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GENE ACTION FOR SEED YIELD AND SOME RELATED CHARACTERS IN FABA BEAN (*Vicia faba* L.)

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ABSTRACT

The present investigation was carried out at El-Kharga Agricultural Research Station, New valley Governorate, to study the importance of types of gene effects on seed yield and some agronomic characters in three faba bean crosses, namely; Giza 40 x Nubaria 1 (cross I), Giza 674 x Triple white (cross II) and Giza 429 x Triple white (cross III).

Mean of F_1 hybrids surpassed the high parent in all crosses for all studied traits, with some exceptions, indicating over dominance. The backcross populations mean was intermediate between the F_1 mean and mid-parents in most cases.

Non-allelic gene interaction was found to be involved in the control of genetic variation among genotypes for all crosses in all studied traits with few exceptions. Estimates of gene effects showed the importance of dominance and non-allelic gene interaction in the inheritance of all studied traits in most crosses.

INTRODUCTION

In practicing plant breeding to improve a quantitative trait, the breeder estimates gene effects and the components of genetic

variability in his own materials. The genetical knowledge of the type of gene action is helpful to establish the most advantageous breeding procedures for the improvement of the desired traits. Different genetic models were proposed to estimate genetic effects (Comstock and Robinson, 1948; Mather, 1949 and Anderson and Kempthorne, 1954). Also, Camble (1962) pointed out that the information about epistatic gene effects and the relative importance of the three types of gene effects in genetic variation of different quantitative traits are highly desired.

Most of the genetic studies on faba bean (*Vicia faba* L.) referred to the additive and dominance genetic effects considering the major components of gene effects (Bond, 1966; Poulsen, 1977; Moreno and Martinez, 1980 and Attia *et al.*, 2002). However, additional evidence for the incorporation of epistatic gene effects in the inheritance of different quantitative characters was detected by Hayes and Hanna (1968). El-Hossary (1982), El-Hifny *et al.* (2001) and Attia and Salem (2006). They reported that additive and dominance genetic effects were significant for all studied traits, and epistatic gene effects seemed to be important for the most traits.

The present investigation was carried out to evaluate the importance of additive, dominance and digenic epistatic gene effects for some plant characters in three crosses of faba bean.

MATERIALS AND METHODS

The present study was carried out at El-Kharga Agricultural Research Station, New valley Governorate, during 2003/2004, 2004/2005 and 2005/2006 growing seasons.

The materials used in this study involved five parents of faba bean. The parents were chosen to represent local and introduced genotypes with diverse origin as presented in Table 1.

Table 1: Description and origin of five faba bean parental genotypes.

Genotypes	Type	Origin	Flowering	Seed	
				Size	Color
Giza 40	Equine	Egypt, selection from Rebaya 40	early	medium	buff
Giza 429	Equine	Egypt-selection from Giza 402	early	medium	buff
Giza 674	Equine	Egypt, through hybridization	early	medium	buff
Nubaria 1	Major	Egypt, through single plant selection from Giza Blanca	late	large	greenish
Triple White	Equina	an-introduction from Sudan	early	medium	white

The following three crosses were made in 2003/2004 season:

Cross No. 1: Giza 40 x Nubaria 1.

Cross No. 2: Giza 674 x Triple White.

Cross No. 3: Giza 429 x Triple White.

In 2004/2005 season, the F_1 seeds of the three crosses with their parents were sown and the F_1 plants were backcrossed to both parents to produce BC_1 (F_1xP_1) and BC_2 (F_1xP_2) for each cross. In addition, the F_2 seeds were harvested from the selfed F_1 plants.

In 2005/2006 season the P_1, P_2, F_1, BC_1, BC_2 and F_2 populations from each cross were grown in a complete randomized block design with three replications. Each parent was represented by two ridges, each F_1 by one ridge, F_2 by 5 ridges and each BC by 3 ridges in each replicate. Each ridge was 3 m long with spacing of 60 cm apart and 20 cm between plants within ridges. Recommended cultural practices were followed during the growing season.

Days to maturity was calculated for each entry in each replicate on plot basis. At harvest, ten guarded plants were randomly chosen from each ridge and the following agronomic characters were measured:, number of pods/plant, 100-seed weight, g. (seed index) and seed yield/plant (g).

Statistical analysis:

The six parameters model was used to estimate gene action as described by Mather (1949), Hyaman and Mather (1955), Hayman (1958) and Jinks and Jones (1958). This method is used when non-allelic interactions are present.

RESULTS AND DISCUSSION

Mean performance:

The mean performance of P_1, P_2, F_1, F_2, BC_1 and BC_2 generations for all studied traits is presented in Tables 2 and 3.

F_1 hybrid surpassed the high parent in all crosses for all studied traits with some exceptions, indicating over dominance. The backcross population means were in the mid-way between the F_1 means and their respective parental genotypes in most cases. The "t" values were significant for all traits in all studied crosses indicating clear differences between parental genotypes of each cross.

Scaling test and gene effects:

The results of scaling tests for the presence of non-allelic interaction are presented in Tables 4 and 5. Results revealed significant epistasis in most cases, indicating that simple genetic model was inadequate to explain the genetic mechanism in those tested crosses. Therefore, assisting the interaction types are necessary.

In all crosses for the studied traits, the mean effects parameter (m); which reflects the contribution due to the overall mean plus the locus effects and interactions of the fixed loci; was highly significant. The analysis of six-parameter genetic model indicated significant values of additive (d) effect in all crosses for all studied traits except the number of pods/plant in cross 3. Also, the dominance effect (h) was significant in all crosses for all studied traits except the number of pods/plant in cross 2. The magnitude of dominance (h) was higher than additive (d) effects in all cases (Tables 4 and 5). These results indicate the importance of dominance gene effects in the inheritance of these traits. Similar conclusions were obtained by Hays and Hanna (1968), Poulsen (1977), Moreno and Martinez (1980), Abul-Naas *et al.* (1991), El-Hifny *et al.* (2001), Attia *et al.* (2002) and Attia and Salem (2006).

The digenic interaction types, additive x additive (i), additive x dominance (j) and dominance x dominance (l) were significant in most cases with some exceptions. Additive x additive type of gene action was significant for days to maturity, and seed index in all crosses and for no. of pods/plant and seed index in cross 3, but it was insignificant for seed yield/plant in the three crosses.

Additive x dominance type of gene action was significant for days to maturity, no. of pods/plant and seed index in crosses 1 and 3 and for seed index in all crosses, while this type of gene action was significant for seed yield in cross 1 only.

Table 2: Means of number of days to maturity and no. of pods/plant for the six populations of the three faba bean crosses.

Item	Cross 1 Giza 40 x Nubaria 1	Cross 2 Giza 674 x Triple white	Cross 3 Giza 429 x Triple white
Days to maturity			
P_1	142.33±1.56	146.67±1.47	144.97±2.40
P_2	159.10±2.66	138.00±2.86	137.17±1.49
F_1	151.93±1.57	144.93±3.83	141.17±1.23
F_2	151.16±2.27	144.99±4.54	144.77±3.59
Bc_1	151.05±2.88	141.77±3.08	141.27±1.16
Bc_2	153.05±1.59	137.43±3.64	140.72±1.15
t test between parents	*	*	**
No. of pods/plant			
P_1	25.63±2.04	28.90±4.24	23.50±1.92
P_2	13.20±1.16	35.10±3.40	32.63±2.22
F_1	27.20±1.47	36.17±4.62	34.13±0.86
F_2	23.96±4.44	35.14±6.38	30.04±4.06
Bc_1	26.48±3.60	33.33±5.33	31.30±6.68
Bc_2	22.57±2.43	37.48±5.60	32.27±4.69
t test between parents	**	*	**

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

Table 3: Means of 100-seed weight (seed index) and seed yield/plant for the six populations of the three faba bean crosses.

Item	Cross 1 Giza 40 x Nubaria 1	Cross 2 Giza 674 x Triple white	Cross 3 Giza 429 x Triple white
100 seed weight			
P_1	79.63±1.46	82.45±3.06	81.69±2.25
P_2	123.54±2.36	59.71±2.96	60.00±2.61
F_1	123.29±3.96	78.75±4.55	83.30±3.75
F_2	114.66±12.62	71.02±7.39	82.54±7.30
Bc_1	113.62±6.56	77.94±6.24	80.94±6.39
Bc_2	122.35±7.00	71.43±7.24	74.06±6.26
t test between parents	**	**	*
Seed yield/plant			
P_1	61.13±4.39	59.77±4.85	58.67±4.55
P_2	43.20±4.22	53.20±3.47	52.13±3.42
F_1	74.10±1.92	67.93±4.95	62.67±2.99
F_2	65.87±10.96	65.83±7.83	60.41±7.37
Bc_1	68.28±9.68	66.92±4.54	61.70±4.51
Bc_2	64.78±8.76	62.50±4.90	59.32±4.88
t test between parents	**	*	**

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

Table 4 : Scaling tests and genes effects for days to maturity and no. of pods/plant in the three faba bean crosses.

Estimates		Cross 1 Giza 40 x Nubaria 1	Cross 2 Giza 674 x Triple white	Cross 3 Giza 429 x Triple white
Days to maturity				
Scaling test	A	7.83**±0.85	-8.07**±1.09	-3.60**±0.57
	B	-4.93**±0.70	-8.07**±1.28	3.10**±0.46
	C	-0.67±1.16	5.43*±2.34	14.60**±1.43
Gene effect	m	151.16**±0.21	144.99**±0.41	144.77**±0.33
	d	-2.0**±0.42	4.33**±0.62	0.55**±0.31
	h	4.78**±1.05	-18.97**±2.17	-15.00**±1.40
	i	-3.57**±1.19	-21.57**±2.07	-15.10**±1.38
	j	6.38**±0.51	0.0±0.68	-3.35**±0.33
	l	-6.47**±2.05	37.7**±3.34	15.60*±1.70
No. of pods/plant				
Scaling test	A	0.13±1.04	1.60±1.79	4.97**±1.27
	B	6.73**±0.71	3.70*±1.78	-2.23±1.28
	C	2.60±1.74	4.23±3.06	-4.23**±0.37
Gene effect	m	23.96**±0.40	35.14**±0.58	30.04**±0.37
	d	2.92**±0.56	-4.15**±0.99	-0.97±0.85
	h	12.05**±1.79	5.23±3.03	13.03**±1.94
	i	4.27±1.97	1.07±3.06	6.97**±2.26
	j	-3.3**±0.60	-1.05±1.11	3.60**±0.89
	l	-11.13**±2.85	-6.37±5.01	-9.70**±3.78

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

Table 5: Scaling tests and genes effects for seed index and seed yield/plant in the three faba bean crosses.

Estimates		Cross 1 Giza 40 x Nubaria 1	Cross 2 Giza 674 x Triple white	Cross 3 Giza 429 x Triple white
Seed index				
Scaling test	A	24.33**±1.88	-5.33**±1.90	-3.11±1.83
	B	-2.13±1.99	4.40*±2.12	4.83**±1.82
	C	8.93±4.90	-15.59**±3.32	21.88**±3.11
Gene effect	m	114.66**±1.15	71.01**±0.67	82.54**±0.67
	d	-8.72**±1.25	6.50**±1.23	6.87**±1.15
	h	34.98**±5.06	22.34**±3.51	-7.71*±3.28
	i	13.27*±5.24	14.67**±3.66	-20.17**±3.53
	j	13.23**±1.27	-4.86**±1.29	-3.97**±1.20
	l	-35.47**±6.96	-13.74**±5.92	18.44**±5.54
Seed yield/plant				
Scaling test	A	1.33±2.65	6.13**±1.72	2.07±1.53
	B	12.27**±2.41	3.87**±1.68	3.83*±1.51
	C	10.93**±4.15	14.50**±3.56	5.50±3.02
Gene effect	m	65.87**±1.00	65.83**±0.71	60.41**±0.67
	d	3.50*±1.68	4.42**±0.86	2.38**±0.86
	h	24.60**±4.65	6.95**±3.42	7.67*±3.11
	i	2.67±5.23	-4.50±3.34	0.40±3.19
	j	-5.47**±1.77	1.13±1.02	-0.88±1.00
	l	-16.27*±7.95	-5.50±4.95	-6.30±4.61

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

Dominance x dominance type of gene action was significant in all crosses for days to maturity and seed index and in cross 1 and 3 for number of pods/plant, whereas the type of gene action was significant in cross 1 only for seed yield/plant.

The results of the present study showed that epistatic gene effects had a significant contribution in the inheritance of the studied traits. In most cases, the magnitude of dominance x dominance gene effects appeared to be higher than additive x additive or additive x dominance types of gene effects indicating that epistasis in the basic mechanism control the inheritance of the studied traits.

These results are in accordance with those reported by; Hayes and Hanna (1968), El-Hady *et al* (1998), Attia *et al*, (2002) and Attia and Salem (2006) who reported the importance of the dominance and non-allelic interaction combined to give heterotic effects in most traits.

In general, the results of the present study showed that the studied material had a considerable potentiality to improve local faba bean cultivars utilizing introduced stocks.

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فعل الجين لمحصول البذور وبعض الصفات ذات العلاقة فى الفول البلدى

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أجرى هذا البحث فى محطة البحوث الزراعية بالخارجة – محافظة الوادى الجديد خلال مواسم ٢٠٠٤/٢٠٠٣ ، ٢٠٠٥/٢٠٠٤ و ٢٠٠٦/٢٠٠٥ على ثلاثة هجن من الفول البلدى الأول: جيزه ٤٠ × نوباريه ١ ، الثانى : جيزه ٦٧٤ × تربل وايت ، الثالث : جيزه ٤٢٩ × تربل وايت.

أظهرت النتائج أن متوسط هجن الجيل الأول يتفوق عن أفضل الآباء لكل الصفات فى كل الهجن مع إختلافات فى بعض الحالات مشيراً إلى السيادة الفائقة . أما متوسط عشائر الهجن الرجعية كانت ما بين متوسط الجيل الأول والآباء فى معظم الحالات لجميع الهجن . تبين أن التفاعل الجينى الغير أليلى هو المتحكم فى التباين الوراثى بين الأجيال فى كل الهجن لكل الصفات دليلاً على فشل الموديل البسيط الاضافى – السيادى باستثناء بعض الحالات . أوضحت تقديرات التأثير الجينى الأهمية النسبية للسيادة والتفاعل الجينى الغير أليلى فى وراثة الصفات فى معظم الهجن .