0.494	17.125**	-0.385	3.84**	4.281**	-0.067	-5.27**
9) Number of grains per ear	I	-35.379**	10.362**	-0.683	-14.30**	-31.29**	59.739**	-16.94**	-20.15**	-5.349	4.738*	67.92**
	II	-7.175	10.483**	-3.11	-7.229**	-18.807**	48.265**	-0.780	-11.85*	-8.698	-1.794	46.31**
	III	-24.810**	-31.582**	-1.39	9.596**	0.268	57.467**	-2.424	-46.24**	-37.84**	-8.44**	37.31**
	IV	-10.112**	0.613	0.132	0.123	10.902**	50.079**	-6.297**	22.17**	21.312**	0.235	-43.11**
10) Number of grains per spikelet	I	-6.006	13.607*	0.665	-0.302	-0.957**	3.605**	-0.234	-0.174	-0.706	0.564*	2.620*
	II	-9.621	16.166**	-0.125	-0.482**	0.246	2.412**	-0.270*	2.388**	2.423**	0.002	-2.916**
	III	1.692	-17.78*	1.34	0.567**	0.382	3.162**	-0.428	-1.326**	-1.505	-0.563*	0.742
	IV	-8.501	4.199	-0.22	-0.147	0.398	2.791**	-0.386	1.334	1.382	-0.164	-2.178

Table (2): Cont.

Character	Cross	Heterosis %	Inbreeding depression %	Potence ratio	F_2 deviation E_1	Backcross deviation E_2	Gene action parameters					
							m	a	d	aa	ad	dd
11) Ear yield	I	-19.765**	1.983	0.202	0.043	-0.771*	3.752**	-0.974**	-1.476	-1.715	0.208	3.256*
	II	6.658	37.364**	1.904	-1.115**	-0.494*	2.268**	0.145	3.947**	3.471**	-0.106	-2.484**
	III	-20.829**	-15.84**	0.066	0.451**	0.285	3.113**	-0.473**	-1.183*	-1.233*	-1.230**	0.662
	IV	-13.063*	-7.920	0	0.199	0.727**	2.715**	-0.502**	0.656	0.656	-0.124	-2.110*
12) 1000-grain weight	I	22.15**	-3.421	4.86	8.407**	4.829**	58.612**	0.368	-11.03**	-23.97**	3.027*	14.31*
	II	-8.223**	12.36**	-0.292	-6.999**	-0.411	45.857**	-2.225*	26.11**	27.17**	-5.854**	-26.35**
	III	-5.055*	0.589	0.641	2.256*	7.054**	53.814**	0.096	10.23*	5.083	-7.937**	-19.19**
	IV	-2.539	-6.938**	-10.81	2.786**	-0.144	51.858**	-2.058*	-12.58**	-11.43**	-1.951	11.72*
13) Grain yield per plant	I	83.93**	25.125**	15.79	-0.307	-21.25**	30.092**	-0.757	-21.69**	-41.27**	-1.997	83.76**
	II	-36.05**	22.081**	-0.584	-9.001**	-9.401**	21.598**	0.631	11.44*	17.20**	10.50**	1.602
	III	8.099	-80.57**	3.58	21.88**	-0.944	46.080**	-9.970**	-86.78**	-89.43**	-10.71**	91.32**
	IV	-39.29**	-67.127**	-1.11	13.18**	21.36**	43.979**	-5.861**	-18.97*	-10.008	2.209	-32.71**

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

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 four crosses I [Giza168 (P_1) x Sids9 (P_2)], II [Gemmiza 7(P_1) x Sakha 94 (P_2)] , III [Gemmiza7(P_1) x Sakha69 (P_2)] and IV [Giza170(P_1) x Sakha 94(P_2)] for all traits studied.

Character		Heading date		No. of productive tillers, cm		Plant height, cm		Main culm ear length, cm	
Cross no.	generation	$\overline{X}$	S^2	$\overline{X}$	S^2	$\overline{X}$	S^2	$\overline{X}$	S^2
I	P1	85.533	9.430	11.73	9.720	95.50	10.22	16.84	1.062
	P2	90.667	6.092	13.90	8.852	107.7	9.320	17.64	1.025
	F1	80.667	10.250	10.43	7.220	99.70	11.21	16.51	1.137
	F2	85.36	50.00	13.32	38.76	104.8	112.3	17.17	5.000
	BC1	80.944	30.250	11.48	35.64	99.78	80.00	16.90	16.90
	BC2	87.356	34.260	13.30	66.23	103.51	66.23	17.17	3.21
II	P1	79.967	8.378	6.967	3.360	118.43	8.461	15.51	1.186
	P2	90.667	6.092	13.90	5.260	107.70	9.320	17.64	1.025
	F1	79.800	3.545	7.733	5.582	116.83	11.24	17.00	1.650
	F2	89.394	36.891	9.218	9.150	120.71	50.36	13.06	2.288
	BC1	79.158	20.360	7.975	8.150	114.70	27.91	17.22	1.950
	BC2	79.333	30.690	7.717	6.360	110.27	39.36	16.46	1.780
III	P1	79.96	8.378	6.967	3.360	118.4	8.461	15.51	1.186
	P2	82.56	6.599	9.833	7.523	114.5	13.25	12.62	1.240
	F1	81.43	9.000	10.06	5.240	108.9	15.25	16.55	1.110
	F2	83.68	10.41	11.64	17.24	109.1	75.69	17.26	2.370
	BC1	83.95	8.950	7.138	14.24	112.6	52.39	16.35	1.950
	BC2	80.53	9.948	8.550	12.21	109.9	39.83	16.73	1.680
IV	P1	85.53	9.430	11.73	9.720	95.5	10.22	16.84	1.062
	P2	90.66	6.092	13.90	8.852	107.7	9.320	17.64	1.025
	F1	80.66	10.25	10.43	7.220	99.70	11.21	16.51	1.137
	F2	85.36	50.00	13.32	38.76	104.8	112.3	17.17	5.000
	BC1	80.94	30.25	11.48	35.64	99.78	80.00	16.90	4.100

	BC2	87.35	34.26	13.30	19.65	103.5	66.23	17.17	3.210

Table (1): Cont.

Character		No.of spikelets per main culm ear		No. of grains per main culm ear		Main culm ear yield ,g	
Cross no.	generation	$\overline{X}$	S^2	$\overline{X}$	S^2	$\overline{X}$	S^2
I	P1	22.70	2.300	76.20	65.20	3.481	0.345
	P2	23.26	3.210	83.03	52.72	4.295	0.423
	F1	22.93	1.900	76.70	56.24	3.748	0.707
	F2	22.77	10.00	85.85	164.4	4.367	1.004
	BC1	22.55	7.680	85.88	168.0	4.266	0.931
	BC2	22.86	5.640	89.54	110.6	4.441	0.716
II	P1	25.20	1.683	75.16	89.38	4.668	0.568
	P2	23.26	2.100	83.03	70.26	4.295	0.423
	F1	23.60	1.900	79.33	77.33	4.800	0.437
	F2	24.04	4.120	70.91	190.25	3.279	1.230
	BC1	24.46	2.923	92.00	139.6	4.661	0.860
	BC2	23.00	3.600	80.12	150.36	4.170	0.950
III	P1	25.20	1.683	75.16	89.38	4.668	0.568
	P2	23.43	1.289	66.66	85.60	2.669	0.422
	F1	23.23	0.599	79.60	59.36	3.663	0.407
	F2	22.95	2.390	83.02	172.6	4.352	1.236
	BC1	23.07	1.880	76.88	124.3	3.760	0.980
	BC2	23.13	1.780	80.08	134.5	3.839	0.880
IV	P1	22.70	2.300	76.20	65.20	3.481	0.345
	P2	23.26	3.210	83.03	52.72	4.295	0.423
	F1	22.93	1.900	76.70	56.24	3.748	0.707
	F2	22.77	10.00	85.85	164.4	4.367	1.004
	BC1	22.55	7.680	85.88	168.0	4.266	0.931
	BC2	22.86	5.640	89.54	110.6	4.441	0.716

Table (1): Cont.

Character		No.of spikelets per ear		No. of grains per ear		No. of grains per spikelet	
Cross no.	generation	$\overline{X}$	S^2	$\overline{X}$	S^2	$\overline{X}$	S^2
I	P1	17.85	0.620	42.99	50.00	2.740	0.950
	P2	18.48	1.127	56.05	45.00	3.184	0.680
	F1	17.72	1.413	50.38	52.36	2.913	0.870
	F2	17.12	3.240	50.07	100.0	2.791	3.210
	BC1	18.00	2.736	52.25	80.00	2.943	1.980
	BC2	18.38	2.350	58.55	73.36	3.330	2.210
II	P1	21.89	1.548	58.08	85.99	2.640	0.175
	P2	18.48	1.127	56.05	70.36	3.184	0.680
	F1	17.72	1.092	53.91	90.23	2.878	0.428
	F2	20.71	3.980	48.26	170.3	2.412	1.360
	BC1	18.45	3.110	45.70	150.0	2.883	1.110
	BC2	17.52	2.880	46.48	120.3	3.153	0.779
III	P1	21.89	1.548	58.08	85.99	2.640	0.175
	P2	19.10	1.744	46.05	72.75	2.371	0.091
	F1	18.89	1.086	43.67	90.00	2.685	0.430
	F2	18.67	4.230	57.46	150.3	3.162	3.210
	BC1	17.60	3.230	46.79	130.3	2.572	2.110
	BC2	18.12	2.980	49.21	123.3	3.000	2.000
IV	P1	17.85	0.620	42.99	50.00	2.740	0.950
	P2	18.48	1.127	56.05	45.00	3.184	0.680
	F1	17.72	1.413	50.38	52.36	2.913	0.870
	F2	17.12	3.240	50.07	100.0	2.791	3.210
	BC1	18.00	2.736	52.25	80.00	2.943	1.980
	BC2	18.38	2.350	58.55	73.36	3.330	2.210

Table (1): Cont.

Cross no.	generation	Ear yield ,g $\bar{X}$	Ear yield ,g S^2	1000-grain weight ,g $\bar{X}$	1000-grain weight ,g S^2	Grain yield per plant,g $\bar{X}$	Grain yield per plant,g S^2
I	P1	2.137	0.305	49.54	24.69	27.20	51.34
	P2	2.894	0.209	49.75	27.00	43.35	80.00
	F1	2.516	0.552	48.49	30.25	26.31	85.00
	F2	2.715	1.700	51.85	50.00	43.97	300.0
	BC1	2.628	1.050	47.97	36.25	38.54	239.6
	BC2	3.130	1.400	50.02	45.23	44.40	200.0
II	P1	3.394	0.326	57.01	24.25	23.60	60.35
	P2	2.894	0.209	49.75	27.00	43.35	80.00
	F1	3.620	0.669	52.32	23.97	27.71	80.10
	F2	2.268	1.360	45.85	89.99	21.59	170.3
	BC1	3.208	0.823	51.53	69.36	26.21	115.34
	BC2	3.063	0.980	53.76	50.36	25.58	139.44
III	P1	3.394	0.326	57.015	24.25	23.60	60.35
	P2	1.880	0.233	40.949	30.24	22.12	56.36
	F1	2.687	0.319	54.133	22.21	25.51	50.92
	F2	3.113	1.110	53.814	70.250	46.08	241.62
	BC1	2.568	0.880	55.132	60.35	18.73	195.25
	BC2	3.041	0.750	55.036	58.24	28.70	149.57
IV	P1	2.137	0.305	49.54	24.69	27.20	51.34
	P2	2.894	0.209	49.757	27.00	43.35	80.00
	F1	2.516	0.552	48.493	30.250	26.32	85.00
	F2	2.715	1.70	51.858	50.00	43.97	300.00
	BC1	2.628	1.05	47.97	36.25	38.55	239.66
	BC2	3.130	1.40	50.03	45.23	44.41	200.00