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GENE EFFECTS AND VARIANCES IN THREE WHEAT CROSSES USING THE FIVE PARAMETERS MODEL

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ABSTRACT

Three experiments were carried out using three crosses among five parents, namely Pastor x Giza 168, line 2 x Gemmiza 9 and Pastor x Sids 1. Five populations (P_1, P_2, F_1, F_2 and F_3) for each cross were used in this investigation. Significant positive heterotic effects were obtained for most of the characters studied in the F_1 generations. However, significant negative heterotic effects were found for no. of kernels/spike in the three crosses; and for all other characters except for 100-kernel weight in the third one. Over dominance, towards the higher parent was detected for all characters except for no. of kernels/spike where the over dominance in the first and second crosses or the dominance effects were all towards the lower parent for all characters. Inbreeding depression estimates were found to be significant for all studied attributes except for kernels weight in the first cross, for no. of spikes/plant and kernels weight in the second cross and for no. of spikes/plant, no. of kernels/spike and grain yield/plant in the third one. On the other side inbreeding depression was significantly negative for kernels weight in the first and third crosses and for straw and biological yields/plant in the third one. F_2 deviation (E_1) was significant for all studied characters and for all crosses except for straw and biological yields/plant in the first cross, no. of spikes/plant and grain yield/plant in the second cross and for biological yield/plant in the third one. Moreover, F_3 deviation (E_2) was significant for all studied characters and in all crosses except for grain yield/plant. The (additive - additive x dominance) gene effect was significant for all characters in all crosses except for kernel weight in the first cross and biological yield/plant in the third one. These results suggest the potential for obtaining further improvements in most studied characters. In addition, dominance and epistasis were found to be significant for most of the studied attributes. High to medium values of heritability estimates were found to be associated with high and moderate expected and actual gain in most characters. These obtained results indicated that selection for the studied characters could be used in the early generations but would be more effective if postponed to late generations.

Keywords: ***Wheat, Crosses, Heterosis, Heritability, Inbreeding depression, Gene action.***

INTRODUCTION

Wheat (*Triticum aestivum* L. em. Thell) is the most important cereal crop in Egypt. Increasing wheat production to narrow the gap between production and consumption is considered the main goal in Egypt as well as in most countries all over the world. Wheat breeders are always looking for means and sources of genetic improvements in grain yield and its components and in other agronomic characters.

The Egyptian wheat cultivars have somewhat narrow genetic background. Selection among these cultivars for increasing grain yield and its components would not be effective. Hybridization between the Egyptian wheat cultivars and exotic materials should be carried out to increase genetic variability. Genetic diversity is the main tool for the breeders to have better recombinations by developing heritable variability upon which selection can be practiced. Knowledge of the genetic relationships among individuals or populations is essential to breeders for planning crosses to gain better selections for high yield and developing new promising lines. Crumpacker and Allard (1962) reported that efficiency in breeding of self-pollinating crop plants depend, first, on accurate identification of hybrid combinations that have the potentiality of producing maximum improvements and second, on identifying, in early segregating generations, of superior lines among the progeny of the most promising hybrids. Therefore, information on the gene effects and variances of breeding materials could ensure long-term selection gains and better genetic improvements.

Abul-Naas *et al* (1991) and Al-Kaddoussi *et al* (1994) reported that dominance component played an important role in genetic control for number of spikes/plant, number of kernels/spike, 100-kernel weight and grain yield/plant. On the other hand, El-Hosary *et al* (2000) found that grain yield and its components in diallel cross among 8 parents, were controlled by both additive and non-additive gene effects. In addition concerning the heritability estimates, Gouda *et al* (1993) indicated that heritability in narrow sense ranged from 14 to 71% for grain yield. Meanwhile, Moustafa (2002), Hendawy (2003), El-Sayed (2004) and Abdel-Nour *et al* (2005) reported that heritability estimates for yield and its components were medium to high.

This work was conducted to study genetic variance, gene action, heritability and comparison between actual and expected genetic gain of three bread wheat crosses derived from five parental bread wheat genotypes using five populations of each cross. The ultimate goal of this study is to elucidate the breeding value of crosses that could be utilized in breeding programs to improve wheat yield.

MATERIALS AND METHODS

Five, widely-diversed, bread wheat parents were chosen to form three crosses, viz. (1) Pastor x Giza 168, (2) Line # X Gemmiza 9 and (3) Pastor x Sids1.

Table 1. Names, pedigree and origin of parental cultivars and lines.

Parent	Pedigree	Origin
Pastor	CM 85295-0101 top Y-2M-0Y-0M-3Y-0M-0AP.	ICARDA
Giza 168	Mrl/Buc//Seri CM 93046 - 8M - 0Y - 0M - 2Y - 0B	Egypt
Line #	Vee "S" / Saker "s" ICW 86–1034 – 300L–300AP–0L– 5Ap- 0L-0Ap	ICARDA
Gemmiza 9	Ald "S"/Huac "S"//CMH74A.630/sx CGM4583 - 5GM - 1GM - 0GM	Egypt
Sids 1	HD21/PAVON "S"//1158.57/MAYA74 "S"	Egypt

The experimental work of the present study was carried out at El-Giza Research Station during four successive seasons from 2001/2002 through 2004/2005. In the first season (2001/2002), the parental genotypes were crossed to obtain F_1 seeds. In the second season (2002/2003), the hybrid seed of the three crosses were sown to give the F_1 plants. These plants were selfed to produce F_2 seeds. Moreover, the same parents were crossed to have enough F_1 seeds. The new hybrid seed and part of seeds obtained from F_1 selfed plants (F_2 seeds) were kept in refrigerator to the final experiment. In the third season (2003/2004), three F_1 seeds were sown to produce F_1 plants, which were selfed to produce F_2 seeds. In addition, the F_1 and F_2 plants were selfed to produce F_2 and F_3 seeds, respectively.

In the fourth season (2004/2005) the obtained seeds of the five populations P_1, P_2, F_1, F_2 and F_3 of the three crosses were evaluated using a randomized complete block design with three replications. Rows were 4 m long, spaces between rows were 20 cm. The plants within rows were 10 cm apart. Two rows were devoted for each parent and F_1 progenies, five rows for F_2 generation and 20 rows for F_3 families for each cross. Data were recorded on individual guarded plants for no. of spikes/plant, no. of kernels/spike, 100-kernel weight (g), grain yield/plant (g), straw yield/plant (g) and biological yield/plant (g).

Various biometrical parameters in this study would only be calculated if the F_2 genetic variance was found to be significant. Heterosis was expressed as the percentage deviation of F_1 mean performance from better parent values (heterobeltiosis). Inbreeding depression was calculated as the difference between the F_1 and F_2 means expressed as percentage of the F_1 mean. The T-test was used to determine the significance of these deviations where the standard error (S.E) was calculated as follows:

S.E for better parent heterosis

$$\overline{F_1} - \overline{BP} = (V\overline{F_1} + V\overline{BP})^{1/2}$$

and S.E for inbreeding depression

$\overline{F_1} - \overline{F_2} = (V\overline{F_1} + V\overline{F_2})^{½}$

Potence ratio (P) was also calculated according to Peter and Frey (1966). In addition, F_2 deviation (E_1) and F_3 deviation (E_2) were measured as suggested by Mather and Jinks (1971).

Type of gene effects was estimated according to Hayman model in 1958 as described by Singh and Chaudhary (1985) as follows:

The standard error of additive–additive x dominance (d*), dominance (h), dominance x dominance (l) and additive x additive (I) is obtained by taking the squares root of respective variation 'T' test values are calculated upon dividing the effects of d*, h, l and i by their respective standard error.

$m = \overline{F_2}$

$d^* = ½\,\overline{P_1} - ½\,\overline{P_2}$

$h = 1/6\,(4\overline{F_1} + 12\,\overline{F_2} - 16\,\overline{F_3})$

$l = 1/3\,(16\overline{F_3} - 24\,\overline{F_2} + 8\,\overline{F_1})$

$i = \overline{P_1} - \overline{F_2} + ½\,(\overline{P_1} - \overline{P_2} + h) - ¼\,l$

The variances of these estimates were computed as follows:

and $V_m = V\overline{F_2}$

$Vd^* = ¼\,(V\overline{P_1} + V\overline{P_2})$

$Vh = 1/36\,(16V\overline{F_1} + 144V\overline{F_2} + 256V\overline{F_3})$

$Vl = 1/9\,(256\,V\overline{F_3} + 576\,V\overline{F_2} + 64V\overline{F_1})$

$Vi = V\overline{P_1} + V\overline{F_2} + ¼\,(V\overline{P_1} + V\overline{P_2} + Vh) + 1/16\,Vl$

Heritability was calculated in both broad and narrow sense according to Mather (1949) and parent off-spring regression according to Sakai (1960). Furthermore, the expected and actual genetic advance (Δg) was computed according to Johanson *et al* (1955).

Likewise, the genetic gain represented as percentage of the F_2 and F_3 mean performance (Δg %) and was estimated using the method of Miller *et al* (1958).

RESULTS AND DISCUSSION

Parental differences in response to their genetic background were found to be significant in most characters under investigation. The F_2 genetic variances were also significant for all studied characters in three crosses. Means and variances of the five populations (P_1, P_2, F_1, F_2 and F_3) for the studied characters in the three crosses are presented in Table (2).

Table 2. Means $(\overline{x})$ and variances (S^2) for some studied characters using the five populations (P_1, P_2, F_1, F_2 and bulk F_3 families) for three bread wheat crosses.

Characters	Parameters	Pastor x Giza 168				
		P_1	P_2	F_1	F_2	F_3 bulk
No. of Spikes/plant	X	25.57	22.14	26.75	23.60	21.1
	S^2	6.56	5.83	7.46	35.54	25.34
No. of kernels/spike	X	79.44	82.29	76.75	65.60	68.6
	S^2	21.73	20.62	30.20	217.42	148.2
100-kernel weight (g)	X	4.44	4.45	4.94	5.05	4.89
	S^2	0.229	0.04	0.019	0.15	0.09
Grain yield/plant(g)	X	64.57	59.43	68.25	61.80	61.20
	S^2	19.16	17.36	13.88	229.83	185.01
Straw yield/plant(g)	X	121.14	107.71	126.75	118.20	109.80
	S^2	52.48	43.81	48.09	764.59	446.32
Biological Yield/plant (g)	X	185.71	167.14	195.00	180.00	171.00
	S^2	85.71	81.43	78.95	1114.09	796.97
		Sids 1 x Sakha 93				
No. of Spikes/plant	X	21.42	19.85	22.63	21.13	18.64
	S^2	5.83	3.58	5.46	33.67	23.90
No. of kernels/spike	X	80.45	67.90	67.75	67.87	63.36
	S^2	20.25	16.68	18.2	250.99	170.5
100-kernel weight (g)	X	4.45	5.02	5.37	5.26	5.70
	S^2	0.04	0.03	0.03	0.24	0.14
Grain yield/plant(g)	X	55.75	51.20	60.55	58.60	55.36
	S^2	18.85	17.22	16.95	294.87	182.07
Straw yield/plant (g)	X	111.39	134.80	150.75	148.07	119.16
	S^2	42.54	39.57	46.37	494.96	331.53
Biological Yield/plant (g)	X	169.14	183.5	211.25	206.67	174.55
	S^2	74.43	62.46	63.59	492.17	320.25
		Sakha 93 x Dovin-2				
No. of Spikes/plant	X	25.57	18.20	21.10	19.73	16.70
	S^2	6.56	4.75	3.29	22.75	17.40
No. of kernels/spike	X	75.93	79.95	76.60	68.47	58.6
	S^2	20.95	14.14	27.41	110.85	74.38
100-kernel weight (g)	X	4.45	4.07	4.61	5.01	5.07
	S^2	0.02	0.02	0.03	0.22	0.13
Grain yield/plant(g)	X	64.57	52.52	57.80	52.27	50.50
	S^2	19.16	10.04	12.38	183.69	113.38
Straw yield/plant(g)	X	128.43	138.20	111.2	127.73	115.00
	S^2	70.63	68.93	65.64	508.86	301.01
Biological Yield/plant (g)	X	193.00	190.70	169.00	180.0	165.50
	S^2	85.82	83.92	72.63	868.01	628.54

Heterobeltiosis, potence ratio (P), inbreeding depression percentage, E_1, E_2 and different gene actions for the six studied characters are given in Table (3).

Significant positive heterotic effect was found for all characters except for no. of spikes/plant and no. of kernels/spike in the first and second crosses, and for kernel weight in the third one. By contrast, significant negative heterotic effects were found for no. of kernels/spike in the first and second crosses; and for all characters except for kernels weight in the third one. Similar trends were reported by Gautam and Jain (1985), Moshref (1996), Hendawy (1998), El-Hosary *et al.,* (2000), Moustafa (2002), Hendawy (2003), El-Sayed (2004) and Abdel-Nour, Nadya *et al* (2005).

Number of spikes/plant, number of kernels/spike and kernel weight are the main components of grain yield/plant. Hence, heterotic increase, if found, in one or more of these attributes with others being constant would lead to favorable yield increase in a hybrid. The lack of significance in heterosis of no. of spikes/plant in the first and second crosses could be due to the lower magnitude of the non-additive gene action. These results are in agreement with those of Amaya *et al* (1972), Ketata *et al* (1976) and El-Rassas and Mitkess (1985).

The pronounced heterotic effect for kernel weight in the first cross (Pastor x Giza 168) and second cross (Line # x Gemmiza 9) would be of interest in a breeding program for high yielding ability. It is obvious that this cross has higher no. of spikes/plant and consequently higher yield/plant.

The potence ratio (P) indicated over dominance towards the higher parent for all characters except for no. of kernels/spike in the first and second crosses and for kernel weight in the third one. Complete dominance towards the lower parent was found for no. of kernels/spike in the second cross. Moreover, over dominance towards the lower parent was detected for no. of kernels/spike in the first cross and for straw and biological yields/plant in the third one.

Partial dominance towards the lower parent was found for no. of spikes/plant, no. of kernels/spike and grain yield/plant in the third cross. These results are in agreement with those obtained by Ketata *et al* (1976), Jatasra and Paroda (1980), Rady *et al* (1981), Mosaad *et al* (1990), Abul-Naas *et al* (1991), Al-Kaddoussi *et al* (1994), Moustafa (2002) and Hendawy (2003).

Table 3. Heterosis, potence ratio, inbreeding depression and gene action parameters for the three bread wheat crosses.

Characters	Cross	Heterosis % over B.P	Potence ratio (P)	Inbreeding depression %	Gene action parameters						
					m	d*	h	l	i	E_1	E_2
No. of Spikes/plant	1	4.60	1.69	11.8**	23.60**	1.715**	8.767**	-4.933	9.302**	-1.703**	-8.405**
	2	5.70	2.52	6.6*	21.13**	0.785*	7.64**	-9.28*	7.215**	-0.503	-15.648**
	3	-17.5**	-0.21	6.5*	19.73**	3.685**	8.993**	-12.51**	17.149**	-1.763**	-9.585**
No. of kernels/spike	1	-6.7**	-2.89	14.5**	65.60**	-1.423*	-0.567	45.733**	0.701	-13.206**	-20.413**
	2	-15.8**	-1.02	-0.2	67.87**	6.275**	11.947**	-24.373*	30.922**	-3.93**	-15.205**
	3	-4.2*	-0.67	10.6**	-2.01**	31.74**	31.74**	-30.96**	29.06**	-8.8**	-37.34**
100-kernel weight (g)	1	10.90**	98.00	-2.3*	5.048**	-0.005	0.354**	-1.16**	-0.146	0.358**	0.394**
	2	7.00**	2.23	2.1*	5.26**	-0.285**	-1.1**	2.64**	-2.305**	0.208**	1.295**
	3	3.6**	1.84	-8.8**	5.014**	0.19*	0.419**	-0.779*	0.03	0.579**	1.27**
Grain yield/plant(g)	1	5.7**	2.43	9.5**	61.80**	2.57**	5.88	14.00	4.78	-3.325*	-7.85**
	2	8.6**	2.59	3.2	58.60**	2.275**	9.94*	-12.08	7.415*	1.588	-3.305
	3	-10.5**	-0.12	9.6**	52.27**	6.025**	8.407*	5.307	21.202**	-5.9**	-15.345**
Straw yield/plant(g)	1	4.6*	1.84	6.8*	118.20**	6.715**	28.10**	-22.00	13.94*	-2.388	-21.575**
	2	11.8**	2.36	1.8	148.07**	-11.705**	78.88**	-147.04**	0.245	11.148**	-35.525**
	3	-19.5**	-4.53	-14.9**	127.73**	-4.885**	22.927**	-111.973**	35.271**	5.47*	-14.515**
Biological Yield/plant (g)	1	5.00**	2.01	7.7**	180.00**	9.285**	34.0**	8.00	29.995**	3.575	-29.425**
	2	15.1**	4.87	2.2	206.67**	-7.18*	88.707**	-159.093**	39.417**	12.885**	-38.47**
	3	-14.2**	-19.87	-6.5**	180.00**	1.15	31.33**	-106.667**	56.482**	-0.425	-29.85**

Inbreeding depressions were obtained in the three crosses for no. of spikes/plant, in two out of the three crosses for no. of kernels/spike and grain yield/plant and in one out of the three crosses for 100-kernel weight, straw yield/plant and biological yield/plant. This is a valid result, since the expression of heterosis in the F_1 may be followed by reduction in F_2 performance. The obtained results for most crosses were in harmony with those obtained by Gautam and Jain (1985) and Khalifa *et al* (1997).

Significant heterosis and insignificant inbreeding depressions were obtained for biological, straw and grain yields/plant in the second cross. Moreover, significant positive heterosis and significant negative inbreeding depression for kernels weight in the first and third crosses were detected. The contradiction between heterosis and inbreeding depression estimates could be due to the presence of linkage between genes in these materials (Van der Veen 1959).

Significant positive F_2 deviation were indicated for kernels weight for all crosses, for straw and biological yields/plant in the second cross and for straw yield/plant in the third one. Meanwhile, significant negative values were obtained for no. of spikes/plant, no. of kernels/spike and grain yield/plant in the first and third crosses, and for no. of kernels/spike in the second one. These results may refer to the contribution of epistatic gene effects in the performance of these characters.

On the other hand, insignificant F_2 deviation were detected for straw and biological yields/plant in the first cross, for no. of spikes/plant and grain yield/plant in the second cross and for biological yield/plant in the third one.

F_3 deviation (E_2) was revealed to be significantly positive for kernels weight in all crosses. Moreover, significant negative values were indicated for all characters of all crosses except for kernels weight and for grain yield/plant in the second cross. These results would ascertain the presence of epistasis in such large magnitude as to warrant great deal of attention in breeding programs.

Nature of gene action was determined using the five parameters (Table 3). The estimated mean effect of F_2 (m), which reflects the contribution due to the over all mean plus the locus effects and interactions of the fixed loci, was found to be highly significant. The additive gene effect, (d^*) was significantly positive for no. of spikes/plant and grain yield/plant in all crosses, for straw and biological yields/plant in the first cross, for kernels/spike in the second cross; and for No of kernels/spike and kernels weight and biological yield/plant in the third one. Meanwhile, (d^*)

was significantly negative for all other characters in all crosses. These results suggest the potential for obtaining further improvement for the former characters (i.e that showed positive and significant values) by using pedigree selection program. Similar trends were obtained by Amaya *et al* (1972), Hendawy (1998), El-Hosary *et al* (2000), Moustafa (2002), Hendawy (2003), El-Sayed (2004) and Abdel-Nour *et al* (2005).

On the other hand, significant negative (d^*) was obtained for no. of kernels/spike and kernels weight in the first cross, kernels weight, straw and biological yields/plant in the second cross and straw yield/plant in the third one. Dominance gene effect (h) was significant for all characters of all crosses except for no. of kernels/spike and grain yield/plant in the first cross, and kernels weight in second one. The significance of these components indicated that both additive and dominance gene effects are important in the inheritance of these characters. Therefore, selection of desired characters could be practiced in the early generation but would be more effective in late ones (Shehab El-Din 1993).

Dominance x dominance (l) type of gene action was significant for no. of kernels/spike in the first cross and kernels weight in the second one. A significant additive x additive type of epistasis (i) was detected for no. of spikes/plant and biological yield/plant in all crosses, for no. of kernels/spike and grain yield/plant in the second and third crosses, and for straw yield/plant in the first and third crosses.

The important roles of both additive and non-additive gene actions in certain studied characters indicated that selection procedures based on the accumulation of additive effects would be very successful in improving these characters. Similar approaches were reported by Gouda *et al* (1993), Al-Kaddoussi *et al* (1994), El-Hosary *et al* (2000), Moustafa (2002) and Hendawy (2003).

Heritability in both broad and narrow senses, and between generations (parent off-spring regression) are presented in Table (4). High heritability values in broad sense were detected for all studied characters except for no. of spikes/plant in the first and second crosses and no. of kernels/spike in the third cross where moderate broad sense heritabilities were detected.

Table 4. Heritability and expected versus actual gain for all studied characters in three crosses of bread wheat.

Characters	Cross	*Heritability %*			*Expected gain*		*Actual gain*	
		Broad sense	***Narrow sense***	***Parent off-spring regression***	Δg	% of F_2	Δg	% of F_3
No. of Spikes/plant	1	81.40	59.80	70.60	7.34	31.10	7.32	34.70
	2	83.80	59.50	72.40	7.12	33.70	7.29	39.10
	3	85.5	40.10	59.30	3.94	19.90	5.10	30.50
No. of kernels/spike	1	86.10	66.50	77.70	20.20	30.80	9.35	28.20
	2	92.80	64.10	78.40	20.91	30.8	21.08	33.30
	3	81.20	71.70	76.50	15.56	22.70	13.59	23.20
100-kernel weight (g)	1	87.30	78.50	79.90	0.62	12.40	0.48	9.90
	2	86.10	81.50	83.80	0.82	15.60	0.65	11.40
	3	88.70	79.60	84.60	0.77	15.40	0.64	12.60
Grain yield/plant(g)	1	92.70	37.70	65.20	11.78	19.10	18.27	29.80
	2	94.30	76.30	85.10	29.98	46.00	23.66	42.70
	3	93.30	75.80	84.10	21.15	40.50	18.45	36.50
Straw yield/plant(g)	1	[illegible]	83.30	88.50	47.42	40.10	38.51	35.10
	2	90.60	66.70	79.10	30.59	20.70	29.65	24.90
	3	87.10	81.20	83.80	37.71	29.50	29.97	26.10
Biological Yield/plant (g)	1	92.90	56.60	74.60	38.95	21.60	43.41	25.4
	2	87.10	69.20	77.8	31.63	15.30	28.64	16.40
	3	91.60	54.20	72.50	32.92	18.30	37.43	22.60

High to moderate estimates of narrow sense heritability and parent off-spring regression was found for all studied characters in all crosses. The differences in magnitude of both narrow sense and parent off-spring regression heritability estimates for all studied characters would ascertain the presence of both additive and non-additive gene effects in the inheritance of these characters. This conclusion was also confirmed by estimates of gene action parameter. Similar conclusions were also reported by Jatasra and Paroda (1980), Mosaad *et al* (1990), Gouda *et al* (1993), Moshref (1996), El-Sayed (2004) and Abdel-Nour *et al* (2005).

Besides, Table (4) shows the expected versus actual genetic gain for all characters. The expected genetic advance ($\Delta g\%$ of F_2) and actual genetic advance ($\Delta g\%$ of F_3) ranged from moderate to high for all studied characters in all crosses except for kernels weight in all crosses. These results indicated the possibility of practicing selection in early generations to enhance these characters and hence selecting high yielding genotypes. 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.

Generally, the most biometerical parameters resulted from the first and second crosses were higher in magnitude than those obtained from the third one. Consequently it could be concluded that the crosses (Pastor x Giza 168) and (Line # x Gemmiza 9) would be of interest in a breeding program for genetic improvement of wheat.

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التأثيرات العاملية والتباينات في ثلاثة هجن من القمح باستخدام نموذج العشائر الخمسة

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أجري هذا البحث في محطة بحوث الجيزة في أربعة مواسم متتالية من ٢٠٠١/٢٠٠٢ إلى ٢٠٠٤/٢٠٠٥ م ، على ثلاثة هجن من قمح الخبز بين خمسة آباء وهي الهجين (١) باستور × جيزة ١٦٨ ، الهجين (٢) سلالة مبشرة × جميزة ٩ و الهجين (٣) باستور × سدس ١.

واشتملت الدراسة على كل من الأبوين والأجيال الأولى والثانية والثالثة وكانت النتائج كما يلي

١) كانت قوة الهجين في F_1 معنوية وموجبة بالنسبة لكل الصفات ما عدا صفة عدد الحبوب /سنبلة بالنسبة للهجينان الأول والثاني ، وكذلك أظهر الهجين الثالث قوة هجين موجبة ومعنوية لصفة وزن مائة حبه .

٢) تأثير التربية الداخلية في F_2 كان موجباً ومعنوياً في كل الصفات المدروسة في الهجينـــان الأول والثاني ما عدا وزن مائة حبه في الهجين الأول وعدد الحبوب/سنبلة بالنسبة للهجين الثاني ، أما بالنسبة للهجين الثالث فقد أظهر قيماً سالبة ومعنوية بالنسبة لكل من صفة وزن مائة حبه ووزن القش والوزن الكامل للنبات .

٣) أوضحت دراسة طبيعة التوارث أن درجة السيادة كانت سيادة فائقة تجاه الأب الأعلى فـــي كـل الصفات ما عدا صفة عدد الحبوب/سنبلة في كلاً من الهجينان الأول والثاني كما أظهـرت ســيادة كاملة تجاه الأب الأقل في عدد الحبوب /سنبلة بالنسبة للهجين الثاني ، وكذلك أظهرت سيادة فائقة تجاه الأب الأقل بالنسبة لصفة عدد الحبوب /سنبلة في الهجين الأول ،وكذلك بالنسبة لصفتي وزن القش والوزن الكامل للنبات في الهجين الثالث و كذلك أمكن تحديد سيادة جزئية بالنسبة للأب الأقل لكل من صفات عدد السنابل/نبات ، عدد الحبوب / سنبلة ووزن الحبوب /نبات .

٤) كانت انحرافات الجيل الثاني (E_1) وانحرافات الجيل الثالث (E_2) معنوية لمعظم الـصفات فـــي الهجن تحت الدراسة مما يوضح أهمية الفعل الجيني التفوقي في وراثة الصفات .

٥) أظهرت كفاءة التوريث بمعناها الواسع قيماً عالية لمعظم الصفات ، كما أظهرت كفاءة التوريـــث بمعناها الضيق وكذلك الكفاءة الوراثية من الانحدار بين الأجيال قيماً عالية إلى متوسطة مرتبطــة بنسبة تحسين وراثي مرتفع إلى متوسط في معظم الصفات المدروسة .

٦) كانت قيم التحسين الوراثي الفعلي في الجيل التالي المتحصل عليها بصفة عامة متطابقة مع القيم المتنبأ بها لتحسين المحصول ومكوناته من خلال الانتخاب ومن ثم يمكن للمربي الاعتمـــاد علـــى القيم المتنبأ بها في الانتخاب لتحسين الصفات المحصولية .

٧) أظهرت التأثيرات الوراثية المضيفة وكذلك الفعل الجيني غير المضيف دوراً هاماً في وراثة معظم الصفات المدروسة .

٨) يمكن الاستفادة من الهجين الأول والثاني في برامج تربية القمح للحصول على ســلالات جديــدة متفوقة في المحصول .

٩) النتائج المتحصل عليها تدل على أن الانتخاب في الأجيال الانعزالية المبكرة قد يكون مفيداً ولكن سوف يكون أكثر كفاءة إذا تم تأجيله إلى الأجيال الانعزالية المتأخرة .