Correlation and Path Coefficient Analysis of Seed Yield and Yield Components in Some Faba Bean Genotypes in Sulaimani Region

Sherwan E. Tofiq[1], Omer K. Aziz[1] and Sazgar H. Salih[2]

[1]Faculty of Agricultural Science, University of Sulaimani, Kurdistan Region – F.R. Iraq

[2]Sulaimani Agricultural Research Center – Sulaimani, Kurdistan Region – F.R. Iraq

***Abstract*—The present study was conducted at Agricultural Research Center of Bakrajo, Sulaimani, Iraq during three successive seasons 2011-2014. This research was conducted using seven faba bean cultivars namely (Zaina, Seher, Yieldiz, Civilla, Luz di Otono, Tanyari and local). The following measurements and observations were made: 100 seed weight, first node height, number of seeds/plant, number of seeds/pod, pod length, number of pods/plant and seed yield. The results indicated that highly significant and negative correlations were presented between 100 seed weight and seed yield, whereas, significant and positive correlations were presented between the numbers of seed/plant and seed yield at the second season. In addition, the results of the third season indicate that the number of seeds/plant correlated significantly and positively with seed yield, and the number of seeds/pod correlated significantly and negatively with seed yield, whereas, number of pods/plant correlated high significantly and positively with the seed yield. The character first node height showed maximum direct effect value in seed yield at the first season and the third season, while number of pods/plant showed maximum direct effect value in seed yield at the second season.**

***Index Terms*—Broad bean, correlation, path analysis.**

I. Introduction

The Faba bean (*Vicia faba* L.) is a pulse crop and one of the most important legume crops in the Mediterranean Basin (Anonymous, 1997). It is one of the major winter sown legume crops, and has considerable importance as a low cost food rich in proteins and carbohydrates (Sepeto_lu and Grain, 2002). It is a diploid species ($2n = 12$). Botanically, it has been divided based on seed size into types as minor, equine and major, even though there is no discontinuity in seed size between them. This species originated in Southwest Asia but its immediate ancestor is not known. On the basis of morphological and geographical considerations, ancestors have been proposed within the species complex *Vicia narbonensis* L. ($2n = 14$) (Hawtin and Webb, 1982). Faba bean, is the only species known in cultivation of section Faba. It was divided two subspecies; *V. faba* subsp. paucijuga Murat and *V. faba* subsp. *faba* L.. The taxon *V. faba* subsp. *faba* L. was classified in three variety groups, var. minor, var. equine and var. *faba* (major). Variety groups were also referred to as tick bean, horse bean or field bean and broad bean (Duc, *et al.*, 2010). Faba bean is a self-pollinating plant with significant levels of outcross and inter-cross, ranging from 20 to 80% depending on genotype and environmental effects (Suso and Moreno, 1999). Faba bean is a grain legume and grown for its high protein content (25.4%) in the seed Karadavut, *et al.*, 2010). Yield improvement is a major breeding objective of most crop improvement programs (Ghobary and Abd-Allah, 2010). Yield in faba bean, similar to the other crops, is a complex trait and constitute by many of morphological and physiological traits. Seed yield is affected by genotype and environmental factors because it is a quantitative trait. Using as selection criteria of characters, direct relationship with seed yield increase the success of selection in plant breeding (Karasu and Oz, 2010). Therefore, progress of breeding in such traits are primarily conditioned by the magnitude and nature of variation and interrelationships among them (Raffi and Nath, 2004).

Mathematical applications have been widely used in different agricultural researches, Hamid and Abdullah (2008) used mathematical models in sustainable agriculture development as indispensable tool to increase the understand of rice growth, whereas different mathematical formulas represented as regression models were used as a non-destructive method for determine log volume for *Melia azedarach*

ARO-The Scientific Journal of Koya University
Volume IV, No 2(2016), Article ID: ARO.10081, 06 pages
DOI: 10.14500/aro.10081
Received 23 April 2015; Accepted 01 June 2015
Regular research paper: Published 20 June 2016
Corresponding author's e-mail: sherwan.tofiq@univsul.edu.iq

L. trees (Amin, 2014) and the leaf area of oleander (*Nerium oleander L.*) plants (Al-Barzinji and Amin, 2016). Another important mathematical application in agriculture is the correlation analysis, which describes the mutual relationship between different pairs of characters without providing the nature of cause and effect relationship of each character. Significant positive correlations were detected between faba bean seed yield and each of number of pods/plant, number of seeds/plant, seed weight/plant and biological yield (Alghamd, 2007). Tadesse, et al. (2011) indicated number of pods/plants, number of seeds/pod, thousand seed weight and plant height had significant association with seed yield/plot. The seed yield/plant exhibited positive and significant correlation with clusters/plant, pod length, plant height, branches/plant, pods/plant and hundred seed weight (Badolay, et al., 2009). Ulukan *et al.* (2003) also found positive and significant relationships between biological yield and plant height and grain number/pod. Keneni and Jarso (2002) indicated positive and significant correlation between Seed yield and number of pods/plant. Simple correlation analysis is not able to provide detailed and actual knowledge in the relation between dependent variable and predictor variables. Hence, the path analysis was also /formed to determine the direct and indirect contribution of each character to seed yield (Chitra and Rajamani, 2010). Path coefficient analysis has been widely used in crop breeding to determine the nature of relationships between grain yield and its contributing components and to identify those components with significant effects on yield for potential use as selection criteria (Mohammadi, et al., 2003). Correlation and path coefficient have been extensively conducted in various legume crops e.g., for instance, Bingliang and Mingliang (2003), Gonçalves, et al. (2003), Karasu and Oz (2010), Salehi, et al. (2010) and Sadeghi, et al. (2011) on bean, Arshad, et al. (2002), Sagir, et al. (2004) on chickpea, Karadavut (2009) on lentil, Ulukan et al. (2003) on faba bean, Hassan, et al. (2003) on mungbean, Nawab, et al. (2008) on pea, Dursun (2007) on bean, Malik, et al. (2007) on soybean etc. This study was aimed to determine the relationship among seed yield and yield components, and their direct and indirect effects of contributing characters to seed yield in faba bean.

II. Materials and Methods

The experiment was carried out at Bakrajo location during three successive seasons 2011-2014. Seven genotypes were used for this study namely Zaina, Seher, Yieldiz, Cirilla, Luz di Otono, Tanyari, and Local variety. The genotypes were arranged in randomized complete block design with three replications. Each ex/imental plot consisted of four rows four m long with inter-row spacing of 40 cm. Seeding rate was applied at the rate of 200 kg/ha and fertilizers were applied at the rate of 100 kg DAP/ha. Weeds were controlled by hand.

A. *Correlation Coefficient (r)*

Phenotypic correlation, the observable correlation between two variables, which includes both genotypic and environmental effects, and genotypic correlation, the inherent association between two variables were estimated using the standard procedure suggested by Miller, et al. (1958). Covariance analysis between all pairs of the variables followed the same form as the variance. Thus, estimates of genetic covariance component between two traits (σg_{xy}) and the phenotypic covariance component (σp_{xy}) were derived in the same fashion as for the corresponding variance components (Tadesse, et al., 2011).

$$r_{gxy} = \frac{\sigma g_{xy}}{\sqrt{\sigma^2 g_{yx} \times \sigma^2 g_y}} \quad (1)$$

$$r_{pxy} = \frac{\sigma p_{xy}}{\sqrt{\sigma^2 p_{yx} \times \sigma^2 p_y}} \quad (2)$$

where, σg_{xy} = genotypic covariance of two variables x and y, and σp

σp_{xy} = phenotypic covariance of two variable x and y.

B. *Path Coefficient Analysis*

Path coefficient analysis is a statistical technique of partitioning the correlation coefficients into its direct and indirect effects, so that the contribution of each character to yield could be estimated. It is used in plant breeding programs to determine the nature of the relationships between yield and yield components that are useful as selection criteria to improve the crop yield. The goal of the path analysis is to accept descriptions of the correlation between the traits, based on a model of cause and effect relationship and to estimate the importance of the affecting traits on a specific trait (Cyprien and Kumar, 2011).

Path coefficient analysis was carried out using the phenotypic correlation coefficients as well as genotypic correlation coefficients to determine the direct and indirect effects of the yield components and other morphological characters on seed yield (Dewey and Lu, 1959).

The path coefficient is as follows;

$$r_{ij} = p_{ij} + \Sigma r_{ik} p_{kj} \quad (3)$$

Where, r_{ij} = mutual association between the independent character i and dependent character i as measured by the correlation coefficients. p_{ij} = components of direct effects of the independent character i on the dependent variable i as measured by the path coefficients, and $\Sigma r_{ik} p_{kj} =$ summation of components of indirect effects of a given independent character i on a given dependent character i via all other independent characters k.

C. The Statistical Techniques

The data of seed yield and its components were analyzed by the following statistical procedures. Significance of correlation coefficients were tested in the probably levels of 0.05 and 0.01. These correlations were further analyzed using path coefficients as illustrated by LI (1968). The path analysis was done as given by Wright, (1921) and elaborated by Dewey and Lu (1959) to calculate the direct and indirect contribution of various traits to yield. Also, the relative importance of direct and indirect effects on seed yield was determined by path analysis. In path analysis, seed yield was the dependent variable and the other traits were considered as independent variables. All of the statistical analysis carried out using SAS 9.2 statistics program.

III. Results and Discussion

Data in Table I, explain the correlation coefficient among the characters for the first season (2011-2012), there were highly significant and positive correlation between the first node height with number of seeds/plant and pod length, while the first node height correlated significantly and positively with number of seeds/pod, and it correlated significantly and negatively with number of pods/plant. The character number of seed/plant associated high significantly and positively with pod length, while significantly and negatively correlated with number of pods/plant. Regarding to the character number of seeds/pod significant and positive correlation was observed with pod length, while highly significant and negative correlation was noticed with number of pods/plant. Pod length correlated significantly and negatively with number of pods/plant.

TABLE I
Correlation Coefficient Among the Characters for the Season (2011 – 2012)

Traits	Seed yield (Kg/ha)	100 seed weight (gm)	First node height (cm)	No. of seeds/ plant	No. of seeds/ pod	Pod length (cm)
100 seed weight (gm)	0.264					
First node height (cm)	0.456	-0.160				
No. of seeds/plant	0.433	-0.046	0.917**			
No. of seeds/pod	-0.340	0.020	0.576*	0.523		
Pod length (cm)	0.331	-0.231	0.970**	0.842**	0.621*	
No. of pods/plant	0.228	0.254	-0.596*	-0.565*	-0.852**	-0.571*

The values do not bear star are not significant.
**Correlation is significant at the 0.05 level (2-tailed), $t_{0.05}(5)$=2.571.*
*** Correlation is significant at the 0.01 level (2-tailed, $t_{0.01}(5)$=4.0*3.

Table II, explain the correlation coefficient among the characters for the second season (2012-2013), it was observed that the seed yield showed highly significant and negative correlation with 100 seed weight, while it correlated significantly and positively with number of seeds/plant. The character 100 seed weight gave highly significant and negative correlation with number seeds/plant. The character firs node height correlated height significantly and positively with pod length. The character number of seeds/plant showed significant and positive correlation with number of pods/plant.

TABLE II
Correlation Coefficient Among the Characters for the Season (2012 – 2013)

Traits	Seed yield (Kg/ha)	100 seed weight (gm)	First node height (cm)	No. of seeds/ plant	No. of seeds/ pod	Pod length (cm)
100 seed weight (gm)	-0.721**					
First node height (cm)	-0.410	-0.069				
No. of seeds/plant	0.618*	-0.651**	-0.419			
No. of seeds/pod	-0.104	0.070	-0.099	0.288		
Pod length (cm)	-0.304	-0.337	0.904**	-0.202	-0.224	
No. of pods/plant	0.030	-0.392	0.095	0.614*	-0.182	0.357

The values do not bear star are not significant.
** Correlation is significant at the 0.05 level (2-tailed), $t_{0.05}(5)$=2.571.*
*** Correlation is significant at the 0.01 level (2-tailed), $t_{0.01}(5)$=4.0*3.

Table III, explain the correlation coefficient among the characters for the third season (2013-2014), it was observed that the character seed yield produced significant and positive correlation with number of seeds/plant, while significantly and negatively correlated with number of seeds/pod and high significantly and positively correlated with number of pods/plant. The character 100 seed weight showed significant and positive correlation with first node height and pod length, while it correlated significantly and negatively with number of pod/plant. Regarding to the character first node height it was correlated high significantly and positively with number of seeds/pod and pod length. The character number of seeds/plant correlated significantly and positively with number of pods/plant. The character number of seeds/pod showed height significant and positive correlation with pod length, while it correlated height significantly and negatively with number of pods/plant. Regarding to the character pod length it showed significant and negative correlation with number of pods/plant. Cokkizgin (2007) also reported significant positive correlation between numbers of seed/plant with seed yield/plant. All other observed relationships among yield components were not significant. There was a significant correlation between biological yield and plant height as it was also reported by Ulukan, et al. (2003). Bianco, et al. (1979) found positive relationships between yield and plant height, number of branches and pods/plant, number of seeds/pod and 1000-seed weight, whereas, seed yield was negatively correlated with flowering date and the lowest node bearing pods. These findings indicate that selection for each or both of number of pods, nodes and biomass would be accompanied by high yielding ability under such conditions.

http://dx.doi.org/10.14500/aro.10081

TABLE III
CORRELATION COEFFICIENT AMONG THE CHARACTERS FOR THE SEASON (2013 – 2014)

Traits	Seed yield (Kg/ha)	100 seed weight (gm)	First node height (cm)	No. of seeds/ plant	No. of seeds/ pod	Pod length (cm)
100 seed weight (gm)	-0.375					
First node height (cm)	0.132	0.080*				
No. of seeds/plant	0.572*	-0.225	0.381			
No. of seeds/pod	-0.559*	0.137	0.691**	0.015		
Pod length (cm)	-0.431	0.524*	0.710**	0.241	0.808**	
No. of Pods/Plant	0.896**	-0.577*	-0.051	0.617*	-0.621**	-0.509*

The values do not bear star are not significant.
** Correlation is significant at the 0.05 level (2-tailed), $t_{0.05}(5)=2.571$.*
*** Correlation is significant at the 0.01 level (2-tailed),$t_{0.01}(5)=4.03$.*

Data in Table IV, explain the path coefficient analysis between seed yield and its components in the first season. The character first node height showed maximum positive direct effect in seed yield with 1.001, while maximum negative direct effect exhibited by the character number of seeds/pod with -1.512. maximum positive indirect effect in seed yield produced by number of pods plant via number of seeds/pod which was 1.288 and followed by pod length via first node height with 0.971. Maximum negative indirect effect in seed yield was shown by pod length via number of seeds/pod with – 0.940.

TABLE IV
PATH COEFFICIENT ANALYSIS FOR THE CHARACTERS ON SEED YIELD AT SEASON (2011 – 2012)

Traits	100 seed weight (gm)	First node height (cm)	No. of seeds/ plant	No. of seeds/ pod	Pod length (cm)	No. of pods/ plant
100 seed weight (gm)	**0.683**	-0.109	-0.032	0.013	-0.158	0.174
First node height (cm)	-0.160	**1.001**	0.917	0.577	0.971	-0.597
No. of seeds/plant	0.015	-0.306	**-0.334**	-0.175	-0.281	0.189
No. of seeds/pod	-0.030	-0.871	-0.791	**-1.512**	-0.940	1.288
Pod length (cm)	-0.091	0.384	0.333	0.246	**0.395**	-0.226
No. of pods/plant	-0.153	0.358	0.339	0.511	0.343	**-0.600**
Seed yield **Correlation**	**0.264**	**0.456**	**0.433**	**-0.340**	**0.331**	**0.228**

Data in Table V, explain the path coefficient analysis between seed yield and its component in the second season. Maximum positive direct effect in seed yield observed by the character number of pods/plant with 19.310, while maximum negative direct effect exhibited by the character number of seeds/plant with – 28.589. Maximum positive indirect effect showed by the character 100 seed weight via number of seeds/plant with 18.622 and followed by the character number of seeds/plant via 100 seed weight with 13.146. Maximum negative indirect effect in seed yield observed by first node height via pod length with -22.410 and followed by number of pods/plant via number of seeds/plant with -17.566.

TABLE V
PATH COEFFICIENT ANALYSIS FOR THE CHARACTERS ON SEED YIELD AT SEASON (2012 – 2013)

Traits	100 seed weight (gm)	First node height (cm)	No. of seeds/ plant	No. of seeds/ pod	Pod length (cm)	No. of pods/ plant
100 seed weight (gm)	**-20.182**	1.388	13.146	-1.409	6.799	7.909
First node height (cm)	-0.525	**7.626**	-3.192	-0.754	6.890	0.725
No. of seeds/plant	18.622	11.968	**-28.589**	-8.238	5.772	-17.566
No. of seeds/pod	0.577	-0.818	2.381	**8.264**	-1.850	-1.506
Pod length (cm)	8.355	-22.410	5.008	5.551	**-24.801**	-8.843
No. of pods/plant	-7.568	1.836	11.865	-3.518	6.885	**19.310**
Seed yield **Correlation**	**-0.721**	**-0.410**	**0.618**	**-0.104**	**-0.304**	**0.030**

Data of path coefficient analysis between seed yield and their components in the third season are presented in Table VI.

TABLE VI
PATH COEFFICIENT ANALYSIS FOR THE CHARACTERS ON SEED YIELD AT SEASON (2013 – 2014)

Traits	100 seed weight (gm)	First node height (cm)	No. of seeds/ plant	No. of seeds/ pod	Pod length (cm)	No. of pods/ plant
100 seed weight (gm)	**-0.180**	-0.014	0.040	-0.025	-0.094	0.104
First node height (cm)	0.101	**1.264**	0.482	0.873	0.898	-0.065
No. of seeds/plant	-0.172	0.292	**0.764**	0.011	0.184	0.472
No. of seeds/pod	-0.176	-0.883	-0.019	**-1.278**	-1.033	0.794
Pod length (cm)	-0.419	-0.568	-0.193	-0.647	**-0.800**	0.407
No. of pods/plant	0.471	0.042	-0.503	0.507	0.415	**-0.816**
Seed yield **Correlation**	**-0.375**	**0.132**	**0.572**	**-0.559**	**-0.431**	**0.896**

Maximum positive direct effect in seed yield sowed by the character first node height with 1.264 , while maximum negative direct effect was -1.278 showed by number of seeds /pod. Maximum positive indirect effect in seed yield showed by pod length via first node height with 0.898 and followed by 0.873 for the character number of seeds/pod via first node height also. The highest negative indirect effect was -1.033 showed by the character pod length via number of seeds/pod. Previous results were obtained by Bakheit and Mahady (1998), Bora, et al. (1988) and Vandana and Dubey (1993). Abdelmula and Abdalla (1994) were reported that the number of pods/plant had the highest direct positive effect (7.02) on grain yield/plant, followed by 100-seed weight, number of branches/plant and number of seeds/pod. On the other hand, grain yield/plant was directly and negatively affected by number of nodes/stem (-2.85) and number of pods/node (-0.21). The highest negative indirect effects on grain yield/plant were caused by number of branches/plant (-6.93),100-seed weight (-5.38) and number of seeds/pod (-4.13), through number of pods/plant. Although number of nodes/stem and number of pods/node showed negative direct effects on grain yield/plant, they had the highest positive indirect effects via number of pods/plant.

IV. Conclusion

Based on the results achieved in this study, it is concluded that yield components are interrelated with each other, and they affect grain yield/plant directly or indirectly, positively or negatively, through each other. It also concluded that the number of seeds/plant appeared to be the highest contributor to the grain yield. Therefore, direct and indirect selection for higher grain yield may be effective for improving this character, as had been shown by Peksen and Gulumser (2005), Sabokdast and Khyalparast (2008) and Atta, et al. (2008) in various studies on legume crops. Selection for increasing seed yield through these traits might be more successful.

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