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CORRELATION AND PATH COEFFICIENT ANALYSIS OF SOME YIELD COMPONENTS IN THREE EARLY SEGREGATING FABA BEAN POPULATIONS

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ABSTRACT

The experiment was conducted at the experimental station of Sids Research station, Bini Sueif Governorate, during 2010/11, 2011/12 and 2012/13 under insect free cage. Three F_2 faba bean populations and their four parental varieties were evaluated for seed yield and five related components traits.

Highly significant variation was noted for all the studied traits. The tree F_2 populations recorded the higher values than parental ones for all the traits except hundred seed weight, which recorded the least value. High heritability estimates were observed for all the traits except hundred seed weight. In general phenotypic coefficients of variability were greater than their corresponding genotypic coefficient of variability. Higher estimates of heritability coupled with genetic advance were observed for number of seeds per plant, seed yield and number of pods per plant indicating that these characters are mainly controlled by additive genes and selection of such traits may be effective for the improvement of seed yield. All the studied traits had positive and highly significant genotypic and phenotypic correlations with seed yield except hundred seed weight that showed negative and highly significant one. Results showed that number of seeds per plant; number of pods per plant and plant height had the most direct or indirect effect on seed yield. Hence, these traits could be used for the improvement of seed yield resulting in the development of high yielding populations of faba bean.

INTRODUCTION

Faba bean (*Vicia faba* L.) is the major legume crop among pulses in Egypt, due to its high nutritive value in both energy and protein. Total cultivated area in the world was approached 25 million hectares with 18.4 million tones of seed yield (FAO, 2004). The possibility of increasing its cultivated area is limited and hence increasing productivity through developing new high yielding varieties and improving cultural practices is the most needed. It has attracted the attention of geneticists and plant breeders to improve the average yield per unit area, due to its values for both human and animal nutrition. The success of plant-breeding program depends on the choice of populations capable of producing progeny with desired trait combinations. The promising segregating populations make it possible to select lines with superior performance. Careless choice can cause resource and time loss. Procedures making possible early detection of promising populations have been the target of many investigators (Oliveira *et al*., 1996). Seed yield is a complex trait that is quantitatively inherited with low heritability value (Bond, 1966; and Yassin, 1973). The low heritability and consequent limited genetic advance for yield in response to selection had led many scientists to search for characters which are associated with yield but which are more highly heritable (De Pace, 1979).

Since genotypic and environmental factors are components determining yield and quality in plants, a primary aim should be the determination of effect of genotypic factors in selection. As the effect of environment on yield and quality in plants is not hereditable, effects of genotypic factors on yield and quality in plant breeding research need to be examined.

Seed yield is a complex character which is determined by number of yield components and is frequently highly correlated. Selection is an integral part of a breeding program by which genotypes with high productivity in a given environment could be developed. However, selection for high yield is difficult because of yield components, which are polygenicly inherited. Therefore, only little progress could be made over a long span of time through direct selection for yield (Tadesse *et al.* 2011).

Path analysis is used to determine the amount of direct and indirect effects of the variables on the variables on the effect component. Indirect selection through yield components has been proved more effective. A greater chance of success in indirect selection for yield might come from selection for various morphological attributes such as duration of flowering, number of pods, seeds and seed size. These characters may be used in the construction of selection indices for the improvement of yield (El-Hady *et al*., 1998). This selection criterion takes into account the information on interrelationship among agronomic characters. Nevertheless, selection for yield via highly correlated characters becomes easy if the contribution of different characters to yield is quantified using path coefficient analysis (Dewey and Lu, 1959).

The present study was aimed at finding out the nature and magnitude of genetic variability and association studies in segregating populations of faba bean for yield and other yield component traits to select transgressive segregants for further breeding program.

MATERIALS AND METHODS

Four faba bean parents (Nubaria 2, Nubaria 3, Cairo 4 and X-943) as well as some their F_2's populations were evaluated. The origin and characteristics of these parents are shown in Table 1.

Table 1: Origin, pedigree and special characteristics of four faba bean parental genotypes.

Genotype	Origin	Pedigree	Characteristics
Nubaria 2	FCRI	X-735 (Rad.2095/76× ILB1550)	Low water requirements planted in new reclaimed lands.
Nubaria 3	FCRI	Land race, Ahnasia2	Low water requirements planted in new reclaimed lands.
Cairo 4	CU	An *Orobanche* tolerant variety from Cairo university.	Tolerant to *Orobanche*.
X - 943	FCRI	Giza3×641/837A/83	Resistant to foliar diseases and high degree of autofertility.

FCRI: Field crops Res. Institute and CU: Cairo University (Agron. Dept.).

The four parents and three F_2 populations were sown together during the same cropping season (2012/2013) in a randomized complete block design with three replications at Sids Research station, Beni Sueif Governorate, Egypt. Row length was three meters with 60cm raw spacing (approx.10 seeds/row). Since the non–segregating generations represented the homogenous populations, while the F_2 denoted the heterogeneous populations, the sample size (i.e., number of plants analyzed) varied as follows: 20 randomized selected plants for parents and 157 plants for F_2 populations. Table 2 indicates direction of parental crosses of the three populations. The traits assessed were plant height (P.H) , number of branches (bra.), number of pods per plant (pods/pl.) , number of seeds per plant (seeds/pl.), hundred seed weight, (100-s.w.) and seed yield per plant (yield/pl.).

Table 2:List of F_2 faba bean populations, their code and direction of the original cross .

Populations	Code	Parents
1	X -2093	Nubaria 2* Nubaria 3
2	X -2096	Nubaria 2* Cairo 4
3	X -2103	Nubaria 3* X- 943

Statistical manipulations:

The analysis of variance was carried out to test the significance of all studied traits (yield and its components). Breeding value of the material was evaluated by analyzing some genetic parameters. Mean comparisons were done using Least significant differences test at 5% level of probability.

In accordance to the methods used by Johnson *et al.* (1955) and Kumar *et al.* (1985), the phenotypic (*PCV%*) and genotypic variance (*GCV*%), coefficients of variation were estimated as a percentage of their corresponding phenotypic (V_{ph}) and genotypic (σ^2_g) standard deviations to the trait grand mean. Heritability and expected genetic advance (*GA*) as percent of the mean assuming selection of the superior 5% of the genotypes were estimated in accordance with the methods illustrated by Fehr (1987).

Correlation and path coefficient analysis of some yield components

Relationships between the traits were through genotypic and phenotypic correlation and path coefficient. Genotypic and phenotypic correlation coefficients were calculated for each pair of traits after Falconer (1989). All correlation coefficients were worked out between all possible combinations of traits. The path coefficients analysis appeared to provide clue to the contribution of various components of yield to over all seed yield in the populations under study. It provides an effective way of finding out direct and indirect sources of correlation. Path coefficient analysis was carried out using the general formula of Dewey and Lu (1959) to determine the direct and indirect effects of the yield components and other morphological characters on seed yield.

RESULTS AND DISCUSSION

Genotypes' mean performance:

Data in Table 3 revealed the highly significant differences among the investigated generations and their respective parents.

Table 3: Mean performance of yield and some components in four faba bean parents and their F_2's.

Genotype	PH	bra/pl	p/pl	s/pl	100-sw(g)	y/pl(g)
Parents means						
1- Nubaria 2	73.06	3.22	10.72	25.33	89.34	21.92
2- Nubaria 3	83.37	3.11	11.24	28.96	88.28	24.88
3- Cairo 4	82.29	3.40	11.47	28.62	108.73	29.23
4- X- 943	101.21	2.85	20.34	65.68	79.32	51.17
F_2 population means						
1- X -2093	107.63	6.73	31.14	92.86	84.47	77
2- X -2096	119.49	6.93	46.76	130.56	86.3	112.01
3- X -2103	117.81	6.23	37.23	103.53	82.52	84.56
LSD $_{0.05}$	**7.49**	**1.08**	**6.42**	**12.92**	**10.35**	**11.14**

plant height (PH) , number of branches (bra), number of pods per plant (p/pl) , number of seeds per plant (s/pl), hundred seed weight, (100-sw) and seed yield per plant (y/pl.).

Data revealed that X- 943possessed the tallest plants and showed the highest values for number of pods, seeds and seed yield per plant and recorded 101.21 cm, 20.34, 65.68 and 51.17 g, respectively. Cairo

4 had the highest values for number of branches (3.40) and 100-seed weight (108.73 g).

Data revealed that all F_2 population (X -2096) possessed the highest values for all traits and recorded values higher than those in the parental genotype for all traits except 100-seed weight trait. From the above-mentioned results, it could be concluded that the selection prospects within this parents and its F_2 genotypes to improve the performance through breeding program.

Genetic parameters:

Highly significant differences were observed for all the traits. This considerable variability provides a good chance of improvement in studied faba bean populations. In general, phenotypic coefficient of variability (*PCV %*) was higher than corresponding genotypic coefficient of variability (*GCV %*) for all the traits which demonstrated the effect of environment upon the traits (Table 4).

Table 4: Genetic parameter for seed yield and some yield characters in faba bean. in all studied populations .

Characters	V_{ph}	V_g	*GCV%*	*PCV%*	h^2_b	*GA*
Plant height	**351.83**	**334.10**	**18.68**	**19.17**	**94.96**	**36.69**
Branches/plant	**3.78**	**3.41**	**39.82**	**41.91**	**90.27**	**3.62**
Pods/plant	**217.60**	**204.57**	**59.27**	**61.13**	**94.01**	**28.57**
Seeds/plant	**1817.50**	**1764.77**	**61.83**	**62.75**	**97.10**	**85.27**
100-seed weight	**114.40**	**80.55**	**10.15**	**12.10**	**70.41**	**15.51**
Seed yield/plant	**1235.02**	**1195.81**	**60.40**	**61.38**	**96.825**	**70.10**

V_{ph} = Phenotypic variance, V_g = Genotypic variance, *PCV%* = Phenotypic coefficient of variability, *GCV%* = Genotypic coefficient of variability, h_b^2 = heritability in broad sense and *G.A*= Genetic advance.

The highest genotypic and phenotypic coefficient of variability were recorded for number of seed per plant (61.83 and 62.75%), seed yield (60.40 and 61.38 %), number of pods per plant (59.27 and 61.13%) and number of branches (39.82 and 41.91%), respectively. This indicates the presence of exploitable genetic variability for these traits. Heritability (h_b^2 %) estimates were generally high for all studied traits and recorded values from 97.10% for number of seed per plant to 90.27% for number of branches per plant, except hundred seed weight that recorded 70.41%. In general, all traits except hundred seed weight had higher heritable variation. Hence, it can be assumed that phenotypes of almost all the traits are mainly determined by their genotypes. High estimates of heritability indicated that selection based on mean would be successful in improving these traits (Attia, 2007 and El-Hady *et al.* 2009).

High estimates of genetic advance were observed for number of seeds per plant (85.57%), seed yield per plant (70.10%), plant height (36.69%) and number of pods per plant (28.57%). High heritability values coupled with high genetic advance were observed for all last traits. From the results it can be concluded that all these traits are controlled by additive type of gene action as reported by other workers. Similar results were also obtained by Alghamdi (2007) and El-Hady *et al.* (2009) who reported high heritability coupled with high genetic advance for most of the quantitative characters. Improvement in all these traits (number of seeds per plant, seed yield per plant, plant height and number of pods per plant) can be achieved through selection. But number of branches per plant showed high heritability with relative low genetic advance and hundred seed weight showed relative low heritability and low genetic advance, indicating limited scope improvement of these two traits by selection.

Correlation studies:

The estimates of correlation coefficient between seed yield and some yield related traits indicated that in general genotypic correlation coefficients were higher than their corresponding phenotypic correlation coefficients in all traits (Table 5). Hundred seed weight per plant had negative and significant genotypic and phenotypic correlation with all other traits including seed yield per plant. Highly significant positive correlation values were detected between seed yield per plant and each of number of branches, number of pods and number of seeds per plant at both the genotypic and phenotypic levels. Similar results were observed by Ulukan *et al*. (2003), Alghamdi (2007) and Tadesse *et al*. (2011). These findings indicate that indirect selection for each or both of number of pods per plant, number of seeds per plant and number of branches per plant would be accompanied by high yield. This agrees with Osman *et al*. (2013).

Table 5: Estimates of phenotypic (p) and genotypic (g) correlation coefficient (r) of yield and yield components traits in faba bean (n = 237).

Characters	r	Plant height	Branches /plant	Pods/ plant	Seeds/ plant	100-seed weight
Branches /plant	p	0.782**				
	g	0.852**				
Pods/plant	p	0.928**	0.885**			
	g	0.966**	0.923**			
Seeds/plant	p	0.956**	0.871**	0.950**		
	g	0.968**	0.902**	0.964**		
100-seed weight	p	-0.462**	-0.258**	-0.395**	-0.468**	
	g	-0.585**	-0.326**	-0.509**	-0.547**	
Seed yield/plant	p	0.943**	0.887**	0.951**	0.964**	-0.386**
	g	0.951**	0.901**	0.960**	0.978**	-0.488**

* and ** indicate significant at 0.05 and 0.01 level of probability, respectively

Path analysis:

The genotypic correlation coefficients were individually partitioned into direct and indirect effects. Genotypic direct and indirect effects for different five yield-related traits on seed yield are summarized in Table (6). It's noticed that all the direct effects were positive and below one, suggesting that inflation due to multicolinearity was minimal (Gravois and Helms 1992). Hundred seed weight (0.025) showed positive direct effect on seed yield though the values are low. The results indicated that number of seeds per plant (0.432) exerted the highest positive direct effect on seed yield per plant followed by number of pods per plant (0.217) and plant height (0.216). Mridula *et al*. (1992), Abdelmula and Abdalla (1994) and Tadesse *et al*. (2011) also reported positive direct effect of number of seeds and Yamani *et al.* (2012) confirmed that number of pods and number of seeds were more interest which is in agreement with the present finding. From the results it can be concluded that seed yield can be increased by selecting genotypes having more pods per plant, more seeds and taller plant.

Table 6: Direct (diagonal) and indirect effects of components traits attributing to seed yield in all studied faba bean populations at genotypic level.

Characters	Plant height	Branches / plant	Pods/ plant	Seeds/ plant	100-seed weight	Genetic correlation with seed yield
Plant height	**0.216**	0.109	0.209	0.418	-0.015	**0.951****
Branches/plant	0.184	**0.128**	0.200	0.390	-0.008	**0.901****
Pods/plant	0.208	0.118	**0.217**	0.416	-0.013	**0.960****
Seeds/plant	0.209	0.116	0.209	**0.432**	-0.014	**0.978****
100-seed weight	-0.126	-0.042	-0.110	-0.490	**0.025**	**-0.488****

Residual effect = 7.546%.

Indirect plant height affected seed yield positively and high on seed yield via number of seeds per plant (0.418).As well as, indirect effects were obtained for number of branches on seed yield via number of seeds per plant and high (0.390).Conmen indirect effects were observed for number of pods on seed yield via number of seeds per plant and high (0.416). It is noticed that the indirect effects of number of seeds per plan on seed yield through their association with plant height, number of branches and number of pods were small and recorded (0.209,0.116 and 0.209, respectively). Hundred seed weight affected seed yield negatively and indirectly through all the traits. The component of indirect effect was recorded for hundred seed weight via number of seeds per plant (-0.490). It is observed that the indirect effects of hundred seed weight on seed yield via plant height and number of pods were negative and low, while number of branches was negative and tiny. Then the indirect effects for hundred seed weight were more important compared to direct effects.

The indirect effects for plant height, number of branches, pods per plant, and hundred seed weight were more important compared to direct effects (Tadesse *et al*. 2011). The marked parts of their effects was on seed yield via plant height , number of branches per plant, number of pods per plant and hundred seed weight. Then, there is large scope of simultaneous improvement in faba bean seed yield as well as other yield components through selection taking into consideration these pairs of traits.

The coefficients of determination and relative importance according to path analysis of seed yield and its components at genotypic level are shown in Table 7. The results indicated that seeds per plant, pods per plant and plant height showed highest direct effects on seed yield per plant recording the greatest relative contribution to the total variation of yield as 17.731, 4.463 and 4.427, respectively. The high contribution of these traits on seed yield/plant and its easily selecting make them most important traits in selection program.

Table 7: The coefficients of determination (CD) and relative importance (RI %) according to path analysis of seed yield and its components in faba bean at genotypic level.

Component	Characters	Association	CD	RI%
Direct effects	Plant height		0.047	4.427
	Branches/plant		0.016	1.564
	Pods/plant		0.047	4.463
	Seeds/plant		0.186	17.731
	100-seed weight		0.001	0.059
Total (direct)			**0.297**	**28.244**
Indirect effects	Plant height via	Branches/plant	0.047	4.484
		Pods/plant	0.090	8.585
		Seeds/plant	0.180	17.161
		100-seed weight	-0.006	0.599
	Branches/plant via	Pods/plant	0.051	4.880
		Seeds/plant	0.100	9.503
		100-seed weight	-0.002	0.199
	Pods/plant via	Seeds/plant	0.180	17.155
		100-seed weight	-0.006	0.523
	100-seed weight	Seeds/plant via	-0.012	1.122
Total (indirect)			**0.624**	**64.210**
Total (direct+ indirect)			**0.921**	**92.454**
Residuals			**0.079**	**7.546**
Absolute total			**1.000**	**100**

Correlation and path coefficient analysis of some yield components

It's cleared that plant height and pods per plant recorded the greatest values for the indirect effects on seed yield via seeds per plant (17.161 and 17.155, respectively). This was followed by the joint effect of branches/plant via seeds per plant (9.503) and plant height via pods per plant (8.585). Generally, these studied traits recorded 92.454% of seed yield variation. The residual component (7.546%) may be contributed to unknown variation (other traits that were not considered in this study).

In conclusion, the present investigation indicated that there is some range of variability in faba bean. Understanding the magnitude of variability and the degree of association between the different characters is important to provide the base for effective selection. Though in the present investigation there is large scope of simultaneous improvement in seed yield as well as other yield components through selection. It is for number of seeds per plant, number of pods per plant and plant height, which showed significant association with seed yield per plant at genotypic level.

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الارتباط وتحليل معامل المرور لبعض مكونات المحصول فى ثلاثة عشائر انعزالية مبكرة من الفول البلدى

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مركز البحوث الزراعية – الجيزة – مصر

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مركز البحوث الزراعية – الجيزة – مصر

أجريت هذه الدراسة خلال الثلاث مواسم 11/2.10 – 13/2012 بمحطة البحوث الزراعية بالجيزة تحت الصوبة السلكية في تصميم القطاعات الكاملة العشوائية في ثلاث مكررات بهدف دراسة التقييم الوراثى لثلاثة عشائر هجينية ناتجة من الجيل الثاني لأربعة أصناف أبوية من الفول البلدى.وكان الهدف من هذه الدراسة تقدير بعض المقاييس الوراثية (كفاءة التوريث بالمعنى الواسع, معدل التحسين الوراثى المتوقع) من خلال التباين ومكوناته (وراثى وبيئى ومظهرى) ، والعلاقة بين المحصول و وخمسة من مكوناته باستخدام معامل الارتباط ، ومعامل المرور.

وقد أوضحت النتائج وجود اختلافات معنوية كبيرة بين التراكيب الوراثية فى العشائر تحت الدراسة مما يدل على وجود تباين ، وقد سجلت الهجن الثلاث تفوقا أعلى من الآباء بالنسبة لجميع الصفات تحت الدراسة عدا صفة وزن–100 بذرة. وقد سجلت كفاءة التوريث بالمعنى الواسع قيما عالية لكل الصفات تحت الدراسة حيث كانت صفة وزن–100 بذرة أقل القيم. وكان معامل التباين المظهرى أعلى دائما من الوراثى . وقد لوحظ اقتران كفاءة التوريث العالية مع معدل التحسين الوراثى المتوقع العالى لصفات عدد البذور/النبات، ووزن المحصول، وعدد القرون/النبات مما يدل على أهمية التأثير الوراثي (المضيف) وتحسين هذه الصفات فى الفول البلدى ربما يتم عن طريق الانتخاب. كما

وجدت علاقة ارتباط معنوية موجبة لجميع الصفات تحت الدراسة عدا صفة وزن 100- بذرة التى أظهرت ارتباط معنوي سالب مع جميع الصفات تحت الدراسة .

وقد اشارت نتائج معامل المرور أن صفات عدد البذور/النبات , وعدد القرون/النبات, وارتفاع النبات هى الاكثر اسهاما بطريق مباشر أو غير مباشر فى محصول النبات من البذور. وعليه يتم أخذ هذه الصفات فى الاعتبار عند تنفيذ برامج التربية لتحسين انتاجية الفول البلدى بالانتخاب لهذه الصفات .