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INVESTIGATIONS ON FABA BEANS, *Vicia faba* L. 27. PERFORMANCE AND BREEDING PARAMETERS OF SIX PARENTS AND THEIR HYBRIDS

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ABSTRACT

Six diverse faba bean genotypes, Triple White, Nubaria 1, Cairo 3 Im, Cairo 25, Cairo 5 and Cairo 4 were used as parents in complete diallel mating design to estimate different sources of genetic variability and other derived genetic parameters for flowering, yield and its components.

Results showed highly significant differences among genotypes for all studied traits. The magnitude of variance due to parents was higher than crosses and parents vs crosses for first podded node, number of pods/main stem and number of seeds/main stem. On the other hand, parents vs crosses possessed higher magnitude for all studied traits except first podded node, number of pods/main stem and number of seeds/main stem.

Mean squares due to general combining ability were significant for all studied traits. On the other hand, specific combining ability was highly significant for four traits; flowering date, plant height, plant dry weight and number of branches/plant. Reciprocals showed significant for all studied traits except first podded node, number of pods/main stem, number of seeds/main stem, seed yield/main stem and 100-seed weight.
The parental line Cairo 3 Im gave the desirable GCA effects for all studied traits except plant height, plant dry weight, number of branches/plant, first podded node and 100-seed weight. Results showed that the parental line Cairo 25 possessed the favorable GCA effects for all studied traits except plant height, branches/plant, number of seeds/plant and 100-seed weight.

For seed yield/plant, only two crosses Triple White x Cairo 3 Im and Nubaria 1 x Cairo 25 exhibited significant positive SCA. Estimates values of genetic components revealed that additive genetic variance (D) was significant for all studied traits. The estimates of K_D/K_R were greater than one for all studied traits except number of pods/plant, number of seeds/plant, seed yield/plant and 100-seed weight. Narrow sense heritability was more than 50.0 % for traits; flowering date, first podded node, number of pods/main stem, number of pods/plant and 100-seed weight.

Key words: ***Faba bean, Vicia faba, Combining ability, Additive genetic variance, Narrow sense heritability.***

INTRODUCTION

Faba bean *Vicia faba* L. is an important legume crop in Egypt, due to its high nutritive value in both energy and protein content, and its use as a break crop in intensive cereal systems. The importance of faba bean in Egypt lies not only in its multiple uses in preparing diverse local dishes but also to its important role in the crop rotation (Darwish and Abdalla 1997).

Success of any breeding program depends upon the presence of sufficient genetic variability among genotypes under investigation to permit effective selection. There are many designs to determine type of gene action, i.e. diallel cross, six population method, etc.... Seed yield is a complex trait and is quantitatively inherited with low heritability value, (Bond 1966, Kambal 1969 and Yassin 1973). Therefore, yield itself may not be the best criterion for selection, so that breeding for high yielding ability is associated with yield and its components *viz*, number of pods/plant, number of seeds/plant and 100-seed weight (Rowlands 1955)

The performance of F_1 hybrids in comparison with that of the parents provides the first opportunity in the sequence of events in hybrid populations to obtain information on gene action. Superiority of hybrids over their mid and better parents is usually due to some types of gene action and dominance effects.

Faba bean is known as a partially cross-pollinated crop with natural outcrossing ranged from 30-60 % depending on genetic, environmental, insect pollinator factors and their interactions. Such natural breeding system resulted in some plants in the same variety/field are crossbreds and others are inbreds. Heterozygosity and heterogeneity could improve yield performance and stability (Stelling *et al* 1994 and Darwish *et al* 2001).

Hybridization offers new recombinations and for exploiting genetic variability particularly between divergent material that could be useful for releasing raw material for selection (Abdalla and Fischbeck 1983). Diallel crosses have been frequently used for analyzing the combining ability and gene action of faba bean breeding material. However, diallel mating design provides unbiased estimates of different genetic components under the assumption of the absence of epistatic effects (Cockerham 1961).

Combining ability analysis helps the breeder to identify the best combiners which may be hybridized either to exploit heterosis or to build up the favorable fixable genes.

The present study was conducted to elucidate gene action, combining ability, genetic components using diallel mating designs of six faba bean diverse lines for earliness, yield and its components.

MATERIALS AND METHODS

The field trials of this investigation were carried out at the Research Station, Faculty of Agriculture, Cairo University, Giza during 2008/09 and 2009/10 seasons. Six diverse faba bean lines Triple White, Nubaria 1, Cairo 3 Im, Cairo 25, Cairo 5 and Cairo 4 were used as parents in a diallel mating design including reciprocals in 2008/2009. In 2009/2010, the parents and their F_1's were grown in a randomized complete block design with two replications. The experimental plot consisted of 3 and 1 ridges for each parents and F_1, respectively. Each ridge was 3 m long and 60 cm apart.

Seeds were sown at one side of ridges at 20 cm distance. The origin and some features of the parental lines are presented in Table (1). The history of Cairo genotypes are documented in Abdalla and Darwish (2004) and Abdalla and Darwish (2008).

Table 1. Origin, pedigree and features of the six parental genotypes.

Genotype	Origin	Features
Triple White(P_1)	FCRI	Small seeds, colourless hilum and seeds
Nubaria 1 (P_2)	FCRI	Large-seeded, foliar disease resistant, coluorless - hilum seed and late in maturity
Cairo 3 Im. (P_3)	ADFACU	Medium seeds, colourless hilum
Cairo 25 (P_4)	ADFACU	Medium seeds, tolerant to *Orobanche*
Cairo 5 (P_5)	ADFACU	Medium seeds, tolerant to *Orobanche*
Cairo 4 (P_6)	ADFACU	Medium seeds, tolerant to *Orobanche*

ADFACU = Agron. Dept. Fac. Agric. Cairo Univ., FCRI = Field Crops Research Institute, ARC, Giza

General (GCA) and specific (SCA) combining ability of single crosses were conducted in two successive steps using Method I Model I of Griffing (1956). The first step is the testing of genotypic differences (null hypothesis) among the parents and the F_1's. The second step, i.e. combining ability analysis was conducted in the existence of significant differences among the tested genotypes. Genetic parameters were estimated using Hayman's approach developed by Jinks (1954), Hayman (1954) and Mather and Jinks (1971). Data were statistically analyzed on plot mean basis.

RESULTS AND DISCUSSION

Results of statistical analysis presented in Table (2) revealed highly significantly differences among tested genotypes for all studied traits except number of seeds/main stem and seed yield/main stem, indicating genetic variability of parents for these traits. The magnitude of variance due to parents was higher than both crosses and parents *vs* crosses for first podded node, number of pods/main stem and number of seeds/main stem. However, parents *vs* crosses possessed higher mean squares than parental genotypes and crosses for majority of studied traits which indicated pronounced heterosis for these traits.

The general combining ability analysis of diallel cross that performed in the existence of significant genotypic variance showed that both additive and non-additive gene effects were operating in the heredity of all studied traits. These results were in harmony with the results obtained by Poulsen (1977), Attia and Salem (2006) and El-Hady *et al* (2009).

The specific combining ability variances were insignificant for all studied traits except for flowering, plant height, plant dry weight and

Table 2. Significance of mean squares due to different sources of variation for six faba bean genotypes and their crosses.

SOV	df	Flowering date	Plant height	Plant dry weight	Branches /plant	First pod node	No. pods/ main stem.	No. seed/ main stem	Seed yield/ main stem	No. pods/ plant	No. seeds/plant	Seed yield/plant	100-Seed weight
Genotypes	35	24.965 **	93.472 **	134.473 **	0.614 **	9.125 **	1.814 *	9.519 ns	4.319 ns	11.985 **	74.148 **	34.572 *	306.483 **
Parents(P)	5	48.88**	100.82**	100.82ns	0.97**	16.36**	3.97**	18.14*	7.53ns	7.85ns	47.58ns	30.65ns	517.06**
Crosses (C)	29	19.77**	81.75**	115.45**	0.51**	8.00**	1.49*	8.36ns	3.82ns	12.29**	72.12**	28.71**	258.42**
P vs C	1	56.01**	396.69**	854.39**	1.97**	5.55ns	0.39ns	0.07ns	2.63ns	23.87*	265.91**	224.16**	647.35**
GCA	5	49.472 **	90.199 **	84.142 **	0.924 **	17.181 **	3.822 **	18.273 **	7.143 **	17.89 **	82.412 **	26.159 *	841.192 **
SCA	15	7.227 **	42.101 **	61.961 **	0.218 **	2.653ns	0.605 ns	3.496 ns	1.73 ns	3.481 ns	24.181 ns	14.409 ns	54.044 ns
Reciprocals	15	5.408**	36.883**	66.878**	0.190*	2.267ns	0.237ns	1.518ns	0.928ns	4.539*	34.855*	17.206*	23.122ns
Error	35	1.24	20.99	43.90	0.15	2.98	0.87	5.72	[illegible]	3.77	27.18	15.86	64.80

ns, * and ** indicates insignificant, significant and highly significant at 0.05 and 0.01 level of probability, respectively.

number of branches/plant. On the other hand, variances due to reciprocal variances were significant for all studied traits except first podded node, number of pods/main stem, number of seeds/main stem, seed yield/main stem and 100-seed weight.

The mean performance of parents and crosses are presented in Table (3). Cairo 5 was the earliest parent for flowering (48.0 days) with insignificant differences from all parents except Nubaria 1 (61.5 days). Triple White possessed the highest values for number of pods/main stem and number of seeds/main stem. On the other hand, Triple White exhibited the lowest values for plant height, plant dry weight, number of branches/plant, seed yield/plant and 100-seed weight. These results may be due to the Triple White is an introduced entry that has not been subjected to any improvement methods. Also results revealed that Cairo 3 Im possessed the highest values for seed yield/main stem, number of pods, number of seeds and seed yield/plant.

For flowering date, crosses P_1 x P_5 and P_4 x P_5 possessed the earliest crosses (47.5 and 49.0 days, respectively) with significant differences with the majority of crosses. Cross P_3 x P_1 exhibited the good performance for the traits plant dry weight, number of pods/plant, number of seeds/plant and seed yield/plant with values (46.8g, 15.56, 36.7 and 23.4g, respectively). Cross P_3 x P_2 possessed the heaviest 100-seed weight (102.0 g) and significantly different for most of studied crosses.

Percent increase for crosses from its parents ranged from -10.24% for number of pods/main stem to 50.92% for seed yield/plant, which indicating that the hybridization is playing an important role for increasing the performance of the hybrids comparing with its parents. These results are in accordance with those obtained by Soliman (2006).

The percentage of single crosses superiority over parental genotypes were pronounced being (43.26, 17.95, 17.78, 26.25, 33.80, 50.92 and 11.55 %) for plant dry weight, number of branches/plant, seed yield/main stem, number of pods/plant, number of seeds/plant, seed yield/plant and 100-seed weight, respectively

Estimation of general combining ability effects of the six parents for studied traits is given in Table (4). For flowering date, all parental lines exhibited significant favorable effect except Nubaria 1 and Triple white. For plant height only Cairo 4 possessed highly significant desirable effects (4.13) for this trait. For plant dry weight, Cairo 25 and Cairo 4 possessed significant favorable effect (2.81 and 2.47, respectively). On the other hand, Triple white possessed highly significant negative effects for this trait (-4.18). For number of branches/plant, only two parents Nubaria 1 and Cairo 4 exhibited significant effects (0.400 and 0.051 in the same order). Whereas, the remaining parents; Triple White, Cairo 25 and Cairo 5 possessed significant negative effects for this trait. For first podded node, only three

Table 3. Mean performance of parents and their crosses for different traits.

Genotype	Flowering date (day)	Plant height (cm)	Plant dry weight (g)	Branches /plant	First pod. node	No. pods/main stem..	No. seed/main stem	Seed yield/ main stem (g)	No. pods/ plant	No. seeds/ plant	Seed yield/ plant (g)	100-Seed weight (g)
Triple White(P_1)	60.5	59.5	9.0	1.2	8.6	3.9	7.7	3.2	4.5	9.0	3.8	41.8
Nubaria 1 (P_2)	61.5	73.9	17.5	3.0	1.1	0.2	0.3	0.3	2.4	5.4	4.9	90.7
Cairo 3 Im. (P_3)	50.5	70.5	26.3	2.6	6.1	2.9	6.0	4.8	7.7	17.1	13.4	78.1
Cairo 25 (P_4)	49.5	74.5	22.6	2.3	8.1	2.3	5.2	3.5	6.4	15.8	11.0	69.4
Cairo 5 (P_5)	48.0	77.8	24.2	2.3	7.1	2.7	6.5	4.6	6.8	16.3	11.3	68.4
Cairo 4 (P_6)	49.5	79.3	28.8	3.2	3.7	0.7	1.2	0.7	7.1	16.1	11.1	69.2
Mean of parents	51.6	72.6	21.4	2.4	5.9	2.1	4.5	2.9	5.8	13.3	9.3	69.6
$P_1 \times P_2$	58.5	71.5	18	2.6	2.9	0.6	1.3	1.2	3.7	8.9	8.1	90.8
$P_1 \times P_3$	49.5	70.8	18.1	2.1	6.5	2.4	5.1	3.1	6.3	14.5	8.8	61.1
$P_1 \times P_4$	52.5	73.8	26.0	2.5	10.8	2.2	4.7	3.0	8.0	18.4	12.3	67.5
$P_1 \times P_5$	53.0	82.3	21.0	2.2	9.2	1.7	2.9	1.9	5.5	12.[illegible]	7.[illegible]	63.3
$P_1 \times P_6$	50.5	82.5	21.5	2.0	9.3	2.7	7.0	4.7	6.0	14.8	10.0	67.6
$P_2 \times P_3$	58.0	78.0	2[illegible]	3.1	4.6	1.0	2.8	2.5	5.3	14.0	11.6	82.6
$P_2 \times P_4$	57.0	82.9	43.3	3.5	6.7	1.3	3.6	3.4	6.8	20.8	19.7	95.1
$P_2 \times P_5$	55.0	74.4	31.4	4.0	2.1	0.4	1.4	0.9	4.9	13.8	12.6	90.2
$P_2 \times P_6$	56.5	79.8	24.5	3.3	4.2	0.5	1.2	1.1	4.0	10.4	9.4	90.4
$P_3 \times P_4$	50.0	83.3	25.7	2.6	6.6	1.9	3.8	3.9	6.6	14.8	12.7	83.9
$P_3 \times P_5$	47.5	75.5	30.3	2.6	9.1	2.1	6.5	3.4	8.3	21.5	14.3	67.1
$P_3 \times P_6$	50.5	78.0	29.2	2.9	6.9	1.5	3.7	3.3	7.6	19.3	14.2	72.9
$P_4 \times P_5$	49.0	83.5	34.7	2.6	6.6	2.4	5.7	3.7	8.0	21.4	14.9	70.7
$P_4 \times P_6$	55.5	86.3	45.1	3.6	6.9	2.5	5.3	3.9	10.5	23.7	17.5	76.1
$P_5 \times P_6$	54.5	78.4	29.2	2.9	9.1	2.6	6.2	4.3	8.4	19.1	14.0	72.7
$P_2 \times P_1$	57.0	84.3	32.5	3.5	5.6	1.2	3.3	2.8	5.9	16.4	14.0	85.4
$P_3 \times P_1$	58.0	80.8	46.8	3.5	7.2	2.8	6.8	4.2	15.5	36.7	23.4	63.3
$P_4 \times P_1$	51.0	68.6	34.2	2.5	8.3	2.1	6.2	3.6	9.1	23.5	15.7	66.7
$P_5 \times P_1$	57.5	75.7	23.8	2.6	5.7	1.4	3.4	2.0	7.7	19.2	12.2	65.0
$P_6 \times P_1$	52.0	77.8	38.6	2.8	5.3	3.0	7.7	5.3	10.4	26.4	18.3	68.9
$P_3 \times P_2$	56.0	80.3	33.9	3.4	3.7	0.7	2.0	1.6	5.7	15.8	15.9	102.0
$P_4 \times P_2$	59.5	87.9	33.8	3.3	5.7	0.8	1.9	1.9	4.9	12.9	12.7	97.8
$P_5 \times P_2$	54.5	77.1	27.5	3.4	6.6	2.3	5.0	4.0	5.4	13.4	11.1	84.4
$P_6 \times P_2$	56.0	85.3	28.0	2.9	4.6	0.7	1.8	1.4	4.4	12.9	12.1	91.8
$P_4 \times P_3$	53.0	80.7	35.9	2.9	7.0	2.5	6.5	4.8	8.6	23.4	17.3	74.4
$P_5 \times P_3$	51.5	69.7	33.6	3.0	7.7	2.8	7.1	5.0	10.5	28.3	18.1	68.7
$P_6 \times P_3$	53.5	84.0	29.1	2.2	7.0	2.4	5.9	5.2	7.4	18.2	14.9	81.9
$P_5 \times P_4$	53.0	60.0	19.9	2.3	4.6	2.3	5.6	3.8	6.0	12.1	9.3	76.4
$P_6 \times P_4$	55.5	89.0	39.0	2.7	6.8	3.0	7.3	5.1	9.3	24.2	17.7	73.4
$P_6 \times P_5$	53.0	85.0	37.2	2.6	8.8	3.2	7.6	5.7	9.6	24.3	18.7	77.1
Mean of crosses	54.0	78.9	30.6	2.9	6.5	1.9	4.6	3.4	7.3	18.4	14.0	77.6
[illegible]	[illegible]	[illegible]	43.26	17.95	12.95	10.24	2.08	17.78	28.26	[illegible]	60.92	[illegible]
LSD 0.05	2.65	10.91	15.73	0.82	4.11	2.22	5.70	4.27	4.62	12.42	9.48	19.57

Table 4. Estimates of the relative general combining ability effects (g_i) of parental lines in the F_1 generation for studied traits.

Parent	Flowering date (day)	Plant height (cm)	Plant dry weight (g)	Branches /plant	First pod. node	No. pods/ main stem.	No. seeds/ main stem	Seed yield/ main stem (g)	No. pods/ plant	No. seeds/ plant	Seed yield/ plant (g)	100-Seed weight (g)
Triple White (P_1)	-0.18ns	-3.90**	-4.18**	-0.407**	0.90**	0.41**	0.67**	-0.09ns	0.17ns	-0.17ns	-1.68**	-11.03**
Nubaria 1 (P_2)	4.03**	1.28ns	-1.19ns	0.460**	-2.33**	-1.12**	-2.48**	-1.50**	-2.42**	-5.06**	-1.78**	14.68**
Cairo 3 Im. (P_3)	-1.18**	-0.99ns	1.07ns	-0.007ns	0.14ns	0.22**	0.53**	0.62**	1.01**	2.30**	1.65**	-0.12ns
Cairo 25 (P_4)	-0.64*	0.86ns	2.81*	-0.032**	0.76**	0.20**	0.44*	0.40**	0.46**	1.33ns	1.14*	0.43ns
Cairo 5 (P_5)	-1.51**	-1.39ns	-0.98ns	-0.065**	0.58**	0.28**	0.72**	0.39**	0.23*	0.40ns	-0.24ns	-3.61ns
Cairo 4 (P_6)	-0.51*	4.13**	2.47*	0.051**	-0.04 ns	0.02 ns	0.12 ns	0.17 ns	0.55[illegible]	1.21 ns	[illegible]	[illegible]
S.E. gi	0.29	0.85	1.24	0.005	0.10	0.03	0.20	0.11	0.13	0.94	0.55	2.25
S.E. (gi- gj)	0.46	1.32	1.91	0.013	0.25	0.07	0.48	0.27	0.31	2.27	1.32	5.40

ns, * and ** indicates insignificant, significant and highly significant at 0.05 and 0.01 level of probability, respectively.

parental lines (Triple White, Cairo 25 and Cairo 5) exhibited significant positive effects. On the other hand, Nubaria 1 possessed the significant negative effect for this trait. For number of pods/main stem, four parents; Triple White, Cairo 3 Im, Cairo 25 and Cairo 5 out of six showed significant positive effects (0.41, 0.22, 0.20 and 0.28 in the same order). For traits number of pods/main stem, number of seeds/main stem and seed yield/main stem; three parental lines (Cairo 3 Im, Cairo 25 and Cairo 5) exhibited significant positive effects for these traits. For number of seed/plan and seed yield/plant, only one parental line (Cairo 3 Im) exhibited significant positive effects (2.30 and 1.65, respectively). These results were in accordance with those obtained by Mahmoud (1977), Poulsen (1977), Abdalla *et al* (1999) and Attia *et al* (2002).

From the previous mentioned results it could be concluded that the investigated parents showed variable GCA effects in direction and magnitude that greatly varied between traits. However, generally, Cairo 3 Im and Cairo 25 are good combiners for most of studied traits.

Estimates of the specific combining ability effects in the six diallel crosses for the studied traits are shown in Table (5). For flowering date, results revealed that five out of 15 crosses P_1 x P_4 , P_1 x P_6 , P_2 x P_5 , P_2 x P_6 and P_3 x P_5, showed significant negative SCA effects (-0.986, -1.611, -1.319, -0.819 and -1.361, respectively). For plant height, only 4 crosses out of 15 (P_1 x P_5, P_2 x P_4, P_3 x P_4 and P_4 x P_6), exhibited significant positive SCA effects (6.449, 5.444, 4.290 and 4.344, respectively). For plant dry weight, only 3 crosses (P_1 x P_3, P_2 x P_4 and P_4 x P_6) possessed significant positive SCA effects (6.524, 7.844 and 7.678, in the same order). For number of branches/plant 3 crosses (P_1 x P_3, P_2 x P_5 and P_4 x P_6) possessed significant positive SCA effects (0.403, 0.519 and 0.319, in the same order). Concerning first podded node, four crosses (P_1 x P_4, P_2 x P_4, P_3 x P_5 and P_5 x P_6) possessed significant positive SCA effects (1.358, 1.383, 1.296 and 2.025, respectively). Only one cross P_1 x P_6 exhibited significant positive SCA effects (1.989 and 1.646, respectively) for number of seeds/main stem and seed yield/main stem. For number of pods and number of seeds/plant only two crosses (P_1 x P_3 and P_4 x P_6) possessed significant positive SCA effect (2.617; 5.860 and 1.808; 3.826, respectively). For seed yield/plant, two crosses (P_1 x P_3 and P_2 x P_4) possessed significant positive SCA effect (2.975 and 3.665, in the same order). For 100-seed weight, only one cross P_1 x P_2 exhibited highly significant positive SCA effect (8.156).

Estimates of the reciprocals effects in the six diallel crosses for the studied traits are shown in Table (6). For flowering date, results revealed that seven out of 15 crosses P_3 x P_1 , P_5x P_1 , P_4x P_2 , P_4 x P_3, P_5 x P_3, P_6 x P_3 and P_5 x P_4 , showed significant negative effects (-4.25, -2.25, -1.25, -1.50, -2.00, -1.50 and -2.00, respectively). For plant height and plant dry weight, only one cross (P_5 x P_4), exhibited significant positive effects (11.75 and

Table 5. Estimates of specific combining ability effects (S_{ij}) of diallel crosses for studied traits.

Cross	Flowering date	Plant height	Plant dray weight	Branches /plant	First pod node	No. pods /main stem..	No. seeds /main stem	Seed yield/ main stem	No. pods /plant	No. seeds /plant	Seed yield /plant	100-Seed weight
P_1 x P_2	0.347 ns	2.674 ns	1.565 ns	0.161 ns	-0.754 ns	-0.319 ns	-0.440 ns	0.283 ns	-0.008 ns	0.322 ns	1.328 ns	8.156*
P_1 x P_3	1.556**	2.844 ns	6.524*	0.403**	-0.596 ns	0.064 ns	0.176 ns	-0.160 ns	2.617**	5.860**	2.975*	-2.944 ns
P_1 x P_4	-0.986*	-3.522*	2.407 ns	0.178 ns	1.358*	-0.365 ns	-0.690 ns	-0.276 ns	0.842 ns	2.206 ns	1.363 ns	1.422 ns
P_1 x P_5	3.389**	6.449**	-1.497 ns	0.061 ns	-0.413 ns	-1.049**	-2.840**	-1.628*	-0.900 ns	-2.194 ns	-1.372 ns	2.494 ns
P_1 x P_6	-1.611**	2.074 ns	2.674 ns	-0.031 ns	0.033 ns	0.518 ns	1.989*	1.646*	0.371 ns	2.026 ns	1.769 ns	3.347 ns
P_2 x P_3	0.597 ns	1.011 ns	1.236 ns	-0.014 ns	-0.046 ns	-0.232 ns	-0.219 ns	-0.327 ns	-0.171 ns	0.076 ns	0.670 ns	1.387 ns
P_2 x P_4	1.306**	5.444**	7.844**	0.236 ns	1.383*	0.039 ns	0.239 ns	0.490 ns	0.729 ns	3.072 ns	3.665*	5.051 ns
P_2 x P_5	-1.319**	-1.935 ns	2.565 ns	0.519**	-0.313 ns	0.256 ns	0.414 ns	0.290 ns	0.288 ns	0.697 ns	0.623 ns	-0.075 ns
P_2 x P_6	-0.819*	-0.710 ns	-4.064 ns	-0.197 ns	0.358 ns	-0.253 ns	-0.707 ns	-0.706 ns	-0.992 ns	-2.082 ns	-1.564 ns	0.473 ns
P_3 x P_4	-0.236 ns	4.290**	-2.172 ns	0.003 ns	-0.508 ns	-0.153 ns	-0.394 ns	0.060 ns	-0.971 ns	-2.140 ns	-0.943 ns	2.548 ns
P_3 x P_5	-1.361**	-2.814 ns	2.799 ns	0.086 ns	1.296*	0.039 ns	0.481 ns	-0.065 ns	1.063 ns	3.610 ns	1.615 ns	-4.660 ns
P_3 x P_6	0.139 ns	0.011	-3.456 ns	-0.306*	0.417 ns	-0.244 ns	-0.390 ns	0.196 ns	-1.142 ns	-2.344 ns	-1.192 ns	1.611 ns
P_4 x P_5	-0.403 ns	-5.531**	-3.643 ns	-0.264 ns	-2.150**	-0.090 ns	-0.086 ns	-0.303 ns	-0.763 ns	-2.544 ns	-1.992 ns	0.384 ns
P_4 x P_6	3.097**	4.344*	7.678**	0.319*	-0.229 ns	0.601 ns	1.168 ns	0.626 ns	1.808*	3.826*	2.384 ns	-1.613 ns
P_5 x P_6	2.222**	1.115 ns	2.649 ns	-0.047 ns	2.025**	0.693*	1.518 ns	1.156 ns	1.092 ns	2.501 ns	2.509 ns	2.534 ns
Standard error												
S_{ij}	0.474	1.947	2.815	0.166	0.734	0.396	1.017	0.761	0.824	2.215	1.692	3.420
S_{ij} - S_{ik}	0.720	2.958	4.277	0.252	1.115	0.602	1.545	1.157	1.252	3.365	2.571	5.196
S_{ij} - S_{kl}	0.644	2.645	3.825	0.225	0.997	0.538	1.382	1.034	1.120	3.010	2.299	4.647

ns, * and ** indicates insignificant, significant and highly significant at 0.05 and 0.01 level of probability, respectively.

Table 6. Estimates of specific combining ability effects (R_{ij}) of diallel crosses for studied traits.

Cross	Flowering date	Plant height	Plant dray weight	Branches /plant	First pod. node	No. pods /main stem..	No. seeds /main stem	Seed yield/ main stem	No. pods /plant	No. seeds /plant	Seed yield /plant	100-Seed weight
$P_2 x P_1$	0.75 ns	-6.375**	-7.23*	-0.450*	-1.350 ns	-0.300 ns	-1.000 ns	-0.823 ns	-1.075 ns	-3.70 ns	-2.908 ns	2.705 ns
$P_3 x P_1$	-4.25**	-5.025*	-14.35**	-0.675**	-0.375 ns	-0.225 ns	-0.875 ns	-0.555 ns	-4.625**	-11.10**	-7.285**	-1.110 ns
$P_4 x P_1$	0.75 ns	2.500 ns	-4.08 ns	-0.025 ns	1.050 ns	0.025 ns	-0.275 ns	-0.325 ns	-0.550 ns	-2.58 ns	-1.655 ns	0.380 ns
$P_5 x P_1$	-2.25**	3.275 ns	-1.43 ns	-0.225 ns	1.750*	0.125 ns	-0.250 ns	-0.030 ns	-1.125 ns	-3.60 ns	-2.363 ns	-0.873 ns
$P_6 x P_1$	-0.75 ns	2.375 ns	-8.60**	-0.400*	1.975*	-0.175 ns	-0.375 ns	-0.283 ns	-2.225**	-5.83*	-4.145*	-0.650 ns
$P_3 x P_2$	1.00*	-1.125 ns	-3.70 ns	-0.125 ns	0.450 ns	0.150 ns	0.425 ns	0.428 ns	-0.200 ns	-0.93 ns	-2.188 ns	-9.710*
$P_4 x P_2$	-1.25*	-2.500 ns	4.75 ns	0.100 ns	0.500 ns	0.300 ns	0.850 ns	0.730 ns	0.950 ns	3.95 ns	3.535*	-1.348 ns
$P_5 x P_2$	0.25 ns	-1.375 ns	1.93 ns	0.300 ns	-2.225**	-0.950*	-1.800 ns	-1.558*	-0.275 ns	0.20 ns	0.690 ns	2.888 ns
$P_6 x P_2$	0.25 ns	-2.725 ns	-1.75 ns	0.250 ns	-0.225 ns	-0.975*	-0.275 ns	-0.195 ns	-0.175 ns	-1.23 ns	-1.330 ns	-0.665 ns
$P_4 x P_3$	-1.50**	1.275 ns	-5.10 ns	-0.150 ns	-0.225 ns	-0.300 ns	-1.325 ns	-0.420 ns	-1.025 ns	-4.30 ns	-2.283 ns	4.785 ns
$P_5 x P_3$	-2.00**	2.875 ns	-1.63 ns	-0.200 ns	0.700 ns	-0.375 ns	-0.775 ns	-0.828 ns	-1.075 ns	[illegible]	[illegible]	[illegible]
$P_6 x P_3$	-1.50**	[illegible]	[illegible]	0.325 ns	-0.050 ns	-0.475 ns	-1.150 ns	-0.935 ns	0.050 ns	0.53 ns	-0.398 ns	-4.498 ns
$P_5 x P_4$	-2.00**	11.750**	7.38*	0.125 ns	-0.050 ns	0.025 ns	0.025 ns	-0.035 ns	1.000 ns	4.65*	2.808 ns	-2.845 ns
$P_6 x P_4$	0.00 ns	-1.850 ns	3.00 ns	0.425*	0.025 ns	-0.200 ns	-0.975 ns	-0.603 ns	0.600 ns	-0.28 ns	-0.140 ns	1.358 ns
$P_6 x P_5$	0.75 ns	-3.325 ns	-3.98 ns	0.125 ns	0.150 ns	-0.275 ns	-0.700 ns	-0.715 ns	-0.600 ns	-2.63 ns	-2.363 ns	-2.210 ns
Standard error												
R_{ij}	0.557	2.291	3.313	0.195	0.864	0.466	1.197	0.896	0.970	2.607	1.991	4.024
$R_{ij} - R_{kl}$	0.788	3.239	4.685	0.276	1.221	0.660	1.693	1.267	1.372	3.687	2.816	5.692

ns, * and ** indicates insignificant, significant and highly significant at 0.05 and 0.01 level of probability, respectively.

7.38, respectively). For number of branches/plant one cross (P_6 x P_4) possessed significant positive effects (0.425). For first podded node, two crosses (P_5 x P_1 and P_6 x P_1) possessed significant positive effects (1.750 and 1.975 respectively). For number of seeds/plant only one cross out of 15 crosses (P_5x P_4) possessed significant positive effect (4.65). For seed yield/plant, one cross (P_4 x P_2) possessed significant positive effect (3.535).

Estimate values of genetic components and ratios are presented in Table (7). Results showed that the additive genetic variance (D) was significant for all studied traits. This result gave evidence that additive genetic and was more important than dominance for the traits. The covariance of additive and dominance effects overall arrays (F) was significantly different from zero in the positive direction for number of branches/plant, indicating the presence of dominance alleles in the parents. For other traits, no conclusions could be drawn regarding the relative frequency of dominance *vs* recessive alleles in the parents.

The components of H_1 and H_2 were significantly different from zero for most of studied traits. Theoretically, H_2 should be equal to or less than H_1 (Hayman 1954). H_1 was greater than H_2 indicated that the positive and negative alleles at the loci were not equal in proportion in the parents. Since D was greater than H_1 for flowering date, number of branches/plan, first podded node, number of pods/main stem, number of seeds/main stem, seed yield/main stem, suggesting that additive genetic variance was more important. However, the remaining traits showed higher values of H_1 than D, indicating the important part of dominance genetic variance. These results are in harmony with those obtained by El-Hosary (1981).

The proportion ($H_2/4H_1$) was lower than 0.25 for all studied traits except for plant dry weight, number of pods/plant, number of seeds/plant and seed yield/plant, suggesting that positive and negative alleles were not equally distributed among the parents. The parents seemed to have more dominant genes than recessive as indicated by the positive values of F components.

The estimates values of K_D/K_R were greater than one for most of studied traits except for number of pods, seeds, seed yield/plant and 100-seed weight, which indicated excess of dominant genes in the parents for these traits.

The average degree of dominance (H_1/D) were less than one for all studied traits except for plant height, plant dry weight, number of pods/plant, number of seeds/plant and seed yield/plant indicating that the dominance was almost partial.

Narrow sense heritability ranged from 19.94 for plant dry weight to 75.72 % for 100-seed weight. These results are in harmony with those obtained by Abdalla *et al* (2011).

Table 7. Estimates of genetic parameters for studied traits in F_1's diallel cross.

Parameters	Flowering date	Plant height	Plant dray weight	Branches /plant	First pod. node	No. pods /main stem..	No. seeds /main stem	Seed yield/ main stem	No. pods /plant	No. seeds /plant	Seed yield /plant	100-Seed weight
E	0.62 ns	10.50 **	21.91 **	0.08 **	1.49 **	0.43 **	2.86 **	1.61 **	1.87 **	13.55 **	7.93 **	32.40 **
D	23.82 **	39.92 **	28.65 *	0.41 **	6.69 **	1.56 **	6.21 **	2.16 **	2.06 *	10.23 *	7.40 **	226.11 **
F	8.66 ns	25.39 ns	7.77 ns	0.22 *	1.59 ns	0.85 ns	2.58 ns	0.88 ns	-3.51 ns	-16.62 ns	-1.44 ns	-21.80 ns
H1	14.33 **	75.39 **	80.17 **	0.38 **	2.43 *	0.76 **	2.75 ns	0.81 ns	3.01 **	17.25 **	10.19 **	64.96 **
H2	13.21 **	63.28 **	80.15 **	0.29 **	2.32 ns	0.35 ns	1.26 ns	0.25 ns	3.22 ns	21.11 *	12.95 **	43.29 ns
h2	15.47 **	108.78 **	234.67 **	0.54 **	1.32 ns	0.06 ns	-0.38 ns	0.51 ns	6.35 **	71.91 **	61.16 **	175.28 **
a2	2.85	29.57	126.76	0.00	0.58	0.04	2.07	0.39	0.64	17.31	3.67	159.58
Bh2	94.85	73.51	58.19	73.71	68.07	60.20	50.11	38.01	65.10	55.31	44.18	81.80
Nh2	67.48	33.60	19.94	48.74	55.68	52.06	44.62	35.61	50.04	37.91	21.39	75.72
H1/D	0.78	1.37	1.67	0.97	0.60	0.70	0.67	0.61	1.21	1.30	1.17	0.54
UV ($H_2/4H_1$)	0.23	0.21	0.25	0.19	0.24	0.12	0.11	0.08	0.27	0.31	0.32	0.17
KD/KR	1.61	1.60	1.18	1.78	1.49	2.27	1.91	1.99	0.17	0.23	0.85	0.83
r Y& Wr+Vr	-0.29	-0.85	-0.90	-0.86	-0.35	0.06	-0.38	-0.56	-0.06	-0.55	-0.94	-0.90
r^2	0.08	0.72	0.82	0.74	0.12	0.00	0.14	0.31	0.00	0.30	0.88	0.80
h2/H2	1.17	1.72	2.93	1.85	0.57	0.16	-0.30	2.04	1.97	3.41	4.72	4.05

ns, * and ** indicates insignificant, significant and highly significant at 0.05 and 0.01 level of probability, respectively.

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دراسات على الفول البلدى.

27- الأداء والمقاييس التربوية لستة أباء وهجنها

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استخدمت في هذه الدراسة ستة آباء وهي نيل هوايت، نوبارية 1، قاهرة 3 محسن، قاهرة 25، قاهرة 5 وقاهرة 4 في نظام التهجين الدائري (Complete Diallel) لتقدير المصادر المختلفة للتباينات الوراثية وكذا المقاييس الوراثية لصفات التبكير والمحصول ومكوناته

اظهرت النتائج اختلافات عالية المعنوية بين التراكيب الوراثية تحت الدراسة لكل الصفات المدروسة. كما أوضحت النتائج ان التباينات الراجعة للآباء بالمقارنة بالهجن كانت أعلى بالنسبة لصفات أول عقدة ثمرية، عدد القرون للساق الرئيسي وعدد البذور للساق الرئيسي. وعلى الجانب الآخر أظهرت النتائج أن الآباء بالنسبة لهجنها كانت التباينات أعلى بالنسبة لكل الصفات تحت الدراسة فيما عدا الثلاثة صفات السابقة.

أظهرت النتائج أن التباينات الراجعة للقدرة العامة على الائتلاف كانت معنوية لكل الصفات المدروسة. بينما أوضحت النتائج ان تباينات القدرة الخاصة على الائتلاف كانت عالية المعنوية لربعة صفات وهي: تاريخ التزهير، طول النبات، الوزن الجاف للنبات وعدد الأفرع للنبات. اظهرت التباينات الراجعة للهجن العكسية تباينات معنوية لكل الصفات فيما عدا أول عقدة ثمرية، عدد القرون للساق الرئيسي، وعدد بذور الساق الرئيسي، ومحصول البذور للساق الرئيسي ووزن الـ100 بذرة.

أظهر الأب قاهرة 3 محسن تاثيرات مرغوبة للقدرة العامة على الائتلاف لكل الصفات فيما عـدا طـول النبات، الوزن الجاف للنبات وعدد افرع النبات، وارتفاع أول عقدة ثمرية ووزن 100 بذرة. كما أظهرت النتائج أن الأب قاهرة 25 يتميز بتأثيرات مرغوبة عند استخدامه كأب لـ ل الصفات فيما عدا طول النبات، عدد افرع النبـات عدد بذور النبات ووزن 100 بذرة.

بالنسبة لمحصول بذور النبات أظهرت النتائج ان الـ جينين ترنبل هوايت x قاهرة 3 محسن، نوبارية 1 x قاهرة 25 أعطيا تأثيرات مرغوبة ومعنوية للقدرة الخاصة على الائتلاف. كما أوضـحت النتـائج ان تقـديرات المكونات الوراثية أظهرت أن التباينات الوراثية المضيفة كانت معنوية لكل الصفات تحت الدراسة. كمـا أوضـحت قيم نسب العدد الكلي للجينات السائدة الى الجينات المتنحية أنـا أكبر من الواحد الصحيح لكل الصفات المدروسـة فيما عدا عدد القرون للنبات، عدد البذور للنبات، محصول البذ ور للنبات ووزن 100 بذرة. كما أظهرت النتائج أن قيم المكافئ الوراثي الخاص كانت أعلى من 50 % لصفات تار يخ التزهير، وارتفاع أول عقدة ثمرية، عدد قـرون الساق الرئيسي وعدد القرون للنبات، ووزن 100 بذرة.

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