*Minufiya J. Agric. Res. Vol. 33 No.2: 489 - 504 (2008)*

# HYBRIDIZATION EFFECTS ON BROAD BEAN (*Vicia faba* L.) YIELD AND IT'S COMPONENTS

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(Received: Jan. 28, 2008)

***ABSTRACT:*** Twenty one hybrids, developed by crossing 7 female parents and 3 male parents in top crosses scheme (7x3). They were evaluated for hybrid vigour, gene action, combining ability, degree of dominance and inbreeding depression for 10 traits. Significant differences were found between either parents or $F_1$ crosses in all traits. Mean squares of entries, parents, crosses, heterosis, females, males, and female x male were significant to highly significant in all traits, except some ones. For all traits, except average pod weight and total green pod yield the estimated additive genetic variance values were higher, suggesting that the total genetic variability associated with these traits were results of additive and additive x additive types of gene action. Average degree of dominance (ADD) values were more than one for pod weight and total green pod yield, suggesting dominance or over-dominance influenced the expression of these characters.

The cultivars Aquadulce, Mansoura-1 and Reina Mora showed significant GCA effects in 7, 4 and 5 traits, respectively. Therefore, they could be the best donor genotypes for breeding program. Highly significant positive or negative specific combining ability (SCA) effects were detected for most traits. The best $F_1$ crosses were "Kassasein-7 x Reina Mora" and "Kassasein-1 X Luz De Otono" for yield and its components.

Significant positive or negative heterotic effect to high parent's value was detected for all studied traits. The crosses "Aquadulce x Luz De Otono", "Kobrosy x Reina Mora" ," Aquadulce x Reina Mora" and" Mansoura-1x Nubaria-1" gave the highest HP-heterosis values as 61.12% for total green pod yield, 9.62% for seed index, 3.89% for pod weight, and 3.56% for number of pods per plant, respectively. While, in relation to the check cv., they gave significant heterosis values as 84.48, 22.94, 31.61 and 38.84%, for these traits, respectively.

All $F_2$ populations gave positive inbreeding depression values for plant height, number of pods per plant, pod weight, seed index and total green pod yield. Therefore, $F_2$ populations are not suitable for commercial production in broad bean crop.

***Key words:*** Broad bean, Heterosis, Combining ability and Inbreeding depression.

## INTRODUCTION

Cultivated broad bean (*Vicia faba* L.) is used as vegetable, fresh or canned, green or dried for human consumption since it is rich in calories, minerals, vitamins and proteins. In development of high yielding cultivars, the breeder often faces with the problem of selecting parents. The selection of parents has consequently to be based on complete genetic information and knowledge of combining ability of these parents. Combining ability analysis is considered to be an efficient technique not only for selection of desirable parents and crosses, but it also characterizes nature and magnitude of gene action in the expression of a trait. Additive and non-additive genetic effects could be determined from the estimates of combining ability as general (GCA) and specific (SCA).

Basic information on the relative proportion of additive and non-additive gene effects for complex traits used for studying the inheritance pattern and could be used in formulating an efficient breeding program to achieve desired genetic improvement. Where both additive and non-additive gene action are important, it is advisable to adapt recurrent selection for handling such population. Farag (2007) and Farag and Helal (2004) reported that both additive and non-additive gene actions were important to control most of studied traits. They added that GCA was greater than that of SCA for all characters, except some ones. The same conclusion was reported by El-Hady et al., (1991, 1997), El-Refaey (1999),) and Attia et al.,(2006). If the additive gene action appears to be more important, plant breeder through exact designed selection program must expect a maximum improvement in this particular character. El-Hosary (1985) reported that additive and additive x additive types of gene action were more important expression for all traits, except seed yield per plant, while, Farag and Darwish (2005)found that additive x additive type of gene action was significant for all traits, except first fruiting node , number of seeds per pod .Also, El-Tabbakh and Ibrahim (2000) indicated that additive and additive x additive types of gene action controlled some traits ; i.e., number of branches/ plant and number of pods/ plant, while the non additive gene action controlled the inheritance of plant height and seed yield/ plant. El-Hosary et al.(1986) indicated that additive gene action was the dominant component for all traits.On the other hand, the presence of a relatively high non-additive (dominance and epistasis) gene action suggests that a hybrid program will be performed good prospects for the character(s). Salama and Salem (2001) and Salama and Mohamed (2004) found that the non-additive genetic components were more important in the inheritance of 100-seed weight, seed number per plant and pod number per plant. El-Hady et al., (2006) found that dominance genetic variance was more important than additive one for all characters.

Information on heterosis and combining ability helps the breeders to choice the suitable parents for the breeding programs. El-Refaey (1999) found high significant positive heterosis over both mid and better parents for plant height, number of pods, seed yield/ plant. El-Tabbakh and Ibrahim (2000) and Rabie et al., (2004) reported that heterosis values relative to better parent differed for plant height, 100- seed weight, seed yield per plant, number of branches per plant and number of pods per plant. Farag and Darwish (2005) and Salama (2005) found that significant positive heterosis effects to mid-parents were detected for all studied traits. Over dominance for the higher parent was found in number of seeds per pod and total green pod yield. Manifestation of heterotic effects ranged from significantly positive to negative values (El-Hady et al., 1991 and1997, Salama and Salem, 2001, Salama and Mohamed, 2004, Attia et al., 2006 and Farag, 2007).These differences may be due to genetic differences of the parents and/or non-allic interaction.

Regarding the inbreeding depression, El-Refaey (1999), Farag and Darwish (2005) and Attia et al., 2006 found that highly significant inbreeding depression values were observed for most traits. Farag and Helal (2004) found that all $F_2$ populations gave positive values for plant height, number of pods per plant, pod weight, total green pod yield. Also, Rabie et al., (2004) showed that some crosses expressed significantly positive inbreeding depression for number of branches, pods, seeds and seed yield per plant.

The main targets of the present investigation were to estimate general and specific combining ability effects, Heterosis, average degree of dominance and inbreeding depression, to be employed in improving yield and it's components as well as growth characteristics in some broad bean cultivars.

## MATERIALS AND METHODS

This investigation carried out during three successive winter seasons of 2004/05, 2005/06 and 2006/07 at the Experimental Farm of El-Gemmeza Agriculture Research Station, Gharbia Governorate. This experiment involved seven broad bean cultivars (females) and three broad bean cultivars (males).The female parents were($P_1$) Mansoura-1, ($P_2$) Kassasin-1, ($P_3$) Kassasi-7, ($P_4$) Icarus , ($P_5$) Aquadulce , ($P_6$) ILB 4726, ($P_7$) Kobrosy, while the male parents were ($P_8$) Nubaria-1 , ($P_9$) Reina Mora, and($P_{10}$) Luz De Otono. The parents number 1, 2, 3 and 8 are from Egypt; 4 and 6 were from Syria and 5, 7, 9 and 10 are from Spain. In 2004/05, the crosses along with 10 parents; i.e., 7(females) and 3(males) were generate the experimental materials used in this study. In the winter season of 2005/06, total entries being 31(ten parents, and twenty one $F_1$ crosses) were evaluated in a randomized complete block design with three replicates and the data were recorded. Some of the $F_1$ plants were selfed to produce the required $F_2$ seeds. In the final season, 2006/07, the 10 parents, 21 $F_1$ crosses and 21 $F_2$ were sown in a randomized complete block design with three replications. In each replicate, three ridges were allocated to each of the non-segregating populations ($P_1$, $P_2$ and $F_1$) and ten ridges for the $F_2$ populations. Each ridge of one side comprised of fifteen hills spaced at thirty centimeter apart within ridges of sixty five-centimeter widths. Recommended agronomic practices were carried out as usual for the ordinary broad bean fields in the area. The cultivar Aquadulce, which is widely grown, was used as check.

Observation and measurements were recorded on ten, ten and twenty five guarded plants per plot for parents, $F_1$ and $F_2$, respectively .The following characters were recorded: plant height, number of branches per plant (at the end of the growing season), first pod height, number of pods per plant, number of seeds per pod, pod weight, pod length, pod diameter, seed index (100-green-seed weight) (at harvesting time) and total green pod yield.

## Statistical and genetic analysis:

Statistical analysis was performed according to Snedecor and Cochran (1982). The analyses of general and specific combining abilities were computed using the line x tester procedure suggested by Kempthorne (1957). Average degree of dominance (ADD) was worked out as $(\sigma^2D / \sigma^2A)^{½}$ given by Comstock and Robinson (1952). Average degree of heterosis was expressed as the percentage increase or decrease of the $F_1$ performance from the high (Hp) or better parent (Bp) values. Inbreeding depression (ID %) was calculated as the differences between the $F_1$ and $F_2$ means expressed as a percentage of the $F_1$.

# RESULTS AND DISCUSSION

## Combining ability

Analysis of variance along with the estimates of general (GCA) and specific (SCA) combining abilities for some plant and pod characteristics are presented in Table (1). Significant differences were detected among all genotypes, parents, and crosses for all the studied traits.

Data in Table (1) 1 reflected highly significant mean square values in all source of variations; i.e., entries, parents, crosses, heterosis , females ,males, and female x male for most traits. The significant of variance due to entries, parents, crosses and females were significant to highly significant in all traits, except the number of branches per plant, suggesting the existence of non-additive gene action. Also, mean squares of the crosses vs. parent's comparisons were significant for all traits, except number of pods per plant, indicating the expression of heterosis effects for the remaining traits. Mean squares of male parents were found to be significant and highly significant for all traits, except for number of branches and number of pods per plant. Highly significant mean squares of female X male parent's interaction were obtained for all traits, except for number of branches per plant, number of seeds per pod, pod weight and diameter, indicating that females did not express identical orders of ranking for the performance of their crosses with each tester. Highly significant differences for both general and specific combining abilities were found for all characters (Table(1) indicating the importance of both genetic variances for the inheritance of these traits. Similar results were obtained by El-Refaey (1999), Farag and Helal(2004), Farag and Darwish(2005) and Attia et al. (2006 ).

Table(1): Analysis of variance of combining ability, genetic components of variance and average degree of dominance (ADD) for broad bean plant and pod characteristics.

| S.O.V. | df | Plant height | Branch number | First pod height | Seed number /pod | Pod weight | Pod length | Pod diameter | Seed Index | pod number/ plant | Total green pod yield |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Entries | 30 | 175.63** | 1.19 | 87.31** | 0.56** | 131.35** | 18.05** | 0.09** | 1660.4** | 36.73** | 53374.2** |
| Parents(P) | 9 | 127.45** | 0.85 | 50.36** | 1.30** | 75.69** | 33.09** | 0.11** | 1285.4** | 41.76** | 17319.1** |
| Crosses(C) | 20 | 55.96** | 1.12 | 90.65** | 0.21** | 102.00** | 5.78** | 0.07** | 1423.5** | 35.56** | 30331.6** |
| Heterosis ( P vs.C) | 1 | 3002.8** | 5.63* | 355.91** | 0.76** | 1219.18** | 128.0** | 0.25** | 9772.7** | 14.79* | 838723.1 |
| Lines (L) | 6 | 81.71** | 1.47 | 188.50** | 0.32** | 103.65** | 7.17** | 0.19** | 2720.6** | 73.56** | 41600.5** |
| Testers(T) | 2 | 126.74** | 0.14 | 113.84** | 0.50** | 20.76** | 22.74** | 0.05* | 2921.4** | 0.40 | 6962.4** |
| ne Xtester (LXT) | 12 | 31.29** | 1.11 | 37.86** | 0.110 | 114.71** | 2.26** | 0.021 | 525.3** | 22.42** | 28592.1** |
| Error | 60 | 9.32 | 0.91 | 2.03 | 0.064 | 0.518 | 0.470 | 0.008 | 33.5 | 2.447 | 297.2 |
| GCA | 9 | 4.177** | 0.06* | 9.47** | 0.016* | 4.136** | 0.405* | 0.009* | 140.53** | 3.49* | 1832.3** |
| SCA | 20 | 7.324** | 0.06* | 11.94** | 0.015* | 38.065** | 0.598* | 0.0032* | 163.91** | 6.66** | 9431.6** |
| $\sigma^2 A$ | | 8.353 | 0.13 | 18.97 | 0.033 | 8.272 | 0.810 | 0.019 | 281.06 | 6.98 | 3664.6 |
| $\sigma^2 A / \sigma^2 D$ | | 1.140 | 1.98 | 1.59 | 2.132 | 0.217 | 1.353 | 5.930 | 1.71 | 1.048 | 0.389 |
| ADD | | 0.936 | 0.711 | 0.794 | 0.685 | 2.145 | 0.860 | 0.411 | 0.764 | 0.977 | 1.604 |

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

For all traits, except average pod weight and total green pod yield, the estimated additive genetic variance values were higher (more than one) suggesting that the total genetic variability associated with these traits were a result of additive and additive x additive types of gene action which was further confined by $O^2A$ / $O^2D$ and by the degree of dominance whose value was found below unity. The same results were obtained by Farag and Helal (2004 ).Since there was predominance of additive gene effect for all above traits, significant advancement could be achieved in the segregating generation through conventional breeding method's such as pedigree and bulk selection method. Average of dominance (ADD) which was found to be more than one for average pod weight and total green pod yield(2.15 and 1.60,respectively(Table 1) suggest that dominance or over-dominance influenced the expression of this character. High average degree of dominance revealed predominance of non-additive type of gene effect for these traits. Salama and Mohamed (2004), found that the average degree of dominance was more than unit for all character, except plant height. Recurrent selection could be useful for the development of this character.

Analysis of variance along with the estimates of general (GCA) and specific (SCA) combining abilities for all plant and pod characteristics are presented in Tables (2&3). General combining ability (GCA) effects were significant for most traits under study .For plant height; the female parents showed values ranged from –3.65 (in Aquadulce cv.) to 5.46 (in Kassasein-7 cv.) (Table 2). Therefore , the cultivars Kassasein-7,ILB4726, and Rina Mora can be considered as good donor and may be used for increasing plant height through breeding programmes, since they showed the highest positive significant GCA values.On the other hand the cultivars Aquadulce, and Nubaria-1 gave the highest significant negative values(-3.651and -3.281 ,respectivaly) . These results recommend that, these cultivars may be used as good donor for decreasing plant height in broad bean.

Concerning number of branches per plant, three cultivars Mansoura-1, Aquadulce and Reina Mora showed positive significant GCA values. For that, these cultivars can be used as a good donor for increasing number of branches per plant.

Table (2): General combining ability effects for broad bean plant and pod characteristics.

| numb | Character Genotype | Plant height | Branch number | First pod height | Seed number /pod | Pod weight | Pod length | Pod diameter | Seed index | pod number/ plant | Total green pod yield |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Female parents: | | | | | | | | | | |
| 1 | Mansoura-1 | -0.89 | 0.19* | -4.41** | 0.19* | -5.14** | -0.43 | -0.06 | -0.5 | 4.06** | -26.08* |
| 2 | Kassasein-1 | -2.05* | 0.09 | -6.70** | 0.09 | -1.27** | 1.41** | -0.08** | -5.7** | -2.22** | -90.33** |
| 3 | Kassasein-7 | 5.46** | -0.31** | -0.81 | -0.31** | -1.67** | -0.26 | 0.16** | -24.4** | -0.90 | -59.52** |
| 4 | Icarus | -0.34 | -0.09 | -0.34 | -0.09 | -1.71** | -0.28 | -0.09** | -18.8** | 2.25** | 23.16* |
| 5 | Aquadulce | -3.65** | 0.19* | 1.50** | 0.19* | 1.88** | 1.11** | 0.25** | 14.3** | 2.41** | 118.79** |
| 6 | ILB 4726 | 2.34* | 0.06 | 5.79** | 0.06 | 4.48** | -0.67** | -0.10** | 14.9** | -3.19** | 9.03 |
| 7 | Kobrosy | -0.86 | -0.13 | 4.98** | -0.13 | 3.44** | -0.88** | -0.09** | 20.1** | -2.40** | 24.94* |
| | LSD at p. 0.05 | 2.03 | 0.17 | 0.951 | 0.17 | 0.48 | 0.46 | 0.06 | 3.86 | 1.08 | 22.78 |
| | 0.01 | 2.71 | 0.22 | 1.265 | 0.22 | 0.64 | 0.61 | 0.08 | 5.13 | 1.43 | 30.29 |
| | Male parents | | | | | | | | | | |
| 8 | Nubaria-1 | -3.28** | -0.08 | 2.39** | -0.08 | 1.30** | 1.20** | -0.06** | -15.6** | -0.07 | 24.16** |
| 9 | Reina Mora | 2.01** | 0.21** | -2.95** | 0.21** | -0.92** | 1.23** | 0.01 | 10.3** | -0.12* | -15.77 |
| 10 | Luz De Otono | 1.27 | -0.12* | 0.56 | -0.12* | -0.39* | -0.03 | 0.06* | 5.4** | 0.18* | -8.38 |
| | L.S.D at p. 0.05 | 1.43 | 0.12 | 0.673 | 0.12 | 0.34 | 0.32 | 0.04 | 2.73 | 0.76 | 16.12 |
| | 0.01 | 1.91 | 0.16 | 0.894 | 0.16 | 0.45 | 0.430 | 0.057 | 3.63 | 1.01 | 21.42 |

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

As regards to general combining abilities (GCA) effects, the negative values denote desirable values to first pod height. Data in Table (2) showed that, from 10 parents, five ones showed significant negative GCA values ranging from -0.34 (Icarus cv.) to -7.00 (Kassasein-1 cv.). The remaining parental cultivars showed significant positive GCA values. The cultivars; i.e., Kassasein-1 and Mansoura-1 showed highly significant negative GCA values, indicating that these two parents had desirable genes for short height to first pod and considerable good combiners for breeding to short length to first pod. In contrast, the cultivars ILB4726 and Kobrosy may be posse's genes of late first pod height since they reflected the highest positive GCA values.

Relating to number of seeds per pod, average pod weight, length, and diameter, the parental cultivars Rina Mora, ILB 4726, Kassasin-1 and Aquadulce showed high positive significant values (0.21, 4.48, 1.41, and 0.25, respectively). Therefore, they could be considered as good combiners for breeding to large number of seeds per pod, heavy, long, and wide pod. The cultivars Kobrosy (for seed index), Mansoura-1 (for number of pods per plant), and Aquadulce (for total green pod yield) gave high positive significant GCA values (20.13, 4.06 and 118.79, respectively). For the previous results these parental cultivars could be considered as the best combiner cultivars for seed index, number of seeds per pod and total green pod yield and could be used as donors for breeding to these traits.

Generally, the cultivars Aquadulce,Mansoura-1 and ILB4726( female parents) ,Reina Mora and Luz De Otono (male parents) showed significant GCA effects in 7,4,4 and 5 traits, respectively(Table 2). For that these cultivars could be used in broad bean breeding programs.

Table 3 : Estimates of specific combining ability effects for broad bean plant and pod characteristics.

| Character / Cross | Plant height | Branch number/ Plant | First pod height | Seed number /pod | Pod weight | Pod length | Pod diameter | Seed index | pod number/ plant | Total green pod yield |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 x 8 | 1.124 | -0.095 | -2.49** | -0.283* | 0.49 | 0.206 | 0.040 | -1.172 | 2.723** | 83.67** |
| 1 x 9 | 0.919** | 0.048 | -2.65** | 0.100 | 2.13** | -0.809* | 0.075 | 5.795 | -1.667 | 10.76 |
| 1 x 10 | -2.043 | 0.048 | 5.14** | 0.183 | -2.63** | 0.603 | -0.114* | -4.623 | -1.057 | -94.44** |
| 2 x 8 | 2.746 | -0.429 | 3.09** | 0.150 | 5.49** | 0.628 | 0.050 | -15.138** | -3.537** | 33.75** |
| 2 x 9 | -6.692** | 0.048 | 1.88* | 0.033 | 1.49** | -0.653 | -0.075 | -3.002 | -0.713 | 28.64** |
| 2 x 10 | 3.946* | 0.381 | -4.97** | -0.183 | -6.99** | 0.025 | 0.026 | 18.140** | 4.250** | -62.39** |
| 3 x 8 | 0.868 | 0.349 | -3.03** | -0.078 | -5.21** | 1.028* | 0.008 | 10.573** | 2.209* | -62.83** |
| 3 x 9 | 2.697 | -0.841 | 0.18 | -0.111 | 9.49** | -0.287 | 0.047 | -8.071* | -2.164* | 154.43** |
| 3 x 10 | -3.565* | 0.492 | 2.84** | 0.189 | -4.29** | -0.741 | -0.055 | -2.502 | -0.045 | -91.60** |
| 4 x 8 | -0.532 | -0.317 | 0.81 | 0.172 | 2.94** | -0.950* | -0.056 | -16.413** | -1.932 | 34.46** |
| 4 x 9 | 2.163 | 0.825 | -1.98* | 0.022 | -3.42** | -0.198 | 0.006 | 21.924** | 0.278 | -93.35** |
| 4 x 10 | -1.632 | -0.508 | 1.17 | -0.194 | 0.48 | 1.148 | 0.050 | -5.511 | 1.654 | 58.89** |
| 5 x 8 | -2.987 | -0.206 | -3.04** | -0.050 | -6.95** | -0.339 | -0.018 | 14.660** | 2.183* | -122.9** |
| 5 x 9 | 1.008 | -0.063 | 0.84 | 0.200 | 2.35** | 0.913* | 0.077 | -12.063** | -0.170 | 54.49** |
| 5 x 10 | 1.979 | 0.270 | 2.19** | -0.150 | 4.59** | -0.575 | -0.059 | -2.608 | -2.014 | 68.42** |
| 6 x 8 | 0.890 | -0.206 | 1.84* | -0.017 | 2.65** | -0.189 | -0.030 | 9.570** | -1.558 | 21.13* |
| 6 x 9 | -1.114 | -0.063 | 1.92* | -0.033 | -8.45** | 0.997* | -0.052 | -5.966 | 3.772** | -86.65** |
| 6 x 10 | 0.224 | 0.270 | -3.76** | 0.050 | 5.79** | -0.808* | 0.082 | -3.604 | -2.215* | 65.52** |
| 7 x 8 | -2.110 | 0.905* | 2.82** | 0.106 | 0.58 | -0.383 | 0.007 | -2.081 | -0.090 | 12.72 |
| 7 x 9 | 1.019 | 0.048 | -0.20 | -0.211 | -3.61** | 0.036 | -0.077 | 1.373 | 0.663 | -68.33** |
| 7 x 10 | 1.090 | -0.952* | -2.62** | 0.106 | 3.03** | 0.348 | 0.070 | 0.708 | -0.574 | 55.61** |
| L.S.D.0.05 | 3.525 | 0.901 | 1.647 | 0.238 | 0.832 | 0.792 | 0.105 | 6.687 | 1.806 | 19.909 |
| 0.01 | 4.688 | 1.198 | 2.191 | 0.317 | 1.106 | 1.053 | 0.139 | 8.893 | 2.403 | 26.477 |

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

1=Mansoura-1; 2=Kassasein-1;3=Kassasein-7; 4= Icarus; 5=Aquadulce; 6= ILB 4726; 7=Kobrosy 8= Nubaria-1 ; 9= Reina Mora ,and 10= Luz De Otono.

Estimates of specific combining ability effects (SCA) showed significant and highly significant positive or negative values for all traits (Table 3). The best $F_1$ crosses were "3 x 9" for total green pod yield and pod weight was; "4 x 9" for seed index and "2 x 10"for first pod height, number of pods per plant and plant height. Since they showed that the highest popular values. These combinations could be considered the most desirable for all traits. It could be said that, the best $F_1$ crosses were 3 x 9 (Kassasein-7 x Reina Mora) and 2 x 10(Kassasein-1 x Luz De Otono) for improving broad bean yield and its component. These top-crosses might be of interest in breeding programs towards pure line varieties as most of them involved in more than one trait in view.

## Heterosis and inbreeding depression

Heterosis values which were calculated as percentage increase or decrease over the high parent for the studied characters are presented in Table (4). For plant height, 14 $F_1$ crosses showed significant to highly significant HP-heterosis values ranging from 5.20 in the cross "5x10" to 20.41% in the cross "7x10", suggesting over-dominance forthe high parent. With regard to branch number per plant, 12 $F_1$ crosses gave HP-heterosis values ranging from 1.65 in the cross" 6x10" to 24.94 in the cross "3x8", suggesting over-dominance for the high parent. Concerning to the height of first pod on the stem, 13 $F_1$ crosses gave negative significant HP-heterosis values ranged from -40.49 in the cross "2x10" to -3.33 in the cross "1x10", suggesting over-dominance towards the better parents (poded at low-height). Over-dominance toward the long height was detected in five ones; i.e., "3x10", "6x8", "6x9", "7x10" and "7x8", since the HP-heterosis values ranged from 3.58 to 24.49. The overall means of heterotic effect relative to high-parent for plant height, branch number per plant and first pod height were 8.60, 3.07 and -6.48, respectively.

**Table (4): Average degree of heterosis (ADH %) based on high parent (Hp) and inbreeding depression (ID %) for morphological characteristics of broad bean crosses.**

| Character | Plant height | | Branch number | | First pod height | | Seed number /pod | | Pod weight | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cross | ADH% | ID% | ADH% | ID% | ADH% | ID% | ADH% | ID% | ADH% | ID% |
| 1X8 | 7.70** | 7.60 | 14.78** | 2.37 | -21.08** | -3.45 | 0.70** | -6.06 | 24.84** | 6.94 |
| 1X9 | 17.39** | 2.11 | 6.24** | -1.91 | -34.61** | 1.42 | -4.58** | -8.94 | -21.67** | 9.26 |
| 1X10 | 13.98** | 7.52 | 11.11** | 10.50 | -3.33 | 4.55 | -3.40** | 3.12 | -30.94** | 13.31 |
| 2 X8 | 6.23* | 5.88 | 9.95** | 9.80 | -12.70* | 8.75 | 8.51** | -2.40 | 89.70** | 7.56 |
| 2X9 | 1.69 | 9.51 | 1.81* | 5.68 | -28.04** | 2.22 | -7.80** | -4.27 | -10.25** | 6.80 |
| 2 X10 | 10.75** | 12.34 | 11.11** | 17.50 | -40.49** | -2.17 | -12.93** | 5.30 | -32.87** | 6.25 |
| 3X8 | 7.82** | 1.43 | 24.94** | 1.62 | -4.57 | 5.64 | -6.32** | 5.42 | 22.42** | 3.64 |
| 3X9 | 13.29** | 13.18 | -7.04** | 5.52 | -8.91** | 7.48 | -18.44** | 11.28 | 16.61** | 7.92 |
| 3X10 | 7.36** | 8.65 | 15.47** | 19.33 | 8.04** | 11.28 | -13.61** | 5.51 | -23.98** | 6.09 |
| 4X8 | -1.96 | 0.64 | -4.50** | 8.07 | -15.16** | 4.64 | 4.61** | -12.11 | 71.52** | 17.17 |
| 4 X9 | 4.03 | 11.28 | 6.24** | -6.29 | -20.69** | 2.21 | -11.67** | -24.57 | -29.21** | 8.58 |
| 4X10 | 0.36 | 9.05 | -9.05** | -3.75 | -7.45** | 14.56 | -17.01** | -22.84 | -5.68** | 0.29 |
| 5 X8 | -2.48 | 5.92 | 1.30 | 5.03 | -11.00** | 9.54 | -11.46** | -8.15 | 13.99** | 7.42 |
| 5X9 | 4.91 | 12.85 | -7.04** | 9.06 | -6.96** | 4.66 | -2.64** | -2.19 | 3.89** | 9.08 |
| 5 X10 | 5.20* | 5.36 | 1.85* | 3.64 | 00.56 | 10.12 | -14.06** | -1.84 | 24.08** | 6.26 |
| 6 X8 | 10.41** | 5.72 | -2.58** | -2.68 | 22.06** | 9.56 | 3.83** | 2.52 | 107.27** | 8.12 |
| 6X9 | 14.51** | 8.77 | -2.58** | -2.15 | 8.82** | 11.25 | -9.74** | 5.51 | -25.09** | 11.62 |
| 6X10 | 15.15** | 10.69 | 1.65* | 14.96 | 00.98 | 7.25 | -8.84** | 9.73 | 38.77** | 7.67 |
| 7X8 | 4.82 | 0.88 | 14.29** | 7.94 | 24.49** | 5.88 | 2.26** | 11.08 | 88.48** | 6.74 |
| 7X9 | 18.87** | 3.62 | -7.04** | 8.65 | 1.78 | 2.45 | -16.83** | 14.88 | -11.66** | 6.07 |
| 7X10 | 20.41** | 5.11 | -16.67** | 2.98 | 3.58 | 11.25 | -11.56** | 8.49 | 24.08** | 3.69 |
| Overall mean | 8.60 | 7.05 | 3.07 | 5.52 | -6.84 | 6.15 | -7.19 | -0.50 | 15.92 | 7.64 |

*,** Significant at 0.05 and 0.01 levels of probability, respectively.
1=Mansoura-1; 2=Kassasein-1;3=Kassasein-7; 4= Icarus; 5=Aquadulce; 6= ILB 4726; 7=Kobrosy 8= Nubaria-1 ; 9= Reina Mora ,and 10= Luz De Otono.

On the subject of seed number per pod and pod weight, 5 and 12 $F_1$ crosses gave positive significant heterosis values ranged from 0.70 to 8.51% and from 3.89 to 107.27 %, respectively, suggesting over-dominance for the high parent. The overall means of heterotic effect relative to high-parent were -7.19 and 15.92%, respectively, for these traits.

About the pod length and diameter, four $F_1$ crosses for each trait gave significant average degree of heterosis values ranged from 4.07 in the cross"1x8" to 18.58% in the cross" 2 x 8" for pod length and from 3.41 in the cross "5 x 10" to 8.25 in the cross "3 x 8" for pod diameter (Table 5), suggesting over-dominance for the high parents. Also, 16 and17 $F_1$ crosses gave negative significant heterosis values, suggesting partial-dominance. The overall means of heterotic effect relative to high-parent were -6.24 and - 5.79%, respectively.

Obtained average degree of heterosis values for seed index, number of pods per plant and total green pod yield (Table 5) showed that 6,9 and 10 crosses significantly surpass their respective high parents in these traits, respectively, suggesting over-dominance towards the high parents. Partial-dominance was detected in 4 $F_1$ crosses for seed index and 11 ones for number of seeds per pod. The overall means of heterosis effect relative to the high-parent were 0.21 for seed index, 5.80 for number of pods per plant and 20.86 for total green pod yield. Similar results were obtained by El-Hosary et al.,(1998), El-Tabbakh and Ibrahim (2000) and Farag and Helal (2004).

In the main, estimates of HP-heterosis showed over- dominance in 4 crosses for pod length, in 4 crosses for pod diameter, in 5 cross for number of seeds per pod, in 6 crosses for 100 green- seed weight, in 9 for number of pods per plant, in 10 for total green pod yield, in 12 crosses for pod weight, in 12 crosses for number of branch per plant, in 13 crosses for first pod height, and in 14 ones for plant height(Tables 4&5). Lastly, the crosses "5 x 10", "7 x 9" ," 5 x 9" and"1 x 8" gave the highest HP-heterosis values as 61.12, 9.62, 3.89, and 3.56% for total green pod yield, seed index , pod weight and number of pods per plant, respectively. While, in relation to the check cultivar, they gave significant heterosis values as 84.48, 22.94, 31.61 and 38.84%, for these traits, respectively.

Table 5: Average degree of heterosis (ADH %) based on high parent (Hp) and inbreeding depression (ID%) for yield and its components in broad bean crosses.

| Character | Pod length | | Pod diameter | | Seed index | | pod number/plant | | Total green pod yield | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cross | ADH% | ID% | ADH% | ID% | ADH% | ID% | ADH% | ID% | ADH% | ID% |
| 1X8 | 4.07** | 1.13 | -1.37** | -1.81 | -4.13 | 20.64 | 3.56** | 24.91 | 41.16** | 25.87 |
| 1X9 | -22.27** | 2.65 | -9.91** | -5.15 | 2.05 | 4.03 | 21.93** | 13.97 | 6.93 | 32.92 |
| 1X10 | -6.67** | 9.97 | -13.49** | 2.98 | 1.73 | 8.28 | 25.90** | 3.72 | -0.95 | 21.70 |
| 2 X8 | 18.58** | 4.01 | -2.23** | -15.79 | -13.76** | 0.56 | -38.17** | 9.66 | 18.04 | 21.18 |
| 2 X 9 | -13.30** | 8.37 | -17.87** | -3.97 | -4.43 | 13.46 | -9.62** | 21.72 | -1.47 | 20.56 |
| 2X 10 | 0.02 | -6.47 | -8.22** | 10.24 | 10.51* | 6.60 | 12.48** | 11.52 | -7.44 | 6.48 |
| 3X8 | 10.47** | 2.10 | 8.25** | 1.76 | -10.24* | 5.70 | -14.66** | 12.59 | 4.73 | 30.40 |
| 3X9 | -19.13** | 11.42 | -1.35** | -4.03 | -15.52** | 10.36 | -17.69** | 9.58 | 26.91 | 28.83 |
| 3X10 | -12.84** | -1.79 | -0.62** | -2.47 | -9.09 | 9.16 | -8.47** | 11.63 | -7.12 | 31.95 |
| 4X8 | -2.32** | 11.41 | -7.90** | 3.18 | -21.04** | 4.82 | -17.97** | 14.22 | 41.17** | 34.14 |
| 4 X9 | -18.83** | -4.26 | -14.41** | 7.68 | 1.06 | 3.97 | -6.85** | 5.47 | -3.01 | 21.51 |
| 4X10 | -2.98** | 8.69 | -7.29** | -16.37 | -7.80 | 6.56 | -1.17 | 7.49 | 39.91** | 23.22 |
| 5 X8 | 10.47** | 14.92 | 8.17** | -10.30 | 11.36* | 1.76 | -3.71** | 4.41 | 28.67* | 21.68 |
| 5X9 | -7.62** | 12.76 | 4.05** | 11.62 | 0.65 | 3.70 | 18.23** | 28.24 | 41.12** | 28.23 |
| 5 X10 | -4.74** | 8.52 | 3.41** | -6.13 | 10.12* | 3.19 | 11.16** | 29.95 | 61.12** | 25.97 |
| 6 X8 | 0.02 | 8.94 | -7.39** | -2.66 | 9.11 | 7.81 | -34.84** | 12.94 | 35.61* | 23.65 |
| 6X9 | -15.25** | 3.66 | -17.72** | 9.15 | 3.79 | 0.77 | 3.99** | 4.79 | -4.36 | 20.34 |
| 6X10 | -15.39** | -5.62 | -6.51** | 1.80 | 9.94* | 10.72 | -19.99** | 20.85 | 38.40** | 7.78 |
| 7X8 | -2.54 | 2.52 | -4.64** | -3.07 | 5.85 | 7.67 | -27.32** | 11.13 | 37.13* | 26.01 |
| 7X9 | -20.48** | 11.20 | -18.17** | 9.06 | 9.62* | 7.04 | 11.73** | 9.22 | 1.84 | 31.09 |
| 7X10 | -10.37** | -1.63 | -6.36** | -3.50 | 14.66** | 9.56 | 6.87** | 11.59 | 39.61** | 15.70 |
| Overall mean | -6.24 | 4.88 | -5.79 | -0.85 | 0.21 | 6.97 | 5.80 | 13.31 | 20.86 | 23.77 |

*,** Significant at 0.05 and 0.01 levels of probability, respectively.
1=Mansoura-1; 2=Kassasein-1;3=Kassasein-7; 4= Icarus; 5=Aquadulce; 6= ILB 4726; 7=Kobrosy 8= Nubaria-1 ; 9= Reina Mora ,and 10= Luz De Otono.

Relating to the inbreeding depression in Tables(4&5), it was noticeable that all crosses showed positive values for plant height, number of pods per plant, pod weight, seed index and total green pod yield. It ranged from 0.64 to 13.18, from 3.72 to 29.95; from 0.29 to 17.17, from 0.56 to 20.64 and from 6.48 to 34.14 %, respectively. The remaining traits showed positive and negative

ID%. The results of heterosis and inbreeding depression were supported by Bargale and Billore (1990), El-Refaey (1999), Farag and Helal(2004), Rabie et al., (2004), Farag and Darwish(2005) and Attia et al., (2006 ).

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# تاثيرات التهجين على محصول الفـول الرومي ومكوناتة

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## الملخص العربي

بمزرعة الجميزة البحثية / محافظة الغربية والتابعة لمركز البحوث الزراعية؛ أجريت هذه الدراسة خلال المواسم الشتوية 2005/04، 2006/05، 2007/06 ، وذلك لقياس تأثيرات القدرة على الائتلاف وقوة الهجين ودرجة السيادة لبعض الصفات الهامة في الفول الرومي والتدهور الناتج عن التربية الداخلية بهدف تحسين هذه الصفات بالتربية. لقد أجرى التهجين بين سبعة آباء(أمهات) وثلاثة آباء(ملقحات) بنظام التلقيح القمى لإنتاج بذور الجيل الأول . وفى الموسم الثاني تم زراعة الأباءالعشره مع هجن الجيل الاول(21 هجينا) للتقييم ودراسة السلوك الوراثي وإنتاج بذور الجيل الثاني . في الموسم الأخير زرعت الآباء وهجن الجيل الأول وعشائر الجيل الثاني لدراسة عشرة صفات من الصفات الهامة في الفول الرومى .

وتتلخص النتائج بعد تحليلها تبعا لطريقة كيمثورن 1957 فيما يلي :

وجدت اختلافات معنوية بين التراكيب الوراثية فى جميع الصفات التي درست ، كما أوضحت حسابات القدرة العامة والخاصة على الائتلاف أن التأثير الجينى المضيف والغير مضيف كان معنويا فى وراثة معظم الصفات التي درست . أظهرت حسابات النسبة بين متوسط مربعات الانحرافات للقدرة العامة والخاصة للائتلاف ان فعل الجينات المضيفة يلعب دوراً أساسياً فى وراثة جميع الصفات فيما عدا صفة عدد القرون/ نبات والمحصول الكلى الطازج ، بالمقارنه بتأثير الجينات الغير مضيف مما يتيح التحسين لمعظم هذه الصفات بالتربية عن طريق الانتخاب.

أوضحت حسابات تأثيرات القدرة العامة على الائتلاف ان أفضل الأباء هو رينا مور , ليوز دى أوتون، نوباريه -1 و أكوادولسى . بينما أوضحت حسابات القدرة الخاصة على

الائتلاف ان الهجين القمى " قصاصين -1 × , ليوز دى أوتون " و" قصاصين-7 X رينا مورا " هما الأفضل في الصفات الهامه للمحصول ومكوناته .

لقد كانت درجة قوة الهجين على أساس الأب الأفضل معنوية وموجبةاو سالبة بالنسبه للاب الاعلى او الافضل لكل الصفات التى درست.كما وجدت سيادة فائقه تجاه الاب الاعلى فى 5 هجن بالنسبة لصفةعدد البذور بالقرن، وفى 6 هجن بالنسبه لوزن 100 بذرة و فى 9 هجن بالنسبة لصفة عدد القرون /نبات ، وفى 12 هجين بالنسبة لصفة وزن القرن و فى 10 هجن للمحصول الكلى من القرون الخضراء حيث أعطت قيم موجبة معنوية. لقد تفوقت الهجن جميعا على الأب الاعلى بنسبة20.86% فى اعطاء اعلى محصول كلى من القرون الخضراء. وبمقارنة افضل الهجن بالصنف الكنترول وجد ان الهجين" أكوادولسى X رينا مورا" تفوق بنسبه31.61% فى وزن القرن , و الهجين " قبرصى X رينا مورا" تفوق بنسبه 22.94% فى دليل البذره , والهجين "منصوره-1 X نوباريه-1" تفوق بنسبه 38.84% فى عدد القرون لكل نبات , كما تفوق الهجين " أكوادولسى X ليوز دى اوتون " بنسبه 84.48% في إنتاج أعلى محصول كلى من القرون . وبالنسبة للتدهور الناتج عن التربية الداخلية فان قيم التدهور كانت موجبة لصفات طول النبات وعدد القرون /نبات ومتوسط وزن القرن و وزن 100 بذرة ومحصول القرون الخضراء، مما يشير الى ان بذور الجيل الثانى لاتصلح للاستخدام فى الانتاج التجارى للفول الرومى .