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HETEROSIS AND GENETIC ANALYSIS OF YIELD AND SOME CHARACTERS IN FABA BEAN (VICIA FABA L.)

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ABSTRACT

A diallel cross excluding reciprocals among six faba bean genotypes (Aquadolce, Nubaria 1, Giza 716, Sakha 3, Giza 429 and Triple white) was used to estimate the heterotic effect of F_1 crosses, combining ability and genetic components for yield and its variables viz: plant height, number of branches, pods, seeds, seed yield/plant and 100-seed weight. Analysis of variance indicated highly significant differences among the entries for all characters. Heterotic effects over mid and better parents were detected in most crosses. Based on the two estimates of heterotic effects, the three following crosses: P_1 x P_3; P_2 x P_3 and P_2 x P_5 exhibited significant positive heterotic effects over both mid and better parents for most studied characters. The two parents: Nubaria 1 and Giza 716 showed substantial and significant positive general combining ability (gca) effects for seed yield/plant. Meanwhile, Giza 716 and Triple white had highly significant positive (gca) effects for number of pods and seeds/plant. On the other hand Aquadolce and Nubaria 1 recorded highly significant positive (gca) effects for 100-seed weight. Three crosses (Aquadolce x Giza 716, Nubaria 1 x Giza 429 and Sakha 3 x Triple white) had significant specific combining ability (sca) effects for number of seeds and seed yield/plant. The ratio of gca/sca revealed the preponderance of additive gene action for number of pods, seeds and 100-seed weight. The regression coefficient was close and not significant from unity, indicating absence of epistasis for all characters and revealed simple additive gene action system controlling these characters. D component was less than H_1 for all characters except 100-seed weight, indicating the importance of dominance genetic variance. Narrow sense heritability ranged from 13% for seed yield/plant to 76% for 100-seed weight.

INTRODUCTION

Faba bean (*Vicia faba* L.) is considered one of the most important legume crops in Egypt being used for human food and animal feed, due to its high nutritive value. Seed yield is a complex trait and is quantitatively inherited with low heritability value (Bond, 1966). The genetic improvement of various traits depends on the nature and magnitude of genetic variability in addition to hybridization which offers new recombinations and releases new materials for improvement and helps the breeders to identify the best combinations to be crossed either to exploit heterosis or to build up the favorable fixable genes. Therefore, yield itself may not be the best criterion for selection, so that breeding for high seed yield is associated with yield and its components; number of branches, pods, seeds/plant and 100-seed weight (Rowlands, 1955).

Superiority of hybrids over the mid and better parents for seed yield was found to be associated with manifestations of heterotic effect, for yield components i.e. number of branches, pods, seed /plant and 100-seed weight (Abdalla, 1977; El-Hady *et al.*, 1991; El-Hady *et al* 1997; El-Hady *et al.*, 1998; Attia *et al.* 2002; Attia and Salem, 2006; Attia *et al.*, 2006; El-Hady *et al.*, 2006 and El-Hady *et al.*, 2007). The difference in percent heterosis might be due to genetic differences of the parents used and or non- allelic interaction which can either increase or decrease the expression of heterosis (Cress, 1966). Abdalla (1977) reported that, heterosis was very pronounced in F_1 especially among widely divergent materials but was less manifested in hybrids between local varieties.

Combining ability analysis helps the breeders to identify the best combiners which may be hybridized either to exploit heterosis or to build up the favorable fixable genes. El-Hady *et al.* (1997); El-Hady *et al.* (1998); Abdalla *et al.* (1999), Abdalla *et al.* (2001); Attia *et al.* (2006) and El-Hady *et al.* (2006) reported that both GCA and SCA variance were important for yield and components. The low heritability and consequent limited genetic improvement for yield in response to selection has led many scientists to search for characters which are associated with yield and are relatively highly heritable. El-Hady *et al.* (1997); El-Hady *et al.* (1998); Attia *et al.* 2002, Darwish *et* *al.* (2005); El-Hady *et al.* (2006) and El-Hady *et al.* (2007) revealed that non- additive effects were more important for number of branches, pods, seeds and seed yield/plant than additive effects. On the other hand, the additive variance was important for 100-seed weight.

Heritability estimates provide values of relative importance of genetic components to phenotypic variation and is useful in predicting the expected genetic advance from selection in segregating populations. Estimates of heritability for different characters were calculated by several researchers using different materials and methods and reported that heritability values were high for 100-seed weight and low to moderate for seed yield along with number of branches, pods, seeds/plant (El-Hady *et al.*, 1997; El-Hady *et al.*, 1998; Abdalla *et al.*, 2001; Attia *et al.* 2001; Attia *et al.* 2002; El-Hady *et al.* 2006; El-Hady *et al.* 2007 and Attia and Salem 2006).

The present study aimed to determine the magnetite of heterosis, general and specific combining ability and nature of gene action of some faba bean hybrid combinations.

MATERIALS AND METHODS

This investigation was conducted under insect free cages at Giza Research Station during three successive seasons 2004/05, 2005/06 and 2006/2007. Six faba bean genotypes; Aquadolce (P_1), Nubaria 1 (P_2), Giza 716 (P_3), Sakha 3 (P_4), Giza 429 (P_5) and Triple white (P_6) were crossed in all possible combinations excluding reciprocals during 2004/05 growing season. The pedigree and different characteristics of the parental genotypes are shown in Table 1. In 2005/06 season re-hybridization was made in order to obtain more hybrid seeds. The parents and their 15 F_1's were sown in a randomized complete block design with three replications in 2006/07 season. Each block included 15 F_1's as well as six parents. Seeds were planted in single seeded hills, 20 cm apart. Each genotype was represented by one row, 3 meters long, and 50 cm in between. At maturity, ten guarded individual plants were taken at random from each entry and the following characters were recorded; plant height, number of branches, pods, seeds, seed yield/plant (g) and 100-seed weight (g).

Table 1: Origin and some characteristics of the six faba bean parental genotypes.

Genotype	Origin	Special remarkable characters	Genotype	Origin	Special remarkable characters
Aquadolce (P_1)	Spain	Large seeded type	**Sakha 3 (P_4)**	Egypt	Early maturing and tolerant to foliar diseases
Nubaria 1 (P_2)	Egypt	Large seeded type	**Giza 429 (P_5)**	Egypt	Tolerant to *Orobanche*
Giza 716 (P_3)	Egypt	Early maturing and tolerant to foliar diseases	**Triple white (P_6)**	Sudan	Small seeded type, early maturing.

Differences among genotypes were tested by conducting a regular analysis of randomized complete block design on plot mean basis. The heterotic effects of F_1's were estimated as percentage over mid and better parents. Estimates of combining ability effects and variances were calculated according to Griffing (1956), method 2, model 1. Partitioning of genetic variance was calculated according to the procedure outlined by Hayman (1954).

RESULTS AND DISCUSSION

Mean performance of parents and F_1's:

Results presented in Table 2 revealed significant differences among tested entries for all studied characters indicated genetic variability for all variables. The parental mean were 112.78, 4.22, 17.22, 42.00, 87.89, and 32.52 with a range of 106.67-118.33; 3.33-

4.67; 5.00-40.67; 21.33-80.33; 52.17-124.09 and 26.10-42.00 for plant height, number of branches; pods/plant, seeds/plant, 100-seed weight and seed yield/plant, respectively. Such wide ranges suggested the presence of significant genetic variability between parents. The parental genotype Triple white had low number of pods, seeds as well as seed yield/plant along with shortest plants, lower number of branches and lowest seed index. Moreover, the parental genotype Nubaria1 followed by Aquadolce had the heaviest 100-seed weight with few number of pods and seeds/plant. With respect to F_1's, results indicated that the hybrids mean exceeded the parental mean and recorded 109.44, 5.53, 20.13, 53.38, 89.95 and 47.42 with a range of 100.00-123.33; 3.33-9.00; 6.67-30.00; 29.33-82.00; 71.47-128.83 and 24.67-86.67 for plant height, number of branches, pods, seeds, 100-seed weight and seed yield/plant, in the same order. Two crosses P_1 x P_3 and P_2 x P_5 exhibited high estimates of seed yield/plant, number of branches and seeds/plants. On the other hand, the following two crosses i.e. P_1 x P_2 and P_2 x P_4 had the heaviest 100-seed weight.

It could be concluded that previously mentioned parental genotypes and crosses would prospect in faba bean breeding and therefore may be valuable for improving seed yield and its components.

Heterosis effects:

Estimates of heterosis relative to mid and better parent are given in Table 3. Results revealed significant positive heterosis effects over mid- parents in five, six, six, five and seven crosses with a range of 42.8-92.7; 48.7-121.1; 50.8-134.8; 10.4-25.8 and 39.4-203.6% for number of branches, pods, seeds, 100-seed weight and seed yield/plant, respectively.

Moreover, heterosis (%) relative to the better parent was significantly positive in four, three, two, one and six crosses with a range of 42.8-42.8, 37.7-37.7, 72.3-82.2, 14.5-14.5 and 32.5-179.6 for the same previous traits in the same order. Based on the two estimates of heterotic effects, the three following crosses: P_1 x P_3; P_2 x P_3 and P_2 x P_5 exhibited significant positive heterotic effects over both mid and better parents for most studied characters.

It could be suggested that the heterotic effects for seed yield/plant was associated with other components. Different values of heterosis might be due to genetic diversity between the parents with non-allelic interaction which increase or decrease the expression of heterosis (Cress, 1966). Pronounced and favorable heterosis were obtained by several authors for faba bean traits (Bond, 1966; Abdalla, 1977; El-Hady *et al.*, 1997; El-Hady *et al.*, 1998; Abdalla *et al.*, 1999; Abdalla *et al.*, 2001; Attia *et al.*, 2002; Darwish *et al.*, 2005 and El-Hady *et al.*, 2006).

Table 2: Mean performance of parents and their crosses for yield and its components.

Entries	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	100seed weight	Seed yield/ plant
(P_1) Aquadolce	115.00	4.67	6.33	26.00	121.47	32.00
(P_2) Nubaria1	108.33	4.67	5.00	21.33	124.03	26.10
(P_3) Giza 716	111.67	4.67	17.33	45.00	83.63	37.67
(P_4) Sakha 3	118.33	3.33	13.67	33.67	78.20	26.33
(P_5) Giza 429	116.67	4.67	20.33	45.67	67.83	31.00
(P_6)Triple white	106.67	3.33	40.67	80.33	52.17	42.00
P_1 x P_2	110.00	6.67	6.67	30.33	128.83	39.67
P_1 x P_3	113.33	9.00	22.67	82.00	89.37	73.00
P_1 x P_4	123.33	4.67	12.67	45.00	90.73	40.67
P_1 x P_5	105.00	5.33	12.00	29.33	83.87	24.67
P_1 x P_6	106.67	4.33	15.67	44.00	86.00	38.00
P_2 x P_3	101.67	6.67	19.67	52.00	114.67	59.67
P_2 x P_4	108.33	5.33	18.00	47.33	127.17	58.00
P_2 x P_5	108.33	6.67	28.00	78.67	110.03	86.67
P_2 x P_6	111.67	4.00	19.00	53.33	76.77	41.00
P_3 x P_4	100.00	6.33	22.33	56.67	71.90	40.67
P_3 x P_5	110.00	5.67	28.00	52.00	71.47	37.33
P_3 x P_6	103.33	5.00	25.67	60.00	72.30	44.00
P_4 x P_5	106.67	5.67	28.00	62.67	71.60	45.33
P_4 x P_6	118.33	4.33	30.00	73.00	76.90	55.67
P_5 x P_6	115.00	3.33	13.67	34.33	77.67	27.00
Parental mean	112.78	4.22	17.22	42.00	87.89	32.52
Hybrids mean	109.44	5.53	20.13	53.38	89.95	47.42
C.V.%	5.26	20.10	21.15	21.40	7.63	18.42
LSD 0.05	9.57	2.15	8.33	21.02	11.24	13.12

Table 3: Heterotic percentages for all studied traits relative to mid- and better parents.

Crosses	Plant height (cm)		No. of branches/ plant		No. of pods/ plant		No. of seeds/ plant		100seed weight (g)		Seed yield/ plant(g)	
	Mid-parents	better-parents	Mid-parents	better-parents	Mid-parents	better-parents	Mid-parents	better-parents	Mid-parents	better-parents	Mid-parents	better-parents
$P_1 \times P_2$	-1.5	-4.3	42.8*	42.8*	17.7	5.4	28.2	16.7	5.0	3.9	36.6	24.0
$P_1 \times P_3$	0.0	-1.5	92.7**	92.7**	91.6**	30.8	131.0**	82.2**	-12.9**	-26.4**	109.6**	93.8**
$P_1 \times P_4$	5.7	4.2	16.8	0.0	26.7	-7.3	50.8**	36.4	-9.1	-25.3**	39.4*	27.1
$P_1 \times P_5$	-9.4*	-10.0**	14.1	14.1	-10.0	-41.0*	-18.2	-35.8	-11.4*	-31.0**	-21.7	-22.9
$P_1 \times P_6$	-3.8	-7.2*	8.3	-7.3	-33.3*	-61.5**	-17.2	-45.2**	-0.9	-29.2**	2.7	-9.5
$P_2 \times P_3$	-7.6	-9.0*	42.8*	42.8*	76.2*	13.5	56.8*	15.6	10.4*	-7.5	87.1**	58.4**
$P_2 \times P_4$	-4.4	-8.5*	33.3	14.1	92.8*	31.7	72.1*	40.6	25.8**	2.5	121.2**	120.3**
$P_2 \times P_5$	-3.7	-7.1*	42.8*	42.8*	121.1**	37.7*	134.8**	72.3**	14.7**	-11.3**	203.6**	179.6**
$P_2 \times P_6$	3.9	3.1	0.0	-14.3	-16.8	-53.3**	4.9	-33.6**	-12.9*	-38.1**	20.4	-2.4
$P_3 \times P_4$	-13.0**	-15.5**	58.3*	35.5	44.1	28.9	44.1	25.9	-11.1	-14.0*	27.1	8.0
$P_3 \times P_5$	-3.7	-5.7	21.4	21.4	48.7*	37.7*	14.7	13.9	-5.6	-14.5*	8.7	-0.9
$P_3 \times P_6$	-5.3	-7.5*	25.0	7.1	-11.5	-36.9**	-4.3	-25.3*	6.5	-13.5*	10.5	4.8
$P_4 \times P_5$	-9.2*	-9.9*	41.8	21.4	64.7**	37.7*	58.0*	37.2	-1.9	-8.4	58.1**	46.2*
$P_4 \times P_6$	5.2	0.0	30.0	-7.3	10.4	-26.2**	28.1	-9.1	18.0*	-1.7	62.9**	32.5*
$P_5 \times P_6$	3.0	-1.4	-16.8	-28.7	-55.2**	-66.4**	-45.5**	-57.3**	29.5**	14.5*	-26.0	-35.7*

*,** indicate significant at 5 and 1 % level of probability, respectively.

Combining ability:

Results given in Table 4, revealed highly significant differences among genotypes along with general (gca) and specific combining ability (sca) variances for all studied traits. Moreover, the variances due to GCA were larger than sca for all traits except plant height and seed yield/plant, indicating that additive gene action might be controlling the inheritance of number of branches, pods, seeds and 100-seed weight. Thus, selection could be effective for improving these traits. Due to the significance of gca and sca variances, the additive as well as non-additive components were more important for all traits under study. The ratio of estimates of $\sigma^2 g / \sigma^2 s$ exceeded the unity for 100-seed weight. This indicated that most of the genetic variation among this trait appear to be additive. Since gca and sca variances are mainly due to additive and non additive effects for remain characters.

Table 4: Significance mean squares due to genotypes, general (GCA), specific (SCA) combining ability and ratios of additive ($\sigma^2 g$) to non additive ($\sigma^2 s$) gene effects for yield and some its components.

Source of variation	df	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	100seed weight	Seed yield/ plant
Genotype	20	102.18**	5.59*	235.83**	971.19**	1502.68**	751.52**
GCA	5	32.32*	3.34**	175.27**	355.17**	1676.56**	77.18**
SCA	15	34.64**	1.37*	46.39**	313.17**	109.01**	308.4**
$\sigma^2 g / \sigma^2 s$		-0.28	-0.75	0.77	0.03	3.13	-0.12
Error	40	33.61	1.70	25.48	162.25	46.43	63.19

*,** indicate significance at the 0.05 and 0.01 level of probability, respectively.

Similar results were obtained by Bond (1966), El-Hady *et al.* (1991), El-Hady *et al.* (1997), Abdalla *et al.* (2001), Attia *et al.* (2002), Attia and Salem (2006) and El-Hady *et al.* (1997).

Comparisons between gca effects ($\hat{g}i$) associated with each parent (Table 5), indicated that the parental genotypes Giza 716 showed significant or highly significant positive gca effects for number of branches, pods, seeds as well as seed yield/plant. On the other hand, the parental genotype Nubaria1 exhibited highly significant ($\hat{g}i$) effects for 100-seed weight and seed yield/plant. Moreover, Triple white had highly significant ($\hat{g}i$) effects for number of pods and seeds/plant.

With respect to sca effects ($\hat{s}ij$), results presented in Table 6, revealed that two, one, two, three, four and five crosses had significant or highly significant positive ($\hat{s}ij$) effect for plant height, number of pods, seeds, 100-seed weight and seed yield/plant, respectively. From the breeding point of view parents characterized by good general combining ability for yield and its components along with heterosis and high estimates of sca effects are obviously essential. Therefore, most of the previous parental genotypes and crosses may be important for breeding programs. El-Hady *et al.* (1998), Abdalla *et al.* (1999), Abdalla *et al.* (2001), Attia and Salem (2006) and El-Hady *et al.* (2006), reported that, high general combining lines may not always result in high specific combining ability effects.

Table 5: General combining ability effects ($\hat{g}i$) for various traits.

Parent	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	100 seed weight (g)	Seed yield/ plant(g)
P_1 Aquadolce	2.01	0.38	-6.60**	-8.54**	12.03**	-2.76
P_2 Nubaria 1	-1.94	0.29	-4.22**	-5.83*	22.50**	4.36**
P_3 Giza 716	-2.57*	0.71**	2.24*	5.21*	-4.82**	3.49*
P_4 Sakha 3	2.22*	-0.42	0.40	0.13	-3.85**	-1.14
P_5 Giza 429	0.76	0.13	1.90	-0.33	-9.40**	-2.39
P_6Triplewhite	-0.49	-1.08**	6.28**	9.38**	-16.45**	-1.56
S.E. gi	1.08	0.24	0.94	2.37	1.27	1.48
S.E.gi-gj	1.67	0.38	1.46	3.68	1.97	2.29

*,**0.05 > p < 0.001

Table 6: Specific combining ability effects ($S\hat{i}j$) for different traits.

Crosses	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	100seed weight (g)	Seed yield/ plant(g)
$P_1 \times P_2$	-0.39	0.81	-1.82	-5.43	4.95	-5.09
$P_1 \times P_3$	3.57	2.73**	7.73**	35.19**	-7.20*	29.12**
$P_1 \times P_4$	8.78**	-0.48	-0.44	3.27	-6.80	1.41
$P_1 \times P_5$	-8.10**	-0.36	-2.61	-11.93	-8.12*	-13.34**
$P_1 \times P_6$	-5.18*	-0.15	-3.32	-6.98	1.06	-0.84
$P_2 \times P_3$	-4.14	0.48	2.35	2.48	7.63*	8.66*
$P_2 \times P_4$	-2.26	0.27	2.52	2.90	19.16**	11.62**
$P_2 \times P_5$	-0.80	1.06	11.02**	34.69**	7.58	41.54**
$P_2 \times P_6$	3.78	-0.40	-2.36	-0.35	-18.65**	-4.96
$P_3 \times P_4$	-9.97**	0.85	0.39	1.19	-8.79*	-4.84
$P_3 \times P_5$	1.49	-0.36	4.56	-3.02	-3.67	-6.92
$P_3 \times P_6$	-3.93	0.19	-2.15	-4.74	4.20	-1.09
$P_4 \times P_5$	-6.64**	0.77	6.39	12.73	-4.50	5.70
$P_4 \times P_6$	6.28*	0.64	4.02	13.36*	7.84*	15.20**
$P_5 \times P_6$	4.41	-0.90	-13.82**	-24.85**	14.15**	-12.21**
S.E. (Sij)	2.45	0.67	2.58	6.52	3.49	4.07
S.E. (Sij-Skl)	4.10	0.92	3.57	9.01	4.82	5.62

*,**0.05 > p < 0.001

Values of Vr, Wr and Vr + Wr presented in Table 7 indicated that, none of the tested parental genotypes had the maximum number of dominant alleles for any trait under investigation. The regression coefficient was close and not significant from unity, indicating the absence of epitasis for all studied characters and revealed simple additive gene action system controlling these traits. However, b values significantly differed from zero for all traits, indicating interactions between concerned parents. Wr intercept values (Table 7) were negative which revealed the presence of over dominance for plant height, whereas, number of branches, pods, seeds, 100-seed weight and seed yield/plant, showed partial dominance. Jinks (1955) reported that over dominance effects were frequently artifacts caused by non-allelic interaction involving one or more parental arrays.

Table 7: Values of Vr, Wr and Vr + Wr as well as Wr intercept and regression coefficient values of seed yield and its components.

Sources	Plant height (cm)			No. of branches/ plant			No. of pods/ plant		
	Vr	Wr	Vr + Wr	Vr	Wr	Vr + Wr	Vr	Wr	Vr + Wr
P1	63.89	25.83	89.72	4.29	0.99	5.28	42.64	40.66	83.3
P2	38.06	12.78	50.83	2.60	0.68	3.28	101.66	70.97	172.63
P3	61.67	-3.06	58.61	4.73	0.83	5.67	33.08	25.80	58.88
P4	116.94	8.61	125.56	1.57	0.50	2.07	71.36	77.97	149.33
P5	36.95	0.28	37.22	2.36	0.40	2.76	87.58	-36.71	50.87
P6	59.17	27.22	86.33	0.81	0.11	0.92	123.71	92.79	216.5
Intercept	-3.43 ± 21.88			0.045 ± 0.289			0.886 ± 0.289		
Regression coefficient	0.245 ± 0.15			0.197 ± 0.041			0.579 ± 0.283		

Sources	No. of seeds/ plant			100seed weight (g)			Seed yield/ plant(g)		
	Vr	Wr	Vr + Wr	Vr	Wr	Vr + Wr	Vr	Wr	Vr + Wr
P1	502.71	138.16	640.87	441.76	569.79	1011.55	296.27	44.73	341
P2	567.61	284.27	851.88	443.75	443.14	88.688	485.83	4.23	490.06
P3	258.90	-25.28	233.62	290.86	417.63	708.49	243.54	-19.19	224.35
P4	33.43	246.42	583.86	496.94	450.59	947.53	196.33	29.42	225.75
P5	493.58	-229.68	263.90	259.96	342.02	601.97	593.04	-96.53	496.51
P6	405.62	157.70	563.32	149.31	231.95	381.26	156.37	-32.95	123.42
Intercept	10.836 ± 248.69			183.74 ± 57.77			19.35 ± 61.56		
Regression coefficient	0.197 ± 0.246			0.65 ± 0.084			0.096 ± 0.077		

Estimates of the genetic and environmental components of variance and other derived statistics are presented in Table 8. The additive genetic variance (D) was highly significant for plant height, number of pods, seeds and 100-seed weight, indicating that additive gene action was more important in controlling the inheritance of these characters.

The distribution of relation frequencies of dominant versus recessive genes (F) were positive and significant for number of pods and seeds/plant, suggested greater frequency of dominant alleles in the parents for these traits. The components of H_1 and H_2 significantly differed from zero for all traits. Theoretically, H_2 should be equal or less than H_1 (Hayman, 1954). H_1 was greater than H_2 in all studied characters, indicating that the positive and negative alleles at the loci for these traits were not equal in proportion in the parents. Values of H_1 were greater than the respective D values for plant height, number of branches, pods, seeds and seed yield/plant, indicating the important role of dominant genetic variance. On the other hand, value of D was greater than H_1 for 100-seed weight, suggested that additive genetic variance was more important. The over-all dominance effects as algebraic sum overall the loci in heterozygous phase in all crosses (h_2), was positive and significant for plant height, number of branches, seeds and seed yield/plant, indicating that most of the dominant genes had positive effects. All estimates of the environmental variance (E) were insignificant for all studied variables except plant height and number of branches, indicating that these traits have not been greatly affected by environmental factors. The weighted measure of average degree of dominance $(H_1/D)^{1/2}$ was more than unity for all characters, except 100-seed weight, indicating that over dominance is controlling these traits. The proportion ($H_2/4H_1$) was lower than 0.25, suggesting that positive and negative alleles were not equally distributed among the parents. The parents seemed to carry more dominant alleles than recessive as indicated by the positive values of F components. In a like manner, estimates of KD/KR were greater than one for all characters except number of branches/plant, which indicated an excess of dominant genes in the parents for these traits. These results are in accordance with these obtained by El-Hady *et al.* (1991), Attia *et al.*

Table 8: Estimates of genetic components, heritability and environmental variances.

Components and ratios	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	100seed weight (g)	Seed yield/ plant(g)
D	41.98 ± 12.24**	0.34 ± 0.58 NS	167.26 ± 17.88**	433.67 ± 95.95**	848.07 ± 44.80**	36.65 ± 72.20NS
F	44.13 ± 29.91 NS	-1.28 ± 1.41 NS	158.26 ± 43.68**	522.00 ± 234.41*	69.98 ± 109.44 NS	135.11 ± 176.38 NS
H_1	225.18 ± 31.08**	7.95 ± 1.47**	279.79 ± 45.39**	1673.87 ± 243.58**	573.26 ± 113.72**	1365.00 ± 183.28**
H_2	187.73 ± 27.77**	6.61 ± 1.31**	209.73 ± 40.55**	1405.22 ± 217.60**	489.51 ± 101.59**	1172.21 ± 163.73**
h^2	43.75 ± 18.69*	7.05 ± 0.88**	21.60 ± 27.29 NS	377.67 ± 146.46*	5.83 ± 68.38 NS	617.79 ± 110.20**
E	11.91 ± 4.63*	0.57 ± 0.22*	8.23 ± 6.76 NS	53.59 ± 36.27 NS	15.87 ± 16.93 NS	20.46 ± 27.29 NS
$(H_1/D)^{1/2}$	2.317	4.829	1.293	1.965	0.822	6.103
$H_2/4H_1$	0.208	0.208	0.187	0.210	0.214	0.215
KD/KR	1.587	0.441	2.154	1.883	1.106	1.866
h^2/H_2	0.233	1.067	0.103	0.269	0.012	0.528
Heritability	0.23	0.40	0.39	0.18	0.76	0.13

*,** indicate significance at the 0.05 and 0.01 level of probability, respectively.

(2001), Attia *et al.* (2002), Attia and Salem (2006) and El-Hady *et al.* (2007). Narrow sense heritability ranged from 13% for seed yield/plant to 76% for 100-seed weight. These results revealed that dominant genetic variance were more important for most studied traits and affected by environmental fluctuations than 100-seed weight.

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قوة الهجين والتحليل الوراثي لمحصول البذور وبعض الصفات في الفول البلدي

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أجريت هذه الدراسة علي ستة أباء من الفول البلدي (Aquadolce، نوبارية 1 ، جيزة 716، سخا 3، جيزة 429، Triple white) وجميع الهجن التبادلية الناتجة منها (بدون الهجن العكسية) لدراسة التباين الهجيني والقدرة علي الأتلاف ومكونات التباين الوراثي لصفة المحصول وبعض مكوناتها: طول النبات، عدد الافرع ، القرون والبذورللنبات وكذالك وزن الـ 100بذرة. أظهر تحليل التباين أن هناك فروق معنوية بين الاباء والهجن في جميع الصفات. أوضحت النتائج تفوق بعض هجن الجيل الأول (Aquadolce x جيزة 716 و نوبارية 1 x جيزة 716 و نوبارية 1 x جيزة 429) تفوقا موجبا ومعنويا مقارنة بمتوسط الأبوين والأب الاعلي بالنسبة لمعظم الصفات تحت الدراسة مما يوضح أهمية العوامل ذات السيادة الجزيئية والفائقة في وراثة هذه الصفات. أظهر الابوين نوبارية 1 و جيزة 716 مقدرة عامة علي الائتلاف لصفتي عدد القرون ومحصول النبات. بينما أظهر كلا من Aquadolce ونوبارية 1 مقدرة عامة علي الائتلاف لصفة وزن الـ 100 بذرة. وكان تأثير القدرة الخاصة علي الائتلاف معنويا في ثلاثة هجن (Aquadolce x جيزة 716 و نوبارية 1 x جيزة 429 و سخا 3 x Triple white) لصفات عدد البذور ومحصول بذور النبات. وتشير نسبة القدرة العامة

علي الائتلاف الي القدرة الخاصة علي الائتلاف ان صفات عدد القـرون والبـذور ووزن الـــ100 بذره تتأثر بالعوامل ذات التأثير التجميعي. كان معامل الانحدار قريبـا وغيـر معنويا عن الواحد مشيرا الي غياب التفوق في جميع الصفات ويظهر تأثير نظام العوامـل الجينيه المضيفه انها تتحكم في هذه الصفات. وأشارت النتائج ان مكونات (D) كانت أقل من (H_1) لجميع الصفات تحت الدراسة ماعدا صفة وزن الـــ100بذرة مما يشـير الـي أهمية التباين الوراثي السائد. تراوحت درجة التوريث بالمعني الضيق تراوحت من 13% لمحصول البذور الي 76% لوزن الـــ100 بذرة.