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DETERMINING THE RELATIVE CONTRIBUTION OF YIELD COMPONENTS IN FABA BEAN USING SOME STATISTICAL METHODS

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ABSTRACT

This investigation was carried out at the Agricultural Research Station of Tag El-Ezz, Dakahlia Governorate during 2006/2007 and 2007/2008 seasons to evaluate the performance of eight genotypes of faba bean namely; Sakha 1, Sakha 2, Nubaria 1, Giza 3, Giza 843, Giza 674, Giza 617 and Giza 2. Also, to investigate the relationship between seed yield/plant and its factors using some multivariate techniques namley; correlation, stepwise, multiple liner regression and factor analysis. The results showed that the studied characters were significantly affected by the tested faba bean varieties. Giza 2 was the earliest one concerning number of days to 50% flowering followed by Nubaria 1 and Sakha 2. Sakha 1 variety gave the highest values for number of branches/plant, plant hight, number of pods/main stem and number of seeds/pod followed by Giza 3 and Giza 716. Giza 3 recorded the highest weight of pods, 100 seed ands seed yield/plant followed by Sakha 1 and Giza 716.

Multiple linear regression and stepwise analysis agreed upon the number of branches/plant, number of pods/main stem, weight of pods/plant and 100-seed weight as major contributions to seed yield variation.

Factor analysis grouped the studied variables in two major factors which altogether accounted for 81.31 of the total variation. The first factor includes number of pods/main stem, number of seeds/pod, weight of pods/plant and 100-seed weight. The second factor included the remaining variables. Factor analysis technique was more efficient than the other techniques. It provides more information about cluster of intercorrelated variables.

INTRODUCTION

Faba bean *(Vicia faba* L.) is the most important (food leguminous) pulse crop grown for seed in Egypt. It is used for human as a source of protein. It is important to increase the productivity of this crop. This could be achieved by two ways, releasing high yielding varieties and application of the appropriate agrotechniques.

Yield is the end product of several characters. Relating these characters to define the most important contributing factors to yield is helpful as selection aids in breeding programs. Correlation coefficient is not only an important statistical procedure used to facilitate breeding programs for high yield, but it is also important to examine the direct and indirect contribution of yield components. Huang *et al*. (1983).

Stepwise is used to determine the best prediction equation that includes the variables accounting for the majority of the total yield variability. Nasr and Geweifel (1991) and El-Sergany (1992) reported that stepwise multiple linear regression was more efficient than the full model regression to investigate the relation between yield and its components. Ashmawy *et* al. (1998), Mehasen and Mohamed (2004) and Abd El-Aziz *et al* (2005) used factor analysis in faba bean and related characters.

Walton (1972) criticized some statistical techniques (correlation, multiple and stepwise regression) and suggested factor analysis as a new technique to identify growth and plant characters related to yield in spring wheat. Denis and Adams (1978) used factor analysis to search for and identify patters of morphological characters in a set of faba bean cultivars which could relate to yield.

The objectives of this study were to (1) Investigate the performance of some faba bean varieties. (2) Study the relationship between yield of faba bean and its factors using different statistical techniques.

MATERIALS AND METHODS

Two field experiments were conducted at the Agricultural Research Station of Tag El-Ezz, Dakahlia Governorate during the two successive seasons of (2006/2007) and (2007/2008) using faba bean *(Vicia faba* L.) eight genotypes namely: Sakha 1, Sakha 2, Nubaria 1, Giza 3, Giza 843, Giza 674, Giza 716 and Giza 2. These genotypes were taken from of Legume Crops Section, ARC. The eight genotypes were sown on November 5th 2006/2007 and November 8th 2007/2008 in randomized complete block design with three replicates. Each plot consisted of 6 rows 3 m long and 0.6 m apart. The distance between plants was 20 cm on two sides of the ridge with 3-4 seeds/hill. Recommended practices were done as usual in faba bean fields. Days from planting to 50% flowering were recorded on plot basis. At harvest, a random sample of 10 guarded plants was collected from each plot to record the following characters:

1- Number of branches/plant
2- Plant height (cm)
3- Number of pods/main stem.
4- Number of seeds/pod
5- Weight of pods/plant (g)
6- 100-seed weight (g)
7- Seed yield/plant (g)

Statistical procedures:

1- Analysis of variance:

Single and combined analysis of variance of randomized complete block design over 2006/2007 and 2007/2008 seasons were performed according to Snedecor and Cochran (1980). Treatment means were compared by using least significant difference test (L.S.D.) at 5% level of significance.

2- Basic statistics and correlation matrix:

Arithmetic mean, standard deviation and standard error were calculated. Simple correlation coefficient was computed between seed yield and its components according to Snedecor and Cochran (1980).

3- Multiple linear regression analysis: between seed yield and the studied characters was performed as applied by Draper and Smith (1966)**.** Partial coefficient of determination (r^2) was estimated for each component to evaluate the relative contribution and to construct a prediction model for seed yield of faba bean.

4- The stepwise multiple linear regressions:

It was carried out to determine the variables accounting for the majority of total yield variability. It was used to compute sequence of multiple regression equation in a stepwise manner (Draper and Smith 1966). At each step, one variable was added to the regression equation, it was the one that caused the maximum reduction in residual sum of sequares. Equivalenty, it was the variables that had the highest partial correlation with the dependent variable adjusted for the variables already added. Similarly, it was the variable which if added, had the highest F value in the regression analysis of variance.

5- Factor analysis:

The factor analysis procedure basically reduces a larg number of correlated variables to a small number of uncorrelated factors (Cattel 1965); when the contribution of a factor to the total percentage of the trace is less than 10%, the process stops.

After extraction, the matrix of factor loading is transmitted to a varimax orthogonal rotation as applied by Kaiser (1958). The effect of rotation is to accentuate the larger loading in each factor and to discard the minor loading coefficient for improving the opportunity to achieve meaning full biological interpetation of each factor. A communality (h^2) is the variance amount of variable accounted for the common factors together. Since the purpose was to determine the way in which yield components are related to each other, yield was not included in this structure.

RESULTS AND DISCUSSION

1- Effect of varieties:

Mean values of yield and related characters of the tested faba bean varieties during 2006/07 and 2007/08 seasons and combined analysis are presented in Table 1. The results indicated clearly that the studied characters were significantly affected by the tested varieties.

The results showed that Giza 2 was the earliest variety where it flowered after 49.29 days after sowing followed by Nubaria 1 and Sakha 2 varieties. Significant differences were found among the tested varieties in number of branches/plant. Sakha 1, Giza 3 and Giza 716 varieties developed more branches per plant than the other tested varieties. Sakha 1 variety gave the tallest plants followed by Giza 3 and Sakha 2. The highest values of number of pods/main stem and number of seeds/pod were recorded by Sakha 1 variety followed by Giza 3 and Giza 716, respectively. Variety of Giza 3 gave the heaviest weight of pods/plant whereas Sakha 1 and Giza 716 ranked second and third, respectively. Differences in weight of 100 seeds due to varieties were found to be significant. Giza 3 variety had the heaviest seeds followed by Sakha 1 and Giza 716 varieties, respectively.

The results in Table 1, show that the effect of the tested varieties was significant on seed yield/plant in both seasons and combined analysis. Giza 3 variety surpassed the other varieties followed by Sakha 1 and Giza 716 varieties, respectively. On the other hand, lowest seed yield/plant was given by Giza 2 variety followed by Giza 674 and Giza 843 varieties, respectively. Similar results were obtained by Ashmawy *et al.* (1998)**.**

Table (1): Mean values of the studied characters as affected by faba bean varieties during 2006/07 (S1) and 2007/08 (S2) and their combined analysis.

Characters	Season	Sakha 1	Sakha 2	Nubaria 1	Giza 3	Giza 843	Giza 674	Giza 716	Giza 2	L.S.D 5 %
Dayes to 50% Flowering (day)	S_1	58.23	53.82	50.89	57.67	55.14	56.16	57.20	49.86	3.33
	S_2	55.41	52.11	50.00	55.23	54.03	54.41	56.13	48.70	2.89
	Comb.	56.62	52.95	50.44	56.45	54.58	55.28	56.66	49.29	2.50
Number of branches/ plant	S_1	3.36	2.44	2.16	3.35	2.99	3.06	3.20	2.09	0.223
	S_2	3.09	2.32	2.11	3.01	2.62	2.85	3.13	2.03	0.242
	Comb.	3.22	2.38	2.14	3.18	2.80	2.95	3.16	2.06	0.236
Plant height (Cm)	S_1	88.91	85.25	81.22	89.55	82.36	82.11	83.01	80.22	3.61
	S_2	86.91	83.22	80.89	86.23	81.56	81.22	82.34	79.00	2.89
	Comb.	87.91	84.23	81.05	87.89	81.96	81.66	82.67	79.61	2.75
Number of pods/main Stem	S_1	8.31	7.00	6.73	8.80	7.15	7.00	7.37	6.45	0.316
	S_2	7.65	6.82	6.25	7.05	6.81	6.54	7.03	6.13	0.402
	Comb.	7.98	6.91	6.49	7.92	6.98	6.77	7.20	6.29	0.400
Number of seeds/pod	S_1	3.48	2.89	2.40	3.54	2.98	2.75	3.11	2.31	0.283
	S_2	3.00	2.55	2.30	2.91	2.50	3.48	2.99	2.25	0.212
	Comb	3.24	2.72	2.35	3.22	2.14	2.63	3.05	2.28	0.201
Weight of pods/plant (g)	S_1	50.89	45.32	40.66	53.11	48.52	43.66	49.09	40.10	3.68
	S_2	47.11	41.63	40.39	47.01	40.17	40.01	47.01	38.72	3.29
	Comb.	49.0	43.47	40.52	50.06	44.34	41.83	48.05	39.41	2.89
100-seed Weight (g)	S_1	74.11	69.10	62.47	75.89	67.07	65.55	68.89	60.57	4.18
	S_2	65.22	63.22	62.05	66.31	61.52	62.02	67.11	55.28	3.52
	Comb.	69.66	66.16	62.26	71.10	64.29	63.78	68.0	57.92	3.71
Seed yield /plant (g)	S_1	46.56	41.12	40.26	48.58	43.12	39.33	43.89	33.95	3.09
	S_2	43.02	39.89	40.09	43.17	36.25	36.18	41.92	33.26	3.12
	Comb.	44.79	40.50	40.17	45.87	39.68	37.75	42.90	33.60	3.10

2-Simple correlation coefficients:

The mean values, standard deviation and standard error for the studied variables are presented in Table 2. The results showed that, relationship between seed yield/plant and seven components was positive and highly significant.This indicates that number of days to 50% flowering, number of branches/plant, plant height, number of pods/main stem, number of seeds/pod, weight of pods/plant and 1000-seed weight has great influence on seed yield/plant. These findings were in accordance with those obtained by Huang *et al*. (1983) Sindhu *et al*. (1985), Ashmawy *et al*. (1998), El-Douby and Mohamed (2002), Mehasen and Mohamed (2004) and Abdel Aziz *et al*. (2005).

3- Multiple linear regression analysis:

The prediction model of seed yield/plant of faba bean and its attributes is shown in Table 3. The prediction equation is formulated as:

$Y = -3.213 + 0.004 X_1 + 0.090 X_2^{**} - 0.011 X_3 + 0.308 X_4^{**} + 0.043 X_5 + 0.093 X_6^{**} + 0.370 X_7^{**}$

The results indicated that 81.7 % of the total variation in seed yield could be linearly related to the studied characters and 18.3 % could be due to residual.

Weight of 100-seed, number pods/main stem, weight of pods/plant and number of branches/plant had the highest partial coefficients of determination r^2= 11.23, 6.62, 5.67 and 2.92 %, respectively. The other

studied characters had little contribution in the total yield variance. The addition of a new variable will always increase R^2 but it will not necessary increase the precision of the estimate of the response. Therefore, the stepwise multiple linear regression analysis was carried out to determine the best variables accounted for the most variation in yield.

Table (2): Simple correlation coefficients, means, standard deviation and standard error for faba bean seed yield and its components over both 2006/2007 and 2007/2008 seasons.

Characters	r value	Mean	Standard deviation	Standard error
1- Number of days to 50% flowering	0.614**	54.05	14.851	2.03
2- Number of branches/plant	0.821**	2.74	1.016	0.121
3- Plant height (cm)	0.542**	83.37	11.59	0.952
4- Number of pods/main stem	0.716**	7.07	1.572	0.143
5- Number of seeds/pod	0.599*	2.78	1.199	0.111
6- Weight of pods/plant (g.)	0.803**	44.58	6.921	0.597
7- 100-seed weight (g.)	0.875**	65.39	14.954	1.032
8- Seed yield/plant (g.)		40.66	16.510	1.220

** **Significant at 0.01 level of significant.**

Table (3): Relative contributions of 7 components in seed yield variation over both seasons of 2006/2007 and 2007/2008 using multiple linear regression analysis.

Characters	Markers	Regression coefficient	Standard error	Relative contribution partial (r^2%)
1- Days to 50% flowering	X_1	0.004	0.003	1.23
2-Number of branches/plant	X_2	0.09	0.003	2.92**
3- Plant height	X_3	-0.011	0.008	0.63
4-Number of pods main/stem	X_4	0.308	0.092	6.62**
5- Number of seeds/pod	X_5	0.043	0.030	0.035
6- Weight of pods/plant	X_6	0.093	0.011	5.67**
7- 100-seed weight	X_7	0.370	0.078	11.23**

Y intercept = -3.213 **Standard error of est. = 0.681**
Adjusted R square = 0.809. **R square= 0.817**
Multiple R= 0.904.

4- Stepwise multiple linear regression analysis:

This approach was used to determine the variables that mostly reduce the total yield variability. This could be achieved by introducing the variables in order of importance.

Either variables acceptance or removal, and relative contributions of variables (R^2%) in predicting seed yield are presented in Table 4. According to these results, 81.3% of the total variation was explained by four accepted variables namely; number of branches/plant, number of pods/main stem, weight of pods and 100-seed weight.

While, number of days to 50% flowering, plant height and number of seeds/pod were removed from the equation due to their non-significant relative contributions. The predication equation was formulated as follow:

$\acute{Y} = -4.502 + 0.090\ X_2 + 0.308\ X_4 + 0.093\ X_6 + 0.370\ X_7$.

Table (4): Accepted variables according to stepwise analysis and their relative contributions (r^2 %) in grain yield variation over both seasons of 2006/2007 and 2007/2008.

Components of accepted variables	Markers	Regression coefficient	Standard error	Relative contributions (Partial %)
1- Number of branches / plant	X_2	0.090	0.003	2.93**
2- Number of pods/main stem	X_4	0.308	0.092	6.66**
3- Weight of pods/plant	X_6	0.093	0.011	5.62**
4- 100 – seed weight	X_7	0.370	0.078	11.24**

Y- intercept = -4.502 **Standard error of est. = 0.680**
R square = 0.813 **Adjusted R square = 0.808**
Multiple R = 0.902

5- Factor analysis:

The results of factor analysis are recorded in Tables 5 and 6. Factor analysis grouped the seven variables into two main factors which accounted for 81.31% of the total variability in dependence structure.

Factor 1 included five variables which accounted for 56.514% of the total yield variation. These variables were number of pods/main stem, number of seeds /pod, weight of pods/plant and 100-seed weight.

Factor 2 included three variables which accounted for 24.80 % of the total yield variability. These three variables were number of days to 50% flowering, plant height and number of branches/plant.

The results indicated that the estimated communalities (Table 5) were adequate for conclusion since both obtained factors contributed at 81.314 % to the total variability of dependent structure.

Factor I had high loadings for the included variables (Table 6). Correlation between these variables and factor I is given by the suitable factor loading. Based on the tested genotypes, selection for number of pods/main stem, number of seeds/pod, weight of pods/plant and 100-seed weight will enable plant breeders to obtain higher yield.

The previous results revealed that factor analysis indicates both grouping and percentage contribution to the total variability in the dependent structure. Using factor analysis by plant breeders has the potential of increasing the comprehension of causal relationship of variables and can help to determine the nature and sequence of characters to be selected in breeding program. This may be helpful in planning appropriate selection strategy to improve faba bean crop.

Table (5): Summary of factor leading for 7 variables of faba bean.

Characters	Factors		Communality (h^2)
	Factor 1	Factor 2	
1- Days to 50% flowering	0.088	0.752	0.561
2- Number of branches/plant	0.056	0.861	0.798
3- Plant height	0.017	0.907	0.652
4- Number of pods/main stem	0.883	0.192	0.835
5- Number of seed/pod	0.872	0.167	0.893
6- Weight of pods/plant	0.751	0.153	0.0747
7- 100-seed weight	0.910	0.099	0.860
Latent roots	2.935	2.411	5.346
Factor variance ratio %	56.514	24.800	81.214

Table (6): Summary of factor loading for 7 variables of faba bean.

Variables	Loading	Total communality	Suggested factor name
Factor 1		56.514	Yield
1- Number of pods/main stem	0.883		
2- Number of seeds/pod	0.872		
3- Weight of pods/plant	0.751		
4- 100-seed weight	0.910		
Factor 2		24.800	Growth
1-Number of days to 50% flowering	0.752		
2- Plant height	0.861		
3- Number of branches / plant	0.907		
Commulative variance		81.314	

It could be concluded that the most important variables over all studied statistical procedures were 100-seed weight number of pods/main stem, number of branches/plant and number of seeds/pod. Results of factor analysis approach were more efficient than other procedures. It provides more information about cluster intercorrelated variables that help plant breeders to determine the nature and important of character in the breeding programs.

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تقدير المساهمة النسبية لمكونات المحصول فى الفول البلدى بإستخدام بعض الطرق الإحصائية

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أجريت هذه الدراسة بمحطة البحوث الزراعية بتاج العز محافظة الدقهلية خلال موسمى ٢٠٠٧/٢٠٠٦ و ٢٠٠٨/٢٠٠٧ لتقييم المساهمة النسبية لأهم مكونات محصول البذور فى الفول البلدى بإستخدم اساليب الارتباط البسيط – الانحدار المتعدد والمرحلى وتحليل العامل. استخدم فى هذه الدراسة ثمانية أصناف من الفول البلدى هى سخا ١ وسخا ٢ ونوبارية ١ وجيزة ٣ وجيزة ٨٤٣ وجيزة ٦٧٤ وجيزة ٧١٦ وجيزة ٢. وأستخدم تصميم القطاعات كاملة العشوائية فى ثلاث مكررات وكانت الصفات تحت الدراسة هى عدد الأيام من الزراعة حتى ٥٠% تزهير وعدد الفروع للنبات وإرتفاع النبات وعدد القرون على الساق الرئيسى للنبات وعدد البذور بالقرن ووزن القرون على النبات ووزن الـ ١٠٠ بذرة ومحصول البذور للنبات وقد أظهرت الدراسة النتائج التالية:

اثرت اصناف الفول البلدى اثرت معنويا على جميع الصفات تحت الدراسة. وكان الصنف جيزة ٢ هو اول الاصناف تزهيرا وتلاه الصنفان نوبارية ١ وسخا ٢ وقد اعطى الصنف سخا ١ اعلى القيم لعدد فروع النبات يليه جيزة ٣ وجيزة ٧١٦ وبالمثل لصفة ارتفاع النبات وتحقق اعلى عدد من القرون على النبات وعدد بذور النبات بزراعة الصنف سخا ١ تلاه الصنفان جيزة ٣ وجيزة ٧١٦ على الترتيب. ولقد سجلت اعلى القيم لصفات وزن قرون النبات ووزن ١٠٠ بذرة ومحصول بذور النبات نتيجة زراعة الصنف جيزة ٣ بينما احتل الصنفان سخا ١ وجيزة ٧١٦ المرتبة الثانية والثالثة لهذه الصفات على الترتيب. وقد اظهرت النتائج وجود إرتباط عالى المعنوية وموجب بين محصول البذور للنبات وجميع الصفات تحت الدراسة. كما كانت نتائج تحليل الإنحدار المتعدد والإنحدار المتعدد المرحلى متفقة على أن عدد الفروع للنبات وعدد القرون على الساق الرئيسى ووزن القرون للنبات ووزن ١٠٠ بذرة هى المكونات ذات الإسهامات الأكبر فى المحصول. وأظهرت نتائج تحليل العامل أن المكونات تحت الدراسة تقع فى عاملين ويضم العامل الأول عدد القرون للساق الرئيسى وعدد البذور بالقرن ووزن القرون للنبات ووزن الـ ١٠٠ بذرة، ويساهم بحوالى ٥٦,١٤%، بينما يضم العامل الثانى عدد الأيام حتى ٥٠% تزهير وإرتفاع النبات، وعدد الأفرع للنبات ويساهم بحوالى ٢٤,٨% من التباين الكلى للمحصول كما اوضحت النتائج ان التحليل يتسع لدراسة مزيد من المكونات حيث أن المكونات المدروسة لم تفسر سوى ٨١,٣١% من التباين الكلى. اوضحت النتائج ان طريقة تحليل العامل أكثر الطرق كفاءة وأنها تعطى معلومات أكبر وأسهل عن المتغيرات المتداخلة.