GENETIC BEHAVIOR MANIFESTATION OF YIELD AND ITS COMPONENTS IN BROAD BEAN

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ABSTRACT: The wide genetic variability available in evaluated material suggested scope for selection with regard to yield and its components in the cross "Kobrosy X Luz De Otono". Results obtained showed that all studied characters were controlled by both additive and non-additive gene effects. Number of tillers per plant, number of pods per plant and seed index were significantly higher than the highest parent, suggesting over-dominance for the high parent. The over-dominance over the better parent was in evidence for the days to flowering and number of nodes to 1st pod. One to four pairs of genes are controlling total green pod yield. Significant heterosis and inbreeding depression were found for all traits. Broad sense heritability was high for all traits, except pod weight and total green-pod yield, since It was intermediate. It ranged from 60.98% for seed index to78.51% for days to flowering, indicating that selection can be used for improving these characters. There were considerable genotypic and phenotypic variability for plant height, number of tillers, first pod height number of pods per plant , pod length, number of seeds per pod and 100-seed weight. It was found that 70 to 89 % of the phenotypic variances were due to genetic factors. Therefore, these traits might be more genotypicially predominant and it would be possible to achieve further improvement in them. These results are of great importance to breed high yielding and more stability broad bean cultivars under middle delta conditions.

Key words: Heterosis, heritability, inbreeding depression, genotypic, phenotypic variances.

INTRODUCTION

Good understanding the genetic behaviour of quantitative traits would be useful to the development of planned program in broad bean development .Number of seeds per pod, pod weight, pod length and 100-seed weight appeared to be the principal yield attributes for which selection can be effective (Farag *et al.,* 2005). These characters have been studied by Farag and Darwish (2005), Farag (2007 and 2008) and Farag and Morsy (2009).

The relative contribution of additive and non-additive gene effects for complex traits used to study the inheritance pattern and could be used in formulating an efficient breeding program to achieve desired genetic improvement. Farag (2007 and 2008) and Farag and Morsy (2009) reported that both additive and non-additive gene actions were important to control most of studied traits. This conclusion comply with that reported by Attia *et al.* (2006). El-Tabbakh and Ibrahim (2000) indicated that additive and additive x additive types of gene action controlled some traits, while the non additive gene action controlled the inheritance of plant height and seed yield/ plant. On the other hand, 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. While, El-Hady *et al.* (2006) found that dominance genetic variance was more important than additive one for all characters.

Heterosis and inbreeding depression were achieved by Salama and Salem (2001), Rabie *et al.* (2004), Salama and Mohamed (2004), Attia *et al.* (2006) and Farag, (2007). Farag and Darwish (2005) and Salama (2005) found that significant positive heterosis effects to mid-parents were detected for all studied traits. Regarding the inbreeding depression, Farag and Helal (2004), Farag and Darwish (2005) and Attia *et al.* (2006) found that highly significant inbreeding depression values were observed for most traits. Also, Rabie *et al.* (2004) showed that some crosses expressed significantly positive inbreeding depression for number of branches, pods and seeds and seed yield per plant. Heritability estimates is useful in predicting the expected genetic gain from selection in segregating populations. High heritability in the F_2 populations indicates more importance of genetic factors in controlling a trait. Estimates of heritability for broad bean traits were reported by Farag and Darwish (2005) and Farag and Morsy (2009).They found that heritability estimates in broad sense were moderate to high values, with values ranged from 37.33 to 64.67%. Attia *et al.* (2006) reported that broad sense heritability values were high in all crosses for all studied traits.

This investigation aimed to study the genetic behaviour of some plant growth and pod characteristics to determine the nature of gene action, number of gene and broad sense heritability, average degree of dominance and inbreeding depression to be employment in improving yield and its components as well as growth characteristics in broad bean.

MATERIALS AND METHODS

Two broad bean (*Vicia faba* var major) genotypes were used in this study. They were Kobrosy (P_1, from Syria) and Luz De Otono (P_2, from Spain). Both parents were chosen because of their contrast in number of pods per plant, pod weight and length and total green pod yield. The F_1 seeds of "Kobrosy X Luz De Otono" were developed in 2006/07 winter season at the experimental farm of El-Gemmeza Agriculture Research Station, Gharbia Governorate.In the second winter season of 2007/08, parents and F_1 hybried were sown on October, and some F_1 plants were selfed to produce the required F_2 seeds. In the third winter season of 2008/09, P_1, P_2, F_1 and F_2, populations were evaluated in a randomized complete block design (RCBD) with three replicates. Each replicate consisted of twenty rows for the F_2 population and three rows for each of non-segregating generations (P_1, P_2 and F_1). Each row was 5 m long and 0.75 m wide and 30 cm between hills. All agriculturcl practices were applied according to the recommendation of Ministry of Agriculture for broad bean.

Observations and measurements were recorded on an individual plants of different populations as follow : plant height, number of tillers per plant (at the end of the growing season), number of days to flowering, first pod height(stem length to 1[st] pod on the main stem),number of nodes to 1[st] pod on the main stem, number of pods per plant, number of seeds per pod, pod weight and length, seed index (100-green-seed weight) (at harvesting time) and total green-pod yield.

The following statistical and genetical parameters were determined:

- Mean, range, coefficient of variation among all studied genotypes were calculeted according to Snedecor and Cochran (1982).
- The nature of dominance was obtained by comparing the F_1 and F_2 means with their expected arithmetic means whereas, the nature of gene action was deduced by comparing both F_1 and F_2 actual means with their respective arithmetic and geometeric means. The arithmetic mean were reported by Powers *et al* (1950) and geometric means were calculated according to Powers and Lyon (1941).
- Average degree of heterosis (ADH %) over mid-parents (MP) and high-parent (HP) were calculated (Bhatt, 1971) and inbreeding depression (ID %) was calculated according to Mather and Jinks (1971).
- Broad sense heritability was estimated according to the method of variance components (Burton, 1951) and minimum number of effective genes was estimated according to Castle-Wright(1921).
- Genotypic coefficient of variation (GCV) was estimated using the method of Burton (1952). Phenotypic coefficient of variation (PCV) was estimated using the method of Johnson *et al.* (1955).

RESULTS AND DISCUSSION

Means, range, variance and coefficient of variation of parents, F_1 and F_2 for the different characters are presented in Tables 1 and 2. Data reveal that, the parental genotype Luz De Otono gave the highest number of pods per plant, pod length, pod weight, and the highest estimates of total green-pod yield. However, Kobrosy had the highest plant height, earlier in flowering with heaviest 100-green seed weight. The differences between the investigated genotypes were significant for all traits.

Table 1. Statistical parameters of growth traits in parents, F_1 and F_2 generations

Genotypes		Plant height	Number of tillers/plant	Days to 50% flowering	Number of nodes to 1st pod	1st pod height	Number of pods/plant
Parents							
P_1	Mean	123.8	6.4	57.9	5	24	20.3
	Range	100.2-145.3	5.0-7.0	53-63	4-6	18-28	17-23
	C.V.%	8.19	9.23	5.38	12.06	10.21	6.66
	S^2	102.85	0.349	9.702	0.356	6	1.823
P_2	Mean	101.3	7.2	53.4	5.5	27.4	27
	Range	81.1-120.2	6.0-8.0	45-58	4-8	21-31	24-32
	C.V.%	9.85	7.98	6.16	16.01	9.91	7
	S^2	99.42	0.333	10.81	0.769	7.374	3.563
Cross generations							
F_1	Mean	120.4	7.5	47.3	4.7	24.1	31.4
	Range	103.2-135.1	6.0-8.0	41-55	4-6	21-29	28-36
	C.V.%	5.86	7.40	8.15	12.46	10.36	6.64
	S^2	34.35	0.308	14.892	0.366	6.203	4.343
F_2	Mean	131.2	6.9	55.6	5.8	26.7	30.3
	Range	96.2-155.4	4.0-9.0	41-70	3-9	15-39	20- 36
	C.V.%	14.54	16.79	13.33	20.06	18.39	9.75
	S^2	211.26	1.328	54.927	1.332	24.045	8.697
LSD	0.05	5.34	0.156	1.390	0.159	0.520	0.277
	0.01	7.02	0.205	1.827	0.209	0.683	0.365

C.V.%: Coefficient of variation.

S^2 : Variance

Table 2. Statistical parameters of yield components in parents, F_1 and F_2 generations

Genotypes		Pod length	Number of seeds/pod	Pod weight	Seed index	Total green - pod yield
Parents						
P_1	Mean	15.3	4	33.6	296.3	457.9
	Range	14-16	3-5	27.4-43.8	240-322.3	438.6-475.8
	C.V.%	3.73	13.18	12.16	9.32	2.50
	S^2	0.328	0.281	16.72	763.4	131.3
P_2	Mean	20.2	4.3	37.0	281.4	530.2
	Range	18-22	4-5	29.6-46.3	243.7-316.7	511.1-555.7
	C.V.%	4.75	10.32	11.05	7.13	2.95
	S^2	0.917	0.192	16.72	402.1	244.9
Cross generations						
F_1	Mean	18.2	4.2	35.7	350.3	520.1
	Range	16-19	4-5	28-45.4	306.5-385.3	496.6-534.2
	C.V.%	3.97	9.65	9.75	7.94	2.44
	S^2	0.523	0.164	12.11	774.4	160.8
F_2	Mean	17.4	4.0	33.3	262.6	485.0
	Range	14-20	2-6	24.3-45.2	148.5-348.1	354.2-592.5
	C.V.%	7.09	19.11	16.41	15.5	3.91
	S^2	1.517	0.571	29.76	1657.1	358.9
LSD	0.05	0.186	0.161	1.063	7.258	1.412
	0.01	0.245	0.211	1.397	9.538	1.855

Also, significant genetic variances were detected for all traits and therefore, genetic parameters were estimated. F_2 populations exhibited high coefficient of variability values (Tables 1 and 2), indicating that the effects of both environmental and genetics were involved in the inheritance of all traits. F_2 means of plant height, and number of pod per plant were found to be over HP suggesting the over dominance (non-additive gene effects) for these traits. While, the F_2 means of pod length was found to lie between both parents value, suggesting that the non-additive genetic variance were predominating for this character and played the major part in its inheritance than the other types of gene action. On the other hand, the F_2 means for pod weight was less than the worse parent. However, transgressive segregation was observed in both directions of F_2 populations for all traits.

The gene action involved in the expression of the yield and its components was determined by computing the theoretical arithmetic and geometric means corresponding to additive and non-additive gene actions. The arithmetic and geometric means of the F_1 and F_2 (Table 3) were close to each other for all characters revealing that all studied characters were controlled by genes having additive and non-additive effects. These results are in agreement with those obtained by Farag (2007).

Table 3. Expected mean of F_1 and F_2 populations

Characters	Arithmetic		Geometric	
	F_1	F_2	F_1	F_2
Plant height	112.51	116.46	111.95	116.10
Number of tillers	6.81	7.16	6.80	7.14
Days to flowering	55.64	51.48	55.59	53.36
Number of nodes to1st pod	5.21	4.93	5.21	4.92
1^{st} pod height	25.70	24.88	25.64	24.86
Number of pods/plant	23.63	27.50	23.39	27.09
Pod length	17.75	17.98	17.58	17.89
Number of seeds/pod	4.14	4.17	4.14	4.17
Pod weight	35.32	35.51	35.28	35.49
Seed index	288.85	319.60	288.75	318.06
Total green pod yield/plant	494.02	507.08	492.69	506.16

Average degree of heterosis was estimated in relation to MP and HP values for eleven traits (Table 4). Heterosis achieved ranged from -14.94 to 32.79 over MP; from -11.38 to 18.23% over HP and from -6.06 to -11.38% over the better parents. The comparison between the means of F_1 and both parents showed that the number of tillers per plant, number of pods per plant and seed index were significantly higher than the highest parent , this figure suggests over-dominance for the high parent (Table 4). Obtained high potence ratio values which were more than one (P>1), supported the suggested over-dominance hypothesis (Table 4). The over-dominance over the better parent was in evidence for the days to flowering, and number of nodes to 1^{st} pod. The means of F_1 exceeded that of the better parent by-11.4 %and-6.1 %, respectively. The plant height, pod length and number of seeds per pod showed significant positive MP-heterosis and gave negative HP-heterosis indicating partial dominance. The obtained potence ratio values in these traits (0.70, 0.19 and 0.56, respectively) confirmed the partial dominance suggested. Complete dominance towards the short length to 1^{st} pod height and high total green-pod yield were observed. On the other hand, concerning pod weight, the F_1 means (35.7g) were relatively close to the mid parental values (35.3g), suggesting incomplete dominance. Generally, potence ratio values were found to follow the same pattern of the heterosis degree in all traits. The inbreeding depression (ID %) values ranged from -23.8 to 25.0% (Table 4). Highly significant positive values were obtained for number of tillers per plant, pod number per plant, pod length and weight, seed number per pod, seed index and total green-pod yield. This is logic and expected since the expression of heterosis in F_1 will be followed by a reduction in F_2 performance. These results of heterosis, inbreeding depression and potence ratio were supported by similar findings obtained by El-Hosary (1983 a and b), Melchinger *et al.* (1994), Farag and Helal (2004), Rabie *et al.* (2004), Farag and Darwish (2005), Attia *et al.* (2006) and Farag (2007).

Regarding the heritability in broad sense, the obtained data were high for all traits, except pod weight and total green-pod yield. It ranged from 60.98% for seed index to78.51% for days to flowering, indicating that selection can be used for improving these characters. On the other hand, the moderate values of heritability

Table 4. Quantitative genetic parameters for some traits

Characters	ADH%		Potence ratio	ID	Heritability %	Number of genes	GCV	PCV	GCV/PCV%
	MP	HP							
Plant height	7.1**	-2.73*	0.70	-8.9**	62.67	0.358	8.77	11.08	79.15
Number of tillers	10.1**	3.81**	1.67	8.5**	75.17	0.383	14.56	16.79	86.72
Days to flowering	-14.9**	-11.4**	-3.76	-17.5**	78.51	0.063	11.81	13.33	88.60
No. of nodes to1st pod	-10.8**	-6.1**	-2.14	-23.8**	63.44	0.035	15.98	20.06	79.66
1st pod height	-6.4**	0.21	-0.97	-10.9**	72.86	0.081	15.89	18.81	86.41
Number of pods	32.8**	16.3**	2.31	3.6**	62.71	1.278	7.72	9.75	79.18
Pod length	2.5**	-9.8**	0.19	4.6**	61.15	2.958	5.55	7.09	78.28
Number of seeds/pod	1.5**	-1.2*	0.56	5.9**	62.76	0.016	15.14	19.11	79.23
Pod weight	1.1	-3.6**	0.22	6.8**	48.98	0.080	11.48	16.41	69.96
Seed index	21.3**	18.2**	8.22	25.0**	60.98	0.032	12.10	15.50	78.06
Total green pod yield/plant	5.3**	-1.9	0.72	6.8**	50.13	3.295	2.77	3.91	70.84

*,** Verify the significance at 0.05 and 0.01 levels of probability, respectively.

estimates for total green-pod yield (50.13%) and pod weight (48.98%) indicate that the environmental factors had a moderate effect on the inheritance of these two characters. Therefore, selection may be moderately effective in breeding for higher values of total green-pod yield and pod weight. These results are in agreement with the findings of Farag and Darwish (2005) and Farag and Morsy (2009).

A number of one locus was found to govern all traits, except number of pods per plant, pod length and total green-pod yield (Table4). Two three and four pairs of genes controlled number of pods per plant, pod length and total green-pod yield, respectively. These findings, may be due to the lack of the fulfillment of one or more of the formula assumptions. Mahmoud (1978) showed that at least 1-2 pairs of genes might control number of pods per plant and 2-5 pairs controlled number of seeds per plant.

Regarding genotypic (G.C.V) and phenotypic (P.C.V.) coefficient of variance, data in Table 4 show that all traits had high G.C.V./P.C.V. percent. Such values ranged from 69.99 for pod weight to 88.61 for days to flowering. These results indicated that about 70 to 89% of the phenotypic variances were due to genetic ones. Therefore, these traits might be more genotypicially predominant and it would be possible to achieve further improvement in them. Also, there were considerable genotypic and phenotypic variability for plant height, number of tillers, first pod height, number of pods per plant, pod length, number of seeds per pod, and 100-seed weight. These results are in disagreement with those reported by Kalia and Pathania (2007) who reported that the differences in genotypic and phenotypic coefficients of variation (GCV and PCV) were negligible for days to 50% flowering, plant height, pod length, and pod yield per plant.

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مظاهرالسلوك الوراثى للمحصول ومكوناته في الفــول الرومي

سمير توفيق فرج

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أجريت هذه الدراسة خلال المواسم الشتوية ٢٠٠٦/٢٠٠٧، ٢٠٠٧/٢٠٠٨، ٢٠٠٨/٢٠٠٩ بمزرعة الجميزة البحثية/ محافظة الغربية والتابعة لمركز البحوث الزراعية، وذلك لقياس الاختلافات الوراثية في هجين الفول الرومي"قبرصي x لويز دى اوتو" (الجيل الأول والثاني). ولقد استخدم التحليل الو راثي من حساب الفعل الجينى الحسابي و الهندسي وقوة الهجين ودرجة السيادة ودرجه التوريث وعدد الجينات لبعض الصفات الهامة في الفول الرومي والتدهور الناتج عن التربية الداخلية بهدف تحسين هذه الصفات بالتربية.

وتتلخص النتائج بعد تحليلها فيما يلي:

١- بدراسة مدى تشتت الانسال في الآباء والجيل الثاني ظهرت الانعزالات فائقة الحدود في الاتجاهين في صفات طول النبات، وعدد الأفرع، وعدد العقد حتى أول قرن، وارتفاع أول قرن، وتاريخ التزهير، ووزن القرن، ووزن ١٠٠ بذرة، وعدد البذور بالقرن، والمحصول الكلى. بينما كانت الانعزالات أعلى من الأب الأعلى لصفات عدد القرون للنبات الواحد وطول القرن.

٢- اظهر تقدير الفعل الحسابي والهندسي للجينات وجود كل من الفعل الأضافى والغير إضافي للجينات في كل الصفات التي درست مما يتيح التحسين لهذه الصفات بالتربية عن طريق الانتخاب.

٣- أظهرت حسابات قوة الهجين وجود سيادة فائقة للأب الأعلى في صفات عدد الأفرع للنبات، وعدد القرون للنبات، ودليل البذرة، وسيادة تجاه الأب الأفضل لصفة عدد الأيام اللازمة للإزهار، وعدد العقد حتى أول قرن على الساق الرئيسي، وبالنسبة للتدهور الناتج عن التربية الداخلية فان قيم التدهور كانت موجبة لصفات عدد الأفرع/ النبات وعدد وطول القرون/نبات، ومتوسط وزن القرن، وعدد البذور بالقرن، ودليل البذرة، ومحصول القرون الخضراء.

٤- أظهرت حسابات درجة التوريث على النطاق الواسع أنها عالية وتراوحت من ٦١% إلى ٧٩%، لجميع الصفات ماعدا صفتي وزن القرن والمحصول الكلى فكانت متوسطة، مما يتيح للمربى فرصة جيدة للتربية بالانتخاب لتلك الصفات.

٥- تحكم المحصول ومكوناته في الفول الرومي من١ إلى ٤ زوج من الجينات. ويوجد قدر كبير من التباين الوراثى بلغ من ٧٠ إلى ٨٩% بالنسبة للتباين الكلى مما يشير إلى إمكانية تحسين تلك الصفات بالانتخاب.

٦- مما سبق تتضح أهمية تلك النتائج في التربية لتحسين المحصول ومكوناته في الفول الرومي تحت ظروف وسط الدلتا.