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HETEROSIS, COMBINING ABILITY AND GENE ACTION IN F_1 AND F_2 DIALLEL CROSSES AMONG SIX SOYBEAN GENOTYPES

BY

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ABSTRACT

The present investigation was carried out at Giza Research Station 2002, 2003 and at Mallawi Research Station in 2004 growing seasons. 15 F_1 and F_2 crosses obtained from a half diallel crossing system between six soybean genotypes differing in maturity groups (Holladay, Forrest, PI-416937, Crawford, L 86-k-73 and Giza 21) were studied to estimate different source of genetic variability and other derived parameters for days to maturity, seed yield and its components. Significant differences among parents and crosses were detected for all the studied traits, indicating genetic variability for all variables. Both general and specific combining ability were significant for all characters, revealing that both additive and non-additive effects were important for inheritance of the studied characters. Negative heterosis percentage relative to mid and better parents were significant in three crosses for days to maturity. Meanwhile, heterosis percentage relative to mid and better parents were significantly positive in several crosses for number of pods, seeds, 100-seed weight and seed yield per plant. Some crosses expressed significant inbreeding depression in F_2 ranged from –5.7 to –8.5% for days to maturity, 10.6 to 74.7% for number of pods/plant, 8.1 to 47.8% for number of seeds/plant, 5.0 to 21.9% for seed index and from 14.5 to 48.7% for seed yield/plant. The parents L 86-k-73, Crawford and Giza 21 were good combiners for earliness. Both parents PI-416937 and Crawford seemed to be better combiners for high seed index. Giza 21 was superior combiner for number of pods, seeds and seed yield/plant. Moreover, its F_1 and F_2 crosses showed high estimates for those traits. Additive components of genetic variability (D) was highly significant for days to maturity and seed index, indicating that the additive gene action was more important than the non-additive one in controlling the inheritance of these characters. H_1 values were greater than D for number of pods, seeds and seed yield per plant, suggesting that dominance effect is more important than the additive effect in these cases. The estimates of K_D/K_R were greater than one for number of pods/plant and seed index, indicating excess of dominant genes in the parents. The heritability values in broad sense were high for all the studied traits. Moreover, narrow sense heritability estimates were relatively high for days to maturity, moderate for seed index and low for number of pods, seeds and seed yield per plant.

Key words: Soybean genotypes, Combining ability, Heterosis, Gene action, Heritability.

INTRODUCTION

Soybean (*Glycine max (L.)* Merril) is grown to some extent in most parts of the world and is a primary source of vegetable oil and protein. The oil is used essentially in margarine, salad oils, cooking oil and shortening. Moreover, soybean products became more important in the formulation of new, low-cost nutritionally balanced, high protein foods and beverages for human consumption. Improvement of earliness and high yield potential are the primary objectives of soybean breeding programs. The breeding system needs to be fitted to the type of gene action to maximize the result of improvement. Diallel cross technique have been used to obtain considerable information on the magnitude of heterosis and to gain a better understanding of the nature of gene action involved in controlling quantitative characters. The exploitation of heterosis through synthetics and ultimately hybrids could payoff in improved yield potential. Several investigators reported that the manifestations of hetrotic effects in soybean ranged from significantly negative to significantly positive estimates for number of days to maturity, seed yield and its components (Mehta *et al.*, 1984; Bastawisy, 1988; El-Hosary *et al.*, 1997; Habeeb, 1998; Mansour *et al.*, 2002 and Soliman *et al.*, 2005). In a systematic breeding program, the genetic variance components analysis in terms of type of gene action, heritability and breeding potentials of genetic entries involved in the program are obviously essential. Heritability estimates provide a measure of relative importance of the genotypic to the phenotypic variation and the latter being the sum of genotypic and environmental variations. Narrow-sense heritability is the ratio of additive genetic to phenotypic variances. Soare and Dencescu (1995) found that additive gene effects predominated over dominance and epistatic effects for growth period of soybean. El-Hosary *et al* (2001) obtained moderate to high values of heritability in broad sense accompanied by low values of the narrow sense heritability for days to maturity, seed yield and its components. They reported that, to achieve gentic improvement through selection, heritability must be reasonable high. The present study was therefore planned to obtain information on the magnitude of heterosis and inbreeding depression as well as understanding the nature of gene action and estimating heritability of earliness, seed yield and some of its component for six parental genotypes and their crosses.

MATERIALS AND METHODS

The experiments of the present study were carried out at Giza Research Station during 2002, 2003 and at Mallawi Research Station in 2004 growing seasons. Six soybean genotypes of different maturity groups which were obtained from Food Legume Research Department, Field Crops Research Institute, ARC, were used as parents in a diallel mating design without reciprocals. They are briefly described in Table (1). A half-diallel set of crossing using these parents was carried out during 2002 season. In the second season (2003), hybrid seeds were sown to obtain F_2 seeds and the six parents were recrossed to obtain adequate F_1 hybrid seeds. The evaluation trail was carried out during 2004 involving the six parents, 15 F_1 and F_2 populations using a Randomized Complete Block Design with three replications. Each parent, F_1 and F_2 cross were represented by two, one and three ridges, respectively per each replication. Each ridge was 3 m long and 60 cm apart. Single seed was sown in one side of the ridge at 20 cm distances. All cultural practices were processed as recommended for the production of soybean in the region. The following characters were recorded: number of days from sowing to 95% maturity of pods per plot, number of pods per plant, number of seeds per plant, 100-seed weight (g) and seed yield per plant (g).

Table (1): Maturity group, country of origin, growth habit and flower color of the six soybean genotypes studied.

Genotype		Maturity group	Country of origin	Growth habit	Flower color
Holladay	(P_1)	V	USA	Indeterminate	Purple
Forrest	(P_2)	VI	USA	Indeterminate	White
PI-416937	(P_3)	V	USA	Determinate	Purple
Crawford	(P_4)	IV	USA	Indeterminate	Purple
L 86-k-73	(P_5)	I	USA	Indeterminate	White
Giza 21	(P_6)	IV	Egypt	Indeterminate	Purple

Differences among genotypes were tested by conducting a regular analysis of variance of complete block design on plot mean basis. Heterosis and inbreeding depression determination were conducted as outlined by Foolad and Bassiri (1983). An appropriate "t" test was made for the significance of the F_1 crosses means from mid and better-parent values (Wynne *et al.*, 1970) and for that of the means of F_2 crosses from F_1 values (Al-Rawi and Kohel, 1969). Combining ability effects and variances were calculated according to Griffing's method 2 model 1 (1956) and genetic ratios were estimated according to Jinks (1954) and Hayman (1954a).

RESULTS AND DISCUSSION

Mean square values

The results in Table (2) showed the significance of observed mean squares due to genotypes, general combining ability (GCA) and specific combining ability (SCA) for the studied characters. Highly significant differences among genotypes were detected in both F_1 and F_2 generations for all the studied traits indicating genetic variability. Number of seeds per plant recorded the highest mean square, followed by number of pods per plant and each of those traits are clearly related to the seed yield per plant. These findings could be mainly attributed to genetic diversity between the parental genotypes. Mean square values of GCA and SCA were highly significant in both generations for all the studied characters. These results revealed that both additive and non-additive effects were important for inheritance of these characters. The ratio of GCA/SCA exceeded the unity in both generations for number of days to maturity and weight of 100-seed. This indicated that most of the genetic variation among the investigated genotypes for the forementioned traits appear to be additive. Thus, selection could be favored for improving these traits. However, low GCA/SCA ratios (less than unity) for number of pods, seeds and seed yield per plant reveal the predominance of non-additive gene action in these cases. In most traits, the GCA/SCA ratios were higher in magnitude in the F_2 than F_1 generation, revealing that the additive and additive by additive gene effects were increased and non-additive gene effects were reduced in the F_2 generation. These results are in general agreement with those reported by Bastawisy (1998); Habeeb (1998); Mansour *et al.*, (2002) and Soliman *et al.*, (2005).

Table (2): Mean squares of ordinary analysis and combining ability for the studied characters of six soybean parents and their derived F_1 and F_2 crosses.

Source of variance	d.f.	No. of days to maturity		No. of pods/Plant		No. of seeds/plant	
		F_1	F_2	F_1	F_2	F_1	F_2
Genotypes	20	407.56**	347.22**	11033.38**	3729.73**	86133.05**	28428.35**
G.C.A.	5	1463.69**	1300.13**	3618.41**	2374.38**	71612.45**	24095.32**
S.C.A.	15	55.52**	29.58**	13505.04**	4184.85**	90973.24**	29872.69**
Error	40	2.67	1.71	88.17	39.64	1065.59	464.54
GCA/SCA		26.36	43.95	0.27	0.57	0.79	0.81

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

Table (2) Cont'd

Source of variance	d.f.	Weight of 100- seed (g)		Seed yield/plant (g)	
		F_1	F_2	F_1	F_2
Genotypes	20	3.31**	2.88**	1450.89**	579.27**
G.C.A.	5	7.01**	6.06**	1036.45**	515.48**
S.C.A.	15	2.07**	1.82**	1589.03**	600.54**
Error	40	0.14	0.04	93.38	9.02
GCA/SC		3.39	3.33	0.65	0.86

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

Mean performance

The mean performance of the six parents and their F_1 and F_2 crosses for the studied traits are presented in Table (3). The parent L 86-k-73 (P_5) was the earliest in maturity and recorded the lowest value of number of pods, seeds and seed yield per plant. While Forrest (P_2) was the latest and gave the lowest value of 100-seed weight. Meanwhile, Giza 21 (P_6) which ranked the second in this study for earliness of maturity, recorded the highest number of seeds and seed yield per plant followed by Crawford (P_4). With respect to the tested crosses in both F_1 and F_2 generation, all hybrids were within the range of their parental varieties in number of days to maturity, except Forrest × PI-416937 ($P_2 \times P_3$) it was significantly late. Most of the crosses exceeded significantly the best parent in both number of seeds and number of pods per plant. Moreover, the crosses Hollady × Giza 21 ($P_1 \times P_6$); Forrest × L86-k-73 ($P_2 \times P_5$); Forrest × Giza 21 ($P_2 \times P_6$); PI-416937 × Giza 21 ($P_3 \times P_6$) and L 86-k-73 × Giza 21 ($P_5 \times P_6$) exhibited the highest values for these traits. The crosses Holladay × L86-k-73 ($P_1 \times P_5$), Forrest × L86-k-73 ($P_2 \times P_5$) and PI-416937× Crawford ($P_3 \times P_4$) exceeded significantly the heaviest 100-seed of parent.

Table (3): Mean performance of the parents and their crosses in F_1's and F_2's for the studied characters in soybean.

Genotype	No. of days to maturity		No. of pods/ plant		No. of seeds/ plant		Weight of 100-seed (g)		Seed yield/plant (g)	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Holladay (P_1)	131.0		150.9		285.5		11.7		33.0	
Forrest (P_2)	139.8		123.9		282.6		10.8		30.6	
PI-416937 (P_3)	129.7		118.5		277.5		14.0		39.0	
Crawford (P_4)	119.3		121.5		349.9		13.5		44.8	
L 86-k-73 (P_5)	98.2		83.5		235.7		11.8		27.7	
Giza 21 (P_6)	119.0		137.7		381.7		12.6		48.2	
$P_1 \times P_2$	135.0	137.0	192.5	156.8	388.3	410.4	12.1	11.5	47.0	47.2
$P_1 \times P_3$	129.7	130.0	178.8	148.1	346.7	354.4	14.1	14.1	48.8	50.1
$P_1 \times P_4$	125.3	125.7	199.0	163.9	522.9	457.3	14.0	12.2	73.2	55.6
$P_1 \times P_5$	119.3	119.3	145.6	115.0	328.3	302.8	13.6	13.8	44.7	41.8
$P_1 \times P_6$	125.0	125.0	232.6	175.1	555.6	491.8	12.5	12.6	68.5	61.8
$P_2 \times P_3$	145.3	145.0	156.0	134.4	453.3	363.8	13.8	13.5	62.4	49.0
$P_2 \times P_4$	129.7	132.0	176.0	150.0	498.4	438.9	14.6	11.4	76.1	50.2
$P_2 \times P_5$	130.0	128.0	270.5	214.6	627.1	527.1	13.1	13.3	82.1	70.2
$P_2 \times P_6$	129.7	129.3	275.3	223.9	822.8	595.3	12.0	12.6	99.0	75.5
$P_3 \times P_4$	125.7	125.0	225.8	182.6	584.7	537.2	14.7	14.6	86.2	76.6
$P_3 \times P_5$	120.0	118.7	305.4	156.6	664.9	347.1	12.8	12.5	85.0	43.6
$P_3 \times P_6$	129.7	124.7	207.8	199.8	599.9	573.2	13.2	13.3	79.2	76.1
$P_4 \times P_5$	105.0	111.0	189.0	145.6	547.9	402.1	12.6	13.2	68.9	53.1
$P_4 \times P_6$	110.3	119.7	173.0	154.7	464.6	420.1	13.4	13.3	62.2	56.0
$P_5 \times P_6$	109.3	104.3	301.8	172.8	781.3	440.9	12.3	12.5	96.1	55.4
LSD at 0.05	2.70	2.16	15.49	10.38	53.84	35.55	0.61	0.34	15.93	4.95
LSD at 0.01	3.60	2.88	20.70	13.88	71.96	47.51	0.82	0.46	21.30	6.62

Concerning seed yield per plant. eleven crosses increased significantly positive values relative to the highest parent. Additionally, the crosses Forrest × L 86-k-73 (P_2 × P_5); Forrest × Giza 21 (P_2 × P_6); PI-416937 ×Crawford (P_3 × P_4) and PI-416937 × Giza 21 (P_3 × P_6) recorded the highest mean values for seed yield per plant. It could be concluded that the above mentioned parents and crosses would be interesting and prospective for the future in soybean breeding for improving the maturity date and productivity.

Heterosis and inbreeding effects

Estimates of heterosis percentages over both mid (MP) and better parents (BP) and inbreeding depression (ID) are given in Table (4). Regarding the number of days to maturity, the results showed that two crosses only were highly significant early compared to the respective mid parents with hetrotic effects –3.5 and –7.5%. On the other hand, positive values of heterosis for most hybrids were detected and they were late compared to mid and earlier parent values for the same trait. At the same time, heterosis percentages relative to mid parent were significant or highly significant positive in all crosses ranged from 24.2 to 202.3; 23.2 to 159.1 and 33.8 to 181.2 for number of pods, seeds and seed yield per plant, respectively. Moreover, values were highly significant positive in eight crosses ranged from 6.5 to 15.9% for weight of 100-seed. However heterosis percentage relative to better parent was highly significant in one cross with value –7.3% for number of days to maturity.

Meanwhile, heterosis percentages relative to better parent were significant or highly significant with positive values in some crosses and ranged from 18.5 to 157.7% for number of pods per plant, 21.4 to 139.6% for number of seeds per plant, 5.0 to 15.3% for seed index and from 42.1 to 168.3% for seed yield per plant.

The high magnitudes of heterosis values found in these materials were expected due to the diversity of the parents. Therefore, improvement would be expected from selection in the advanced segregating generations. These findings are in accordance with those reported by Mehta *et al.* (1984), Mansour (1991) and Ibrahim *et al.* (1996).

Results of inbreeding depression in F_2 generation for the studied characters are presented in Table (4). Concerning the number of days to maturity, two crosses showed highly significant depression in F_2 population as a result of inbreeding with values –5.7 and –8.5%.

Moreover, inbreeding depression was significant or highly significant positive in some crosses ranged from 10.6 to 74.7% for number of pods per plant, 8.1 to 47.8% for number of seeds per plant, 5.0 to 21.9% for seed index and from 14.5 to 48.7% for seed yield per plant. However, two crosses: PI-416937 × Giza 21 (P_3 × P_6) and L86-k-73 × Giza 21 (P_5 × P_6), for number of days to maturity, as well as two crosses: Forrest × Giza 21 (P_2 × P_6) and Crawford × L86-k-73 (P_4 × P_5), for seed index, exhibited significantly gain due to inbreeding. The results of El-Hosary *et al.* (2001) and Soliman *et al.* (2005) supported the forementioned findings.

Table (4): Percentage of heterosis relative to mid parents (MP), better parent (BP) and the percentage of inbreeding depression (ID) for the studied characters.

Cross	No. of days to maturity			No. of pods/plant			No. of seeds/plant			Weight of 100-seed (g)			Seed yield/ plant (g)		
	MP	BP	ID	MP	BP	ID	MP	BP	ID	MP	BP	ID	MP	BP	ID
$P_1 \times P_2$	-0.3	3.1**	-1.5	40.1**	27.6**	18.5**	36.7**	36.0**	-5.7	7.1**	3.4	5.0*	47.8*	33.3	-0.4
$P_1 \times P_3$	-0.5	0.0	-0.2	32.7**	18.5**	17.2**	23.2**	21.4**	-2.2	9.3**	0.7	0.0	35.6*	25.1	-2.7
$P_1 \times P_4$	0.1	5.0**	-0.3	46.1**	31.9**	17.6**	64.6**	49.4**	12.5**	11.1**	3.7	12.9**	88.2**	63.4**	24.0**
$P_1 \times P_5$	4.1**	11.3**	0.0	24.2**	-3.5	21.0**	26.0**	15.0	7.8	15.3**	15.3**	-1.5	47.0*	35.5	6.5
$P_1 \times P_6$	0.0	5.0**	0.0	61.2**	54.1**	24.7**	66.5**	45.6**	11.5**	2.5	-0.8	-0.8	68.7**	42.1*	9.8
$P_2 \times P_3$	7.3**	12.0**	0.2	28.7**	25.9**	13.8**	61.8**	60.4**	16.1**	11.3**	-1.4	2.2	79.3**	60.0**	21.5*
$P_2 \times P_4$	0.2	8.7**	-1.8	43.4**	42.1**	14.8**	57.6**	42.4**	11.9*	19.7**	8.2**	21.9**	101.9**	69.9**	34.0**
$P_2 \times P_5$	9.2**	32.4**	1.5	160.8*	118.3*	20.7**	141.9**	121.9**	15.9**	15.9**	11.0**	-1.5	181.2**	168.3**	14.5*
$P_2 \times P_6$	0.2	9.0**	0.3	110.5*	99.9**	18.7**	147.7**	115.6**	27.6**	2.6	-4.8	-5.0*	151.3**	105.4**	23.7**
$P_3 \times P_4$	1.0	5.4**	0.6	88.2**	85.8**	19.1**	86.4**	67.1**	8.1*	6.5**	5.0*	0.7	105.5**	92.4**	11.1
$P_3 \times P_5$	5.3**	22.2**	1.1	202.3*	157.7*	48.7**	159.1**	139.6**	47.8**	-0.8	-8.6**	2.3	154.4**	117.9**	48.7**
$P_3 \times P_6$	0.3	9.0**	3.9**	62.2**	50.9**	3.8	82.0**	57.2**	4.5	-0.8	-5.7*	-0.8	81.7**	64.3**	3.9
$P_4 \times P_5$	-3.5**	6.9**	-5.7**	84.4**	55.6**	23.0**	87.1**	56.6**	26.6**	-0.8	-6.7**	-4.8*	89.8**	53.8**	22.9**
$P_4 \times P_6$	-7.5**	-7.3**	-8.5**	33.5**	25.6**	10.6**	27.0**	21.6**	9.6	2.3	-0.7	0.8	33.8*	29.0	10.0
$P_5 \times P_6$	0.7	11.3**	4.6**	172.9*	119.2*	74.7**	153.1**	104.7**	43.6**	0.8	-2.4	-1.6	152.9**	99.4**	42.4**

* and ** significant differences at 0.05 and 0.01 levels of probability, respectively.

Combining ability

The estimates and significance of general combining ability effects (g_i) for the six parents are included in Table (5). The results suggested that the three parents L86-k-73, Crawford and Giza 21 were good combiners for earliness. They gave highly significant negative GCA effects for number of days to maturity. Both parents PI-416937 and Crawford seemed to be better combiners for high 100-seed weight because they showed highly significant positive GCA effects for this trait. Moreover, Giza 21 was superior combiners for number of pods, seeds and seed yield per plant because it exhibited highly significant positive GCA effects for these traits. The detection of the combining ability of the parental genotypes provides better information not only for selecting the parents for hybridization but also in choosing the proper breeding scheme. Similar results were obtained by Soliman *et al.* (2005), they indicated that L86-k-73 was good combiner for earliness and Giza 21 was superior combiner for seed yield and its components. Specific combining ability effects (Sij) of both F_1 and F_2 crosses are presented in Table (6). Regarding the number of days to maturity in F_1 and F_2 generations, two crosses: ($P_1 \times P_2$) and ($P_1 \times P_3$) expressed negative significant SCA effects. There are also negative significant SCA effects in the F_1 crosses ($P_4 \times P_5$), ($P_4 \times P_6$) and two in F_2 crosses ($P_2 \times P_6$) and ($P_5 \times P_6$) for this trait confirming that the parents P_4 (Crawford), P_5 (L86-k-73) and P_6 (Giza 21) could be considered as good combiners in breeding for earliness. Three F_1 and F_2 crosses: ($P_2 \times P_5$), ($P_2 \times P_6$) and ($P_3 \times P_4$) had positive significant SCA effects for number of pods per plant. Meanwhile, two crosses ($P_3 \times P_5$), ($P_5 \times P_6$) in F_1 and one cross ($P_3 \times P_6$) in F_2 showed positive significant SCA effects for this trait. All crosses in both F_1 and F_2 had insignificant SCA effects for number of seeds per plant. On the other hand, many crosses recorded significant SCA effect for seed index, some crosses are positive in both F_1 and F_2 *i.e.* {($P_1 \times P_3$), ($P_1 \times P_5$), ($P_2 \times P_3$), ($P_2 \times P_5$) and ($P_3 \times P_4$)} and other are negative in both F_1 and F_2 i.e. {($P_1 \times P_2$), ($P_3 \times P_5$) and ($P_3 \times P_6$)}. Breeding programs do not always consider the high seed index as a good trait especially in soybean, where sometimes smaller seed index is recommended because of high germination ratio. With respect to seed yield per plant, six F_2 crosses {($P_1 \times P_4$), ($P_1 \times P_6$), ($P_2 \times P_5$), ($P_2 \times P_6$), ($P_3 \times P_4$) and ($P_3 \times P_6$)}exhibited significant positive SCA effects. Several investigators found the significance of both general and specific combining ability effects for some important agronomic traits in soybean (Bastawisy *et al.*, 1997; Mansour *et al.*, 2003 and Soliman *et al.*, 2005).

Gene action

Estimates of the genetic and environmental components of variance and other derived statistics in the F_1 and F_2 generations are given in Table (7). The additive components of genetic variability (D) were highly significant for number of days to maturity and weight of 100-seed, indicating that the additive gene action was more important than the non-additive one in controlling the inheritance of both traits. Therefore, selection for these traits in segregating generations would be effective. Whereas, dominance gene action played an important role in the inheritance of number of pods, seeds and seed yield per plant. Habeeb (1998) reported that insignificant D value for seed yield per plant inspite of significant GCA mean square was obtained. Dominance may has a role in GCA estimate as emphasized by Jinks (1954).

Table (5): Estimates of general combining ability effects (gi) of the parental genotypes in the F_1 anf F_2 generations for the studied characters.

Genotype	No. of days to maturity		No. of pods /Plant		No. of seeds /plant		Weight of 100-seed (g)		Seed yield/plant (g)	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Holladay (P_1)	3.36**	3.65**	-10.81**	-0.54	-81.65*	-25.57	-0.10**	-0.31**	-10.23**	-4.46**
Forrest (P_2)	10.19**	9.94**	-0.19	5.71**	2.23	9.95	-0.50**	-0.69**	-2.91	-0.91**
PI-416937(P_3)	5..36**	3.78**	-1.39	-2.68	-18.32	-9.57	0.70**	0.81**	1.25	1.83**
Crawford(P_4)	-4.10**	-2.47**	-14.49**	-3.77**	-4.63	10.79	0.64**	0.21**	0.88	2.33**
L 86-k-73(P_5)	-11.56**	-11.14**	7.80*	-14.15**	14.78	-37.27*	-0.44**	-0.04**	1.04	-5.60**
Giza 21 (P_6)	-3.26**	-3.76**	19.09**	15.43**	87.59*	51.67**	-0.31**	0.02**	9.97**	6.82**
S.E. (gi)	0.09	0.06	3.06	1.38	36.99	16.13	0.005	0.002	3.24	0.31
S.E. (gi-gj)	0.22	0.14	7.35	3.30	88.79	38.71	0.011	0.004	7.78	0.75

*and ** significant differences at 0.05 and 0.01 levels of probability, respectively.

Table (6): Estimates of specific combining ability effects (Sij) of different crosses in the F_1 and F_2 generations for the studied characters.

Cross	No. of days to maturity		No. of pods/ plant		No. of seeds/plant		Weight of 100-seed (g)		Seed yield/plant (g)	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
$P_1 \times P_2$	-2.48**	-1.14*	13.74	-1.72	-6.37	20.32	-0.29**	-0.31**	-0.52	0.63
$P_1 \times P_3$	-2.98**	-1.97**	1.20	-2.03	-27.42	-16.11	0.49**	0.83**	-2.89	0.77
$P_1 \times P_4$	2.15**	-0.05	34.50	14.90	135.09	66.45	0.48**	-0.54**	21.88	5.83*
$P_1 \times P_5$	3.16**	2.28**	-41.12	-23.66*	-78.91	-40.01	1.16**	1.34**	-6.74	-0.05
$P_1 \times P_6$	0.98	0.57	34.56	6.90	75.56	60.03	-0.03	0.05**	8.12	7.47**
$P_2 \times P_3$	5.86**	6.74**	-32.15	-21.98*	-4.75	-42.28	0.63**	0.52**	3.41	-3.85
$P_2 \times P_4$	-0.35	-0.01	0.92	-5.29	26.77	12.52	1.47**	-0.92**	-5.93	-3.17
$P_2 \times P_5$	7.44**	4.66**	73.13**	69.69**	135.99	148.80	1.04**	1.21**	23.30	24.72**
$P_2 \times P_6$	-1.19	-1.39**	66.64**	49.44**	258.89	128.01	-0.15**	0.50**	31.26	17.59**
$P_3 \times P_4$	0.48	-0.85	51.88*	35.70**	133.56	130.36	0.40**	0.73**	23.45	20.51**
$P_3 \times P_5$	2.27**	1.49**	109.22**	20.05	194.31	-11.79	-0.45**	-1.06**	22.07	-4.61
$P_3 \times P_6$	3.65**	0.11	0.37	33.70**	56.57	125.42	-0.19**	-0.38**	7.35	15.47**
$P_4 \times P_5$	-3.27**	0.07	5.96	10.17	63.71	22.97	-0.62**	0.23**	6.30	4.46
$P_4 \times P_6$	-6.23**	1.36**	-21.36	-0.05	-92.43	-48.06	0.04	0.27**	-9.35	-5.11*
$P_5 \times P_6$	0.23	-5.30**	85.12**	18.17	204.84	20.81	0.08	-0.25**	24.45	2.19
S.E. (Sij)	0.70	0.45	23.09	10.38	279.08	121.66	0.04	0.01	24.46	2.36
S.E. (Sij - Sik)	1.56	0.99	51.43	23.12	621.59	270.98	0.08	0.03	54.47	5.26

*and ** significant differences at 0.05 and 0.01 levels of probability respectively.

Table (7): Estimates of genetic and environmental components with mean of genetic estimates and heritability values for the studied characters in F_1's and F_2's diallel cross.

Components of variance	No.of days to maturity		No. of pods/ plant		No. of seeds/plant	
	F_1	F_2	F_1	F_2	F_1	F_2
D	227.76** ±3.91	185 27** ±1 44	344.18 ±322.16	594.92 ±233.83	3094.28 ±2140.86	1771.24 ±952.65
F	-3.64 ±9 56	-34.41** ±3.52	1168.52 ±811 47	839.65 ±326.95	-2889.61 ±5230.13	-2040.00 ±2327.32
H_1	76.53** ±9.93	38.90** ±3 65	14976.21** ±843.22	4831 13** ±339.74	93620.91** ±5434.78	31883 49** ±2418 39
H_2	54.45** ±8.88	30.12** ±3.27	13024.02** ±753.27	4130.97** ±303.50	82518.40** ±4855.02	29952 40** ±2160.41
E	2 54 ±1 48	1.65* ±0.54	91.52 ±125.54	31 90 ±50.90	1017.51 ±809.17	408.26 ±360 07
h^2	22 62	9.40	31882.91	8804.70	240829.78	78669.88
$(H_1/D)^{½}$ in F_1 $(H_1/4D)^{½}$ in F_2	0 579	0 229	6.596	1.425	5.501	2.121
$H_2/4H_1$	0.178	0.194	0.217	0.214	0.220	0.235
K_D/KR	0.973	0 663	1.693	1.658	0.844	0.761
h^2/H_2	0 415	0 312	2.448	2.131	2.918	2.626
Heritability:						
Broad sense	0 982	0 987	0.977	0.975	0.966	0.962
Narrow sense	0.887	0.926	0 144	0 176	0.283	0.267

* and ** significant differences at 0.05 and 0 01 levels of probability, respectively.

Table (7) Cont'd

Components of variance	Weight of 100-seed (g)		Seed yield/plant (g)	
	F_1	F_2	F_1	F_2
D	1.37** ±0 15	3.09** ±0.08	62.98 ±39.22	49.39 ±21.36
F	0.60 ±0 38	0.72 ±0.20	-40.96 ±95.82	-24.46 ±52.18
H_1	2.19** ±0.39	2.35** ±0.21	1578.79** ±99.57	613.46** ±54.23
H_2	1.85** ±0.35	2.15** ±0.19	1451.09 ±88.95	588.02** ±48.44
E	0.14 ±5.85	3.08 ±3.09	16.72 ±14.82	9.55 ±8.07
h^2	3.61	0.96	5086.83	1495.06
$(H_1/D)^{½}$ in F_1 $(H_1/4D)^{½}$ in F_2	1.264	0.436	5.007	1.762
$H_2/4H_1$	0.211	0.228	0.230	0.240
K_D/KR	1.418	1.485	0.878	0.869
h^2/H_2	1.957	0.445	3.506	2.543
Heritability:				
Broad sense	0.880	0.970	0.966	0.954
Narrow sense	0.482	0.449	0.234	0.241

* and ** significant differences at 0.05 and 0.01 levels of probability, respectively.

In each case H_1 and H_2 (dominance components of genetic variance) were highly significance different from zero and H_1 was greater than H_2 in all cases, indicating that the positive and negative alleles at the loci for these traits were not equal in proportion in the parents. Theoretically, H_2 should be equal to or less than H_1 (Hayman, 1954b). H_1 values were greater than D for number of pods, seeds and seed yield per plant, suggesting that non-additive genetic variance is more important than the additive variance in these cases. These results are in general agreement with those obtained by Bastawisy *et al* (1997) and Habeeb (1998).

The covariance of additive and dominance effects (F) were negative in number of days to maturity, number of seeds and seed yield per plant, but they were positive in number of pods per plant and weight of 100-seed. Negative estimates of F indicating an excess of recessive alleles, while the positive estimates of F indicating an excess of dominate ones. All estimates of the environmental variance (E) were insignificant for all studied traits, except number of days to maturity in F_2, indicating that all traits have not been greatly affected by environmental factors, except days to maturity. The overall dominance effects of heterozygous loci (h^2) were positive in all traits, indicating that the effect of dominance was due to heterozygosity and that direction of dominance was positive.

Overall degree of dominance estimated by $(H_1/D)^{½}$ in the F_1 and $(H_1/_4D)^{½}$ in the F_2 were less than unity for number of days to maturity, indicating partial dominance for that trait, while the over dominance was important in the inheritance of the other traits.

The proportion $(H_2/4H_1)$ was lower than 0.25, indicating that positive and negative alleles were not equally distributed among the parents. The estimates of K_D/K_R were greater than one for number of pods per plant and 100-seed weight, indicating excess of dominant genes in the parents for those traits. However, K_D/K_R values were less than one for number of days to maturity, number of seeds and seed yield per plant indicating an excess of recessive genes in the parents for these traits. The number of effective factors h^2/H_2 ranged from 0.312 to 3.506. It may be noted that this value is underestimated either when the dominance effective of all genes concerned are not equal in size and direction or when the distribution of the genes is correlated or when both conditions are fulfilled (Jinks, 1954). These results are in accordance with those reported by Habbeb (1998) and Soliman (1999). In general, the heritability values in broad sense were high for all studied characters in both generations. Meanwhile, narrow sense heritability estimates were high and moderate for days to maturity and 100-seed weight, respectively. The relatively inflated estimate of heritability for those traits in F_1 and F_2 generations might be expected since the genetic system controlling the inheritance of those traits in these parents had been shown to b inherited by basically additive genetic effects. Therefore, pedigree selection program for both traits might be quite promising. On the other hand, low heritability values were obtained for the other traits, indicating that dominant genetic variance was more important for number of pods, seeds and seed yield per plant. Therefore. bulk method could be more efficient for obtaining desirable improvement in these traits. Habeeb (1998) obtained high values of heritability in narrow sense for maturity period and 100-seed weight, while he obtained low values of heritability for the other traits, Whereas, Soliman (1999) obtained high estimates of heritability in both of broad and narrow sense for days to maturity, seed yield and its components.

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قوة الهجين، القدرة على التآلف وفعل الجين للهجن التبادلية بين ستة تراكيب وراثية من فول الصويا

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أجريت هذه الدراسة على ستة اباء وهى (PI-416937, Forrest, Holladay, Crawford, L86-k-73، جيزة ٢١ (من فول الصويا وجميع الهجن التبادلية بينها ماعدا الهجن العكسية فى الجيل الأول والثانى خلال ثلاثة مواسم وهى ٢٠٠٢، ٢٠٠٣، ٢٠٠٤ بهدف تقدير قوة الهجين والتدهور نتيجة للتربية الداخلية والقدرة العامة والخاصة على الائتلاف وكذلك لدراسة فعل الجين وتقدير درجة التوريث بمعناها الواسع والمحدود وذلك لصفات عدد الأيام من الزراعة حتى النضج، عدد القرون للنبات، عدد البذور للنبات، وزن ١٠٠ بذرة ووزن محصول النبات، وتم تحليل النتائج حسب ما أقترحه العالم جريفنج (١٩٥٦) والعالم هايمان (١٩٥٤) ويمكن تلخيص النتائج كما يلى:

- كان التباين الراجع للتراكيب الوراثية معنويا لكل الصفات تحت الدراسة وكذلك التباين الراجع للقدرة العامة والخاصة على الائتلاف كان معنويا لكل الصفات فى

كلٌ من الجيل الأول والثانى مما يشير الى أهمية كل من التأثير المضيف وغير المضيف للفعل الجينى على توريث هذه الصفات.

- أظهرت النتائج تفوق بعض هجن الجيل الأول تفوقا معنويا مقارنة بمتوسط الأبوين والأب الأفضل، كذلك حدث تدهور معنوى فى نباتات الجيل الثانى لبعض الهجن نتيجة للتربية الداخلية فى كل الصفات ولو أن بعض الصفات تحسنت فى الجيل الثانى عن الأول فى بعض الهجن.
- أظهرت الآباء Crawford, L86-k-73 وجيزة ٢١ قدرة عامة مرغوبة لصفة التبكير فى النضج كما تفوقت الآباء Crawford, PI-416937 فى قدرتهما العامة لصفة وزن ١٠٠ بذرة، بينما تفوق الصنف جيزة ٢١ فى قدرته العامة لصفات عدد القرون للنبات و عدد البذور للنبات ووزن محصول النبات كما أوضحت الهجن الناتجة من هذا الأب تقديرات عالية للقدرة الخاصة على الائتلاف لتلك الصفات مما يؤكد تميز هذا الصنف.
- أظهر تحليل النتائج أن تأثير العوامل ذات الأثر المضيف كان أكثر أهمية من دور العوامل ذات الأثر غير المضيف فى وراثة صفات عدد الأيام من الزراعة حتى النضج ووزن ١٠٠ بذرة مما يؤكد جدوى الانتخاب لهذه الصفات خلال الأجيال الانعزالية المبكرة.
- كما أظهرت النتائج أن درجة التوريث بمعناها الواسع مرتفعة وثابتة خلال الجيلين لكل الصفات تحت الدراسة، بينما كانت درجة التوريث بالمعنى المحدود مرتفعة لصفة عدد الأيام من الزراعة حتى النضج ومتوسطة لصفة وزن ١٠٠ بذرة ومنخفضة لصفات عدد القرون للنبات وعدد البذور للنبات ووزن محصول النبات.