MULTIVARIATE STATISTICAL ANALYSISOFFABA BEANYIELD AND YIELD COMPONENTS

Ismail S.K.A.,[*] Sahar, A. Farag[**] and Iman Kh. Abbas [**]

*Agronomy Department, Faculty of Agriculture, Fayoum University.

** Center Laboratory for Design & Statistical Analysis Research, Agriculture Research Center, Giza, Egypt.

ABSTRACT

Two field experiments were conducted at Sdment elgabal, Beni-Suef Governorate during the two winter seasons of 2011/2012 and 2012/2013 to evaluate the performance of five faba bean varieties (Giza 2, Giza 40, Giza 429, Giza 843, and Misr1) for seed yield and related traits. Five statistical procedures ,*i.e*., descriptive statistics, simple correlation, multiple linear regression, stepwise regression, factor analysis and path analysis were applied to determine the relationship between faba bean seed yield and its components.

Highly significant and positive associations were detected between seed yield (g/plant) and each of plant height, number of pods/plant and harvest index.

From the multiple linear regression analysis revealed that plant height, number of seed/ pod, weight of seeds/pod, 100seeds weight and harvest index were significantly contributing to seed yield. Stepwise analysis indicated that plant height, number of pods/plant, harvest index and number of seeds/ pod were accepted as major variables contributing to seed yield/plant variation with R^2 =68.9%. Factor analysis classified the eight studied traits into three main factors explaining 70.19% of the total variability in the dependent structure.

Factor 1 was responsible for 26.74% of the total variation in yield and included number of pods/plant and seeds weight /pod. Factor 2 included number of seed/pod and 100-seed weight and contributed by 26.46% of the total variation. Plant height, number of branches/plant and harvest index were the components of the third factor and accounted for 16.99% of the total variation. Path analysis indicated that the highest positive direct effects were scored by plant height, number of seeds/pod, 100-seed weight, harvest index and weight of seeds/pod with relative contribution to total yield variability of 12.13% ,11.78%,7.19%,6.82% and 4.82%, respectively. The greatest components of indirect effects for most traits of 16.45% were shown by number of seeds/pod via 100 seed weight. Consequently, it seems that selection for these last two traits could be useful for improving faba bean productivity.

Keyword :*Faba bean, descriptive analysis, correlation coefficients, stepwise multiple linear regressions, factor analysisand path analysis.*

INTRODUCTION:

Faba bean (*Vicia faba* L.) is one of the most important pulse crop cultivated in Egypt. It is a basic source of high quality and inexpensive protein for middle and low income people. Furthermore, it is known as an atmospheric nitrogen fixer that enriches the soil with nitrogen and organic matter **(Pala *et al*, 1997).** Since, the available water to reclaim more new lands is limited, so it is necessary to increase productivity by choosing the suitable cultural practices such as irrigation regimes, high yielding ability varieties and so on. **Minguez*et al* (1993), AbdAlla and Omran (2002), Ahmed *et al* (2008) and Al Suhaibani (2009)** reported that the shortage of water is considered as a determinant factor on faba bean vegetative growth as well as seed formation.

Improvement of a complex and low heritable trait like yield may be fast successful using indirect selection through other yield components which showed strong association with yield and are more heritable than yield itself. Therefore, finding out the components having the greatest effect on the yield and their relative contributions to yield variation is major importance.

Breeding decisions based only on correlation coefficient may not always be effective since they provide only one-dimensional information neglecting the complex interrelationships among plant traits **(kang, 1994).**

Simple correlation, stepwise multiple linear regression and Path coefficient analyes are statistical techniques applied successfully to identify the relative contribution of some independent variables on a dependent one (**Mohamed 1992 and Ashmawy *et al*. 1998**). Stepwise multiple linear regression is useful in determining the best prediction equation for yield but it could not explain the inter relationship of the measured traits.

Path analysis separates the direct effects from the indirect effects through other traits by partitioning the simple correlation coefficient. The previous two statistical procedures were applied by many investigators in faba bean, such as **Awadalla and Abdel Wahab (1994), Ashmawy*et al* (1998), Salama*et al* (2008) and Tadele *et al* (2011).**

In Egypt, little efforts were done concerning the effect of water limitation on growth and seed yield of faba bean and studying the relationships between seed yield and its components under these conditions.

Therefore, the objective of this study was to investigate the relationships between seed yield and its components using some statistical procedures. The results will help in planning appropriate selection program for improving faba bean crop.

MATERIALS AND METHODS:

Two field experiments were carried out at Sdment elgabal, Beni-Suef Governorate during the two winter seasons of 2011/2012 and 2012/2013 to evaluate the performance of five faba bean varieties i.e. Giza 2, Giza 40, Giza 429, Giza 843 and Misr1.

The relationship between seed yield and its components was studied using five statistical procedures, namely; descriptive analysis, simple correlation, multiple linear regression, stepwise regression, factor analysis and path analysis.

Experimental fieldarea:

The experimental field area was prepared and divided for using randomized complete block design in three replications. Each plot consisted of 5 ridges, 3m long and 0.6m apart (plot area =9 m^2).Seeds were sown in hills spaced 0.2m apart. At harvest, 10 plants were chosen from the inner two ridges to collect data on the following traits:

1- Plant height.	(X_1)	6- Straw weight /plant.	(X_6)
2- Number of branches/plant.	(X_2)	7- 100- Seed weight (g).	(X_7)
3- Number of pods/plant.	(X_3)	8- Straw weight(g/plant).	(X_8)
4- Number of seeds/ pod.	(X_4)	9- Harvest index.	(X_9)
5- Weight of seeds/pod.	(X_5)	10- Seed yield (g/plant).	(Y)

Statistical analysis:

The combined data of seed yield and its components over the two seasons of the study were analyzed by the following statistical procedures:

1. **Simple correlation**: A matrix of simple correlation coefficients between seed yield and its components was computed according to **Snedecor and Cochran (1989).**
2. **Multiple linear regression**: The multiple linear regression and the partial coefficient of determination (R^2) were estimated for each yield component **Snedecor and Cochran, (l98l**). In order to evaluate the relative contribution of each component and to develop a prediction model for seed yield(Y) according to the formula:

$$Y=a+b_1X_1+b_2X_2+b_3X_3+\ldots\ldots\ldots+b_nX_n.$$

Where:

Y= Predicted value ,a= Constant,

b_1= Regression coefficient of X_1,b_2 = Regression coefficient of X_2,

b_3 = Regression coefficient of X_3andb$_n$ = Regression coefficient of X_n.

3.**Stepwisemultiplelinearregressions:**Stepwise program computed a sequence of multiple linear regressions in a stepwise manner. One variable was added to the regression equation at each step. The added variable was the one which induced the greatest reduction in the error sum of squares. It was also the variable which had the highest partial correlation with the dependent variable for fixed values of those variables already added. Moreover, it was the variable which had the highest F- value **Draper and Smith (1981).**

4- **Path analysis:** separates the direct effects from the indirect effects through other traits by partitioning the simple correlation coefficient. Path analysis determines the relative importance of direct and indirect effects on seed yield **(Bhatt, 1973).** In addition, it has been used to organize and present the causal relationships between predictor and response variables through a path diagram based on experimental results or on a priori grounds **(Board *et al.,* 1997).**The two previous statistical procedures were applied by several investigators in faba bean, including **Ashmawy *et al.* (1998) and Salama *et al.* (2008).**

5. **Factor analysis**: Factor analysis **(Cattell, l965)**, reduces a large number of correlated variables to a much small number of clusters of variables called factors. After the loading and calculating of the first factor, the process was repeated on the residual matrix to find further factors. When the contribution of a factor to the total percentage of the trace was less than l0%, the process was stopped. After extraction, the matrix of factor loading was submitted to a varimax orthogonal rotation, as applied by **Kaiser (l958)**.The effect of rotation was to accentuate the larger loadings in each factor and to suppress the minor loading coefficients to improve the opportunity of achieving meaningful biological interpretation of each factor. Thus, factor analysis indicates both groupings and contribution percentages to total variation in the dependence structure. The array of communality, the amount of variance of a variable accounted by the common factors together, was estimated by the highest correlation coefficient in each array.

3. RESULTS AND DISCUSSION:

1- Descriptive statistics :

The descriptive statistics for the studied traits are presented in Table (1).Minimum and maximum values, arithmetic mean and standard deviation (SD) for the estimated variables for each trait were located in the statistically acceptable range indicating the validity of the collected data.

Table (1): The descriptive statistics for studying traits of faba bean over two seasons 2011-2012 and 2012-2013 seasons.

Variables	Statistic			
	Mean	**S.E**	**S.D**	**C.V**
Plant height	73.894	0.418	4.582	6.200
Number of branches/plant	11.575	0.164	1.799	15.546
Number of pods/plant	56.675	0.718	7.865	13.877
Number of seeds/ pod	1.283	0.017	0.191	14.879
Weight of seeds/pod.	15.498	0.231	2.529	16.316
Straw weight /plant	22.465	0.248	2.718	12.098
100 Seeds weight	22.041	0.329	3.608	16.371
Straw weight kg	1830.00	27.516	301.420	16.471
Harvest index	68.514	0.533	4.582	8.515
Seed yield(g/plant)	12.52	0.2044	2.2391	17.884

Where:

S.E=Standard error, S.D=Standard deviation and C.V = Coefficient of the variability.

1.1.Correlation between traits:

Simple correlation coefficients among seed yield(g/plant)of faba bean and its related traits computed and presented in Table (2). These estimates are clearly show that Seed yield(g/plant)exhibited highly significant and positive correlation with plant height (r =0.509**), number of pods/plant (r=0.431**) and harvest index (r=0.414**). **Atta *et al.*(2008)**reported that number of pods/plant had a strong positive and significant relationship with seed yield/ plant. Seed weight/plant had only significant positive association with seed yield(g/plant)recording r value of r=0.312 *.In contrast, the number of seeds/pod showed highly significant and negative correlation with seed yield g (r=-.378**). Similar results were reported by **Naidu *et al* (1985), Mohamed (1992)** and **Ashmawy*et al.* (1998).**

The results clearly indicate that there was insignificant and negative correlation between seed yield (g) negatively with number of branches/plant and positively 100 seed weight. Therefore, faba bean breeder must take in account the interrelationships among the seed yield components when planning the breeding program.

Table (2): Matrix of simple correlation coefficients among yield and its components in faba bean during the 2011-2012 and 2012-2013 seasons.

Variables	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Plant height x_1	1.00						
Number of branches/plantx_2	-.107	1.00					
Number of pods/plant x_3	-.112	-.134	1.00				
Number of seed/ podx_4	-.151	.181	-.164	1.00			
Weight of seeds/podx_5	-.285*	-.116	.696**	-.179	1.00		
100 Seed weight x_6	-.100	-.126	.016	-796**	.368**	1.00	
Harvest indexx_7	-.080	.012	.165	-.048	.267	.169	1.00
Seed yield(g/plant) x_{10}	.509**	-.186	.431**	-.378**	.312*	.150	0.414**

1.2.Multiple linear regression analysis

Data in Table (3) show the regression coefficients and their significance for some agronomic traits in faba bean yield (g/plant)using the `full model regression. The prediction equation was formulated as follows:

The regression equation is:

$SY = -9.147 + .256 X_1 - .048 X_2 + 0.031X_3 – 6.094X_4 + .296 X_5 – .253X_7 + .151X_{٩}$

High significance of the used model (P < 0.01), successfully accounted for 72.3% of the total variation of seed yield expressed as R^2. The residual content (2٨.7%) may be attributed to unknown variation (random errors), human errors during measuring the studied traits and/or some other traits that were not included in the present investigation.

Table (3): Multiple linear regression model to explain seed yield variation using some related traits in faba bean over 2011-2012 and 2012-2013 seasons.

Characters	Regression coefficient (b)	Standard Error (SE)	t- Value	Prob. level (p-value)	Variance Inflation Factor (VIF)
Plant height x_1	.256 **	2.735	9.375	.000	1.267
Number of branches/plant x_2	-.048	6.373	-.760	.449	1.061
Number of pods/plant x_3	0.031	2.694	1.149	.253	3.620
Number of seed/ pod x_4	-6.094 **	133.594	-4.562	.000	5.243
Weight of seeds/pod. x_5	.296 **	8.855	3.339	.001	4.044
Weight of 100 seeds x_7	-.253 **	7.842	-3.224	.002	6.460
Harvest index x_9	.151 **	2.007	7.515	.000	1.106
Intercept	-9.147				
Model sig.	0.000				
R^2	72.3%				
Adjusted R^2	70.6%				

Furthermore, the obtained results indicated that only plant height, number of seeds/pod weight of seeds/pod,100 seed weight and Harvest index significantly contributed towards seed yield (g/plant).

Concerning the multicollinearity, the values of variance Inflation Factor (VIF) for all studied traits were less than 10 indicating a trivial influence of multicollinearity problem. The present results included the goodness of fit for the proposed model of regression.

1.3. The Stepwise linear regression analysis:

Data were subjected to stepwise regression analysis to determine the variables significantly contributing to the total variation in seed yield (g/plant) and estimate their relative contributions. Accepted variables and their relative contributions are shown in Table (4).

Table (4): Regression parameters of the accepted variables according to stepwise multiple linear regression in faba bean over 2011-2012 and 2012-2013 seasons.

Characters	Regression coefficient (b)	Standard Error (SE)	Probability level (p-value)	Partial R^2	R^2	Variance Inflation Factor (VIF)
Plant height X_1	0.270	2.602	0.000	.259	.259	1.049
Number of pods/plant X_3	0.112	1.532	0.000	.241	.500	1.072
Harvest index X_9	0.147	2.028	0.000	.147	.647	1.033
Number of seeds/ pod X_4	-2.476	62.811	0.000	.042	.689	1.060
Intercept	-20.681					
Model sig.	0.000					
R^2	68.9					
Adjusted R^2	67.8					

The results revealed that the most important contributing traits contributing to total variability of seed yield (g/plant) were plant height, number of pods/plant, harvest index and number of seeds/pod. These traits contributed by 68.9% of the variation in seed yield (g/plant). The results in Table (4)also show that in this respect plant height was the most important contributor followed by the number of pods/plant, harvest index and then number of seeds/ pod. The relative contributions to total variation in seed yield(g/plant) for the abovementioned traits were 25.9, 24.1, 14.7 and 4.2% respectively.

These results are in harmony with those obtained by **Mohamed (1992).** The best prediction equation was formulated as follows:

$$SY= -20.681 +0.270 X_1 + 0.112 X_3 + 0.147 X_9 -2.476 X_4$$

1.4.Factor analysis:

The factor analysis technique, used herein divided the seven seed yield components into three independent groups or factors which explain 70.189 % of the total variability in the dependence structure. These factors were determined by applying the principal component approach to establish the dependent relationships between the seed yield attributes in faba bean. Only factor loadings greater than (0.5) were considered important. A summary of the composition of variables of the three extracted factors and their loadings is given in Table (5).

Factor I included two variables which accounted for 26.738% of the total yield variability.

The two variables were number of pods/plant and weight of seeds /pod. The two variables had high loading values in factor I.

Factor II was made up of number of seeds/ pod and 100seed weight. Factor II accounted for 26.459% of the total variability in the dependence structure. The two variables had high communality with factor II. Factor III was responsible for 16.991% of the total variability in the dependence structure. It included three traits, namely: plant height, number of branches/plant and harvest index .These results are in line with those reported by **Gad El-Karim*et al* (1990),Ashmawy*et al* (1998) and Habibi (2011).**

Table (5): Summary of factor loadings for eight traits of faba bean in 2011-2012 and 2012-2013 seasons.

Variable		Loading	Communality	Eigen Values	Variance%
Factor I					
Number of pods/plant	X_3	0.894	0.809	1.872	26.738
Weight of seeds /pod	X_5	0.874	0.842		
Factor II					
Number of seeds/ pod	X_4	-0.774	0.886	1.852	26.459
Weight of 100 seed	X_7	-0.857	0.938		
Factor III					
Plant height	X_1	-0.700	0.571	1.189	16.991
Number of branches/plant	X_2	0.698	0.603		
Harvest index	X_9	0.351	0.265		
Cumulative variance		70.189			

1.5.Path analysis

Information obtained from the simple correlation coefficients can be augmented by partitioning the correlation coefficient into direct and indirect effects for a given set of causal interrelationships. In such situations, the correlation coefficients may be confounded with indirect effects due to common association inherent in trait interrelationships. There for, path coefficient analysis has proven useful in providing additional information that describes the causal relationships such as yield and its components.

In the present investigation, the resultant variable was seed yield (g/plant),while the remaining traits represented the causal variables. The matrices of direct and joint effects for the seven yield-related traits on seed yield(g/plant) are shown in Table (6).

The maximum direct effect was observed for plant height (0.53), followed by harvest index (0.39), weight of seeds /pod (0.33) and number of pods/plant (0.11) .The high positive direct effects of the above mentioned traits, in addition to their highly significant correlation coefficient with seed weight/plant indicated that direct selection through these traits would be effective for faba bean improvement.

Similar results were obtained by **Dursun (2007) and Oz *et al* (2009)**who found the high positive direct effects of the previously by mentioned traits, in addition to their highly significant correlation coefficient with seed weight/plant, and concluded that direct selection through these traits would be effective for faba bean improvement.

Table (6). Path coefficients (direct and joint effects) of seed weight/plant and its related traits in faba bean.

Characters	X1	X2	X3	X4	X5	X7	X9	r_{xy}
Plant height (x1)	0.53	0.00	-0.01	0.08	-0.09	0.04	-0.03	0.51**
No. branches/plant. (x2)	-0.06	-0.04	-0.02	-0.09	-0.04	0.05	0.01	-0.19
No. of pods/plant (x3)	-0.06	0.01	0.11	0.09	0.23	-0.01	0.07	0.43**
No. of seeds/ pod (x4)	-0.08	-0.01	-0.02	-0.52	-0.06	0.32	-0.02	-0.38**
Weight of seeds /pod (x5)	-0.15	0.00	0.08	0.09	0.33	-0.15	0.11	0.31*
Weight of 100 seed (x7)	-0.05	0.01	0.00	0.41	0.12	-0.40	0.07	0.15
Harvest index (x9)	-0.04	0.00	0.02	0.03	0.09	-0.07	0.39	0.41**

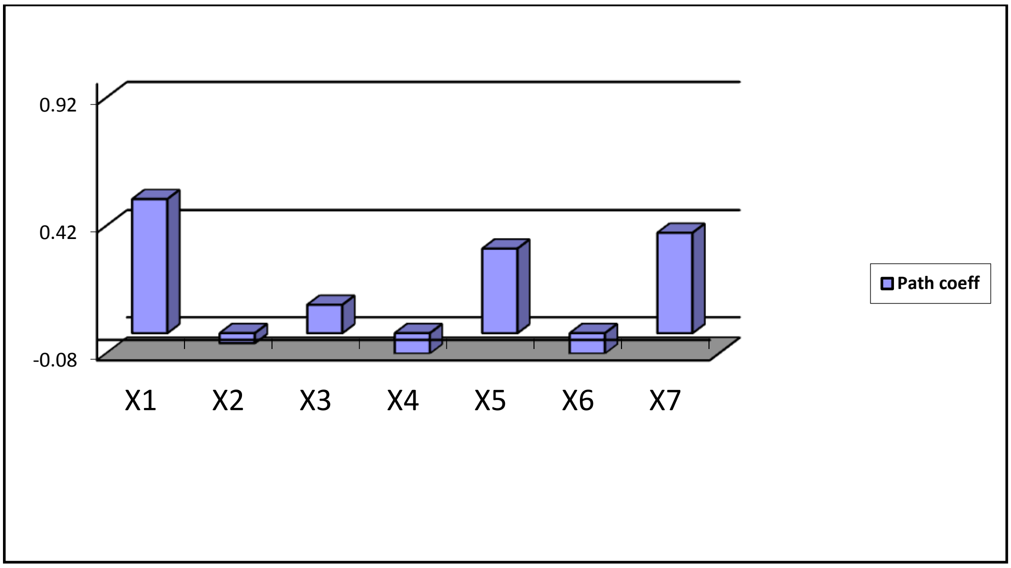

Fig (1): Path coefficients and their correspondinginfaba bean over the 2011/2012 and 2012/2013 seasons.

On the other hand, the direct effects of number of seeds/ pod, weight of 100 seed and number of branches/plant were negative and of secondary importance -0.52, -0.40and-0.04, respectively. In fact, the usefulness of path-coefficient analysis is apparent here. Path coefficients (direct and joint effects) of seed yield (g/plant) and relations between plant height, number of pods/plant and harvest index were highly significantly different and recorded (0.51), (0.43) and (0.41) and were only significant with weight of seeds/pod (0.31).On the other hand, number of seeds / pod was negative and highly significant (-0.38) .Relation between weight 100 seed and seed yield (g/plant) was not significantly different from zero to (0.15), however, the direct effect revealed a negative and moderate relationship between number of branches/plant and Seed yield(g/plant)(-0.19).The correlation coefficients and their corresponding path coefficients are graphically shown in Figure (1).

The coefficients of determination and relative importance, according to path analysis, for seed yield(g/plant) and its related traits are shown in Table (7) .The results revealed that the greatest parts of seeds yield(g/plant) variation were accounted for the direct effects of plant height (12.134) , number of seeds/pod (11.781), 100 seed weight (7.189) ,harvest index(6.817**)** and weight of seeds/plant (4.822).The large contribution of these traits on seed yield(g/plant), plus the ease of visually measuring them supported their importance as selection criteria in faba bean improvement programs. Regarding the relative importance of components of joint effects, it appeared that the highest value was observed for the indirect effect of number of seeds/ pod *via*100 seed weight(14.651%) on seed yield (g/plant) through its association with plant height *via* weight of seeds/pod(4.360%) followed by the joint effect of weight of seeds/pod*via*100 seed weight (4.334%), plant height *via* number of seeds/pod(3.611%). Also, considerable importance was listed for the joint effect of weight of seeds/plant *via* harvest index (3.062%) also, the relative importance of (2.698%), (2.366%) and (2.257) were listed for the joint effects of number of seeds/ pod *via* weight of seeds/plant, 100 seed weight *via* harvest index and number of pods/plant *via* weight seeds /plant, respectively.

Small values of relative importance ranged from 1.868% to 1.455% were obtained by the indirect effects of plant height *via* both 100 seed weight and harvest index, respectively. Generally, the studied traits explained 87.864% of variation in seed weight/plant. According by the residual component (12.136%) may be attributed to unknown variation (random error), human error during measuring traits and/or some other traits that were not under consideration in the present investigation. In fact, path coefficient analysis gave somewhat a different picture than obtained for the correlation coefficient.

Based on the results obtained from the present investigation, it was found that among the components of seed yield (g/plant), number of seeds/pod, weight of seeds /plant and 100 seed weight and harvest index are the most reliable yield components as selection criteria. These traits have a considerable value of genotypic coefficient of variation and also large estimates of heritability coupled with the highest value of genetic advance (%of mean).Furthermore, they reflect highly significant positive correlation with seed weight/plant and their direct effects on yield formation process was also positive and the highest over the other yield attributes. It may be concluded from the present study that number of seeds per pod appeared to be the largest contributor to seed yield. Therefore, direct and indirect selection for high seed yield may be effective for improving through number of seeds/pod, as had been shown by **Peksen and Gulumser (2005), Sabokdast and Khyalparast (2008) and Atta *et al*. (2008),** in various studies on legume crops.

Table (7): The coefficient of determination (CD) and relative importance (RI%) of seed yield components in faba bean.

Characters			Seed yield CD	Seed yield RI %
Direct effects				
Plant height		x1x1	0.275	**12.134**
Number of branches/plant		x2x2	0.001	0.066
Number of pods/plant			0.012	0.545
Number of seeds/ pod			0.267	**11.781**
Weight seeds /pod			0.109	**4.822**
Weight 100 Seeds			0.163	**7.189**
Harvest indexx9x9			0.155	**6.817**
Total (direct)			**0.983**	**43.355**
Indirect effects				
X_1 *via*	Number of branches/plant	x_2	0.004	0.191
	Number of pods/plant	x_3	-0.013	0.576
	Number of seeds/ pod	x_4	0.082	3.611
	Weight seeds /pod	x_5	-0.099	4.360
	Weight 100 seeds	x_7	0.042	1.868
	Harvest index	x_9	-0.033	1.455
X_2 *via*	Number of pods/plant	x_3	0.001	0.051
	Number of seeds/ pod	x_4	0.007	0.319
	Weight seeds /pod	x_5	0.003	0.131
	Weight 100 seeds	x_7	-0.004	0.173
	Harvest index	x_9	0.001	0.016
X_3 *via*	Number of seed/ pod	x_4	0.019	0.831
	Weight seeds /pod	x_5	0.051	2.257
	Weight 100 seeds	x_7	-0.001	0.063
	Harvest index	x_9	0.014	0.636
X_4 *via*	Weight seeds /pod	x_5	0.061	2.698
	Weight 100 seeds	x_7	-0.332	14.651
	Harvest index	x_9	0.020	0.860
X_5 *via*	Weight 100 seeds	x_7	-0.098	**4.334**
	Harvest index	x_9	0.069	**3.062**
X_7 *via*	Harvest index	x_9	-0.054	**2.366**
Total (indirect)			**-0.26**	**44.509**
Total (direct + indirect)			**0.723**	**87.864**
Residuals			**0.277**	**12.136**
Total			**1.000**	**100**

Note: Bold and underline values indicate the highest values of direct and indirect effects.

REFRENCES :

Abd-Alla, A. A. and Omran, M. M. (2002). Response of faba bean varieties to irrigation intervals and some plant spacing in the sandy reclaimed lands. Minufiya J. Agric. 27 (3): 525-540.

Ahmed, A. K., Tawfik, K. M. and. Abd El-Gawad Z. A(2008). Tolerance of seven faba bean varieties to drought and salt stresses. Res. J. of Agric. & Biol. Sci. 4 (2): 175-186.

Al-Suhaibani, N. A. (2009). Influence of early water deficit on seed yield and quality of faba bean under arid environment of Saudia Arabia. Amer. Eurasian J. Agric. & Environ. Sci. 5 (5): 649-654.

Ashmawy, F., Mehasen, S. A. S and Mohamed, M. S. A. (1998). The relative contribution of some characters to seed yield in some faba bean varieties grown under three population densities. Bull., Fac. Agric., Cairo Univ. 49(4): 517 – 532.

Atta B.M , Haq , M.A. and Shah, T.M. (2008). Variation and inter-relationships of quantitative traits in chickpea (*Cicer arietinum* L.). Pak. J. Bot. 40(2): 637-647.

Awadalla, A. A. and. Abdel Wahab H. A(1994). Path coefficient analysis in faba bean. Univ. of Khatoom. J. Agric. Sci. 2(1): 46 – 58.

Bhatt G. M. (1973). Significance of path coefficient analysis in determining the nature of character association. Euphytica 22: 338 – 343.

Board ,J.E , Kang, M.S. and Harville, B.G. (1997). Path analyses identify indirect selection criteria for yield of late-planted soybean. Crop Sci. 37: 879-884.

Cattell R.B. (l965). Factor analysis: an introduction to essentials. l. The purpose and underlying models. Biometrics 2l: l90–2l5.

Draper N.R. and Smith, H. (1981). Applied Regression Analysis. John Wiley and Sons Inc., New York, USA, PP: 397-402.

Dursun A. (2007). Variability heritability and correlation studies in bean **(*Phaseolus vulgaris* L.). genotypes. World Journal of Agric Sci.3 (1):12-16.**

Gad El-Karim,Gh. A. R. A., Thanaa El- Gamal,M., Samia D.Antoun and Hanna L. I. (1990). Factor analysis of yield components in F_2 population of faba bean crosses (*Vicia faba* L.). J. Agric. Sci., Mansoura Univ. 15(12):1947-1952.

Habibi,G. (2011). Influence of drought on yield and yield components in white Bean. W. Aca. Sci., Eng and Tech. 79.

Kaiser, H.F.(l958). The varimax criterion for analytic notation in factor analysis. Psychometricka 23:l87.

Kang, M. S. (1994). Applied Quantitative Genetics. Kang publ. Baton Rouge, LA, USA.

Minguez, M. I., Ruiz-Nogueira, B. and Sau, F. (1993). Faba bean productivity and optimum canopy development under a mediterranean climate. Field Crops Res. 33: 435-447.

MohamedT.A. (1992). Correlation coefficient and step wise regression analysis of yield components in faba bean (*Vicia faba* L.). J. Agric. Sci. Mansoura Univ. 17(2):234-237.

Naidu, M.R., A. Chhabra, Singh,S. and Singh,V.P. (1985). Analysis of yield components in broad bean. .Indian J. of Agric. Sci. 55(4):236-239.

Oz M., A. Karasu, A. T. Goksoy and Turan, Z.M. (2009). Interrelationships of agronomical characteristics in soybean (*Glycine max*) grown in different environments. Inter. J. Agric.& Biol. 11:85-88.

Pala, M., Armestrong, E. and Johanson, C. (1997). The role of legumes in sustainable cereal production in rainfed areas. Linking research marketing opportunities for pulses in the 21st century. In: Knight, R(Ed.), Proceedings of the Third International Food Legumes Research Conference, 22-26 September, Adelaide, Australia.

Peksen ,E. and Gulumser, A. (2005). Relationships between seed yield and yield components and path analysis in some common bean (*Phaseolus vulgaris* L.) genotypes. J. of Fac. of Agric., OMU, 20(3): 82-87.

Sabokdast, M. and Khyalparast F. (2008). A study of relationship between seed yield and yield component in common bean cultivars (*Phaseolus vulgaris* L.). J. Sci. & Technol. Agric. & Natur. Resour. 11(42): 134.

Salama, S. M., A. M. S. A. El- Taweel and Awaad S. S. (2008). Determining the relative contribution of yield components in fababean using some statistical methods. J. Agric. Sci., Mansoura Univ. 33(10): 7063 – 7070.

Snedecor, G.W., Cochran, W.G.(l98l). Statistical Methods, seventh ed. Iowa State University Press, Iowa, USA.

Snedecor, G. W. andCochron W. G. (1989). Statistical Methods. 8th Ed., Iowa State Univ. Press, Ames, Iowa, USA.

Tadele, T., F. Mulusew., L. Teshome and Parven A.(2011). Correlation and path coefficient analysis of yield and its components in faba bean (*Vicia faba* L.) germpasm. Intentional Journal of Biodiversity and Conservation. 3 (8): 376 – 382.

تحليل المتغيرات الإحصائية المتعددة لمحصول الفول البلدي ومكوناته

سمير كامل علي اسماعيل* سحر عبدالعزيز فرج ايمان خليل عباس****

***قسم المحاصيل – كلية الزراعة بالفيوم – جامعة الفيوم**

**** مركز البحوث الزراعية–المعمل المركزي لبحوث التصميم و التحليل الإحصائي –الجيزة–مصر**

اجرى هذا البحث بمحطة البحوث الزراعية بسدمنت الجبل ببنى سويف خلال الموسمين الزراعيين ٢٠١٢/٢٠١١ و ٢٠١٣/٢٠١٢ لدراسة سلوك خمسة سلالات محلية منتخبة من الأصول الوراثية للفول البلدي باستخدام تصميم القطاعات كاملة العشوائية فى ثلاث مكررات وقد درست العلاقة بين المحصول وأهم عوامله باستخدام معامل الارتباط البسيط و الانحدار المتعدد والتعدد المرحلي وتحليل العامل و معامل المرور.

أظهرت النتائج وجود علاقة ارتباط موجب عالية المعنوية بين محصول حبوب النبات وبين كل من ارتفاع النبات وعدد القرون/النبات ودليل الحصاد. وقد اوضحت نتائج تحليل الانحدار المتعدد أن ارتفاع النبات وعدد البذور/قرن ووزن بذور/القرن ووزن ١٠٠ بذرة ودليل الحصاد كانت معنوية الاسهام لمحصول البذور/النبات. كما اوضحت نتائج تحليل الانحدار المتعدد المرحلي ان اكثر الصفات اسهاما في تباين محصول بذور النبات هي ارتفاع النبات وعدد قرون النبات ودليل الحصاد وعدد بذور القرن حيث ساهمت هذه الصفات بحوالى٦٨.٩% من تباين محصول بذور النبات.

أوضحت نتائج تحليل العامل أن الصفات تحت الدراسة تقع فى ثلاث عوامل حيث ساهمت بنحو ٧٠.١٩% من التباين الكلى لمحصول البذور وضم العامل الأول صفات عدد قرون/النبات ووزن بذور/القرن بنسبة ٢٦.٧٤% وضم العامل الثاني صفات عدد بذور/القرن ووزن ١٠٠ بذرة وساهمت بنسبة٢٦.٢٤% من التباين الكلى لمحصول البذور، وضم العامل الثالث ارتفاع النبات وعدد الافرع/النبات ودلبل الحصاد وساهمت بنسبة ١٦.٩٩% من تباين محصول البذور.

ومن نتائج معامل المرور اتضح أن أهم الصفات التى لها تأثير إيجابي مباشر هي ارتفاع النبات وعدد بذور القرن ووزن ١٠٠ بذرة ودلبل الحصاد ووزن بذور القرن بأهمية نسبية قدرت بنحو ١٢.١٣و١١.٧٨ و٧.١٩ و٦.٨٢ و ٤.٨٢ علي الترتيب. وسجل التحليل أعلى تأثير غير مباشر لعدد بذور القرن من خلال وزن ١٠٠ بذرة حيث انها كانت موجبة وقدر الاسهام لكل منها بنسبة ١٤.٦٥%. وعلية يمكن تحقيق تحسين لمحصول البذور بالانتخاب لهاتين الصفاتين.