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A Path Coefficient Analysis Some Yield and Yield Components in Faba Bean (*Vicia faba* L.) Genotypes

[1]Hakan Ulukan, [1]Mustafa Güler and [2]Sıddık Keskin
[1]Department of Field Crops, Department of Biometry-Genetics, Faculty of Agriculture,
University of Ankara, 06110, Dışkapı, Turkey

Abstract: The present study was carried out to investigate a path coefficient with one faba bean cultivar i.e. Filiz 99 and two advanced breeding lines i.e. H_1=PN 55 K.No 584-066 Reine Blance and H_2=PN 54 K.No 7954 x 964-92B. Relationships between yield and yield components were determined by using a correlation and a path-coefficient analysis in 1999-2000. In the investigated characters positive and significant relationships were found statistically between grain number pod^{-1} and pod number plant^{-1}; between biological yield and plant height; between biological yield and grain number pod^{-1}. Direct and indirect effects of plant height, pod length, first pod height and pod number plant^{-1} and grain number pod^{-1} upon biological yield were calculated. The total determination coefficient was found as 0.636 (63.6%) in the model which we used.

Key words: *Vicia faba* L., path coefficient, correlation coefficient, grain yield, yield components, grain protein content

Introduction

Faba bean (*Vicia faba* L.) is a pulse crop that one of the most important legume crops in the Mediterranean Basin (Anonymous, 1997). It is known to be an efficient nitrogen fixer about 80% of nitrogen from the atmosphere and that means 300 kg N/ha/year for a yield of 5000 kg ha^{-1} (Huber *et al.*, 1987), however it depends on availability of *Rhizobium* spp. that colonize the legume plants (Shukla *et al.*, 1987). It has an essential place in regard to multipurpose of their usage as roasted in human diet, dried, green or hay in animal feeding. Straw of it can also be used for brick making and as a fuel in parts of Sudan and Ethiophia. Domestic consumption of dry beans constitutes to rise in response to consumer and scientific recognition of beans as a major health food. Dried seeds have high protein level (18.60-41.00% of Dry Matter %) (Abdallah and Shaaban, 1982; Kaul and Vaid, 1996; Şehirali 1979; Tewatia and Virk, 1996) than other cultivated plants and they are used as food for human nutrition or feed for livestock, with fresh stems and leaves also serves as fodder. As in all cultivated plants, the main objective of the faba bean breeding programme are to overcome the specific problems of this plant (adaptation of current varieties, susceptibility to foliar diseases-*Ascochyta fabace*, *Uromyces viciae* and *Botrytis fabae*), pests, viruses and to get high yield and quality. On the other hand, 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. When studying with correlations it is of prime importance to recognize the nature of the population under consideration (Dewey and Lu, 1959). In addition, simple correlation does not consider the complex relationships between the various characters related the dependent variables (Mebrahtu *et al.*, 1991). Correlation coefficients show relationships among independent variables and the linear relationship between these variables. But, it is not sufficient to describe this relationship when the causal relationship among variables is needed (Korkut *et al.*, 1993). But, reasons of the path analysis usage are different. They could be mentioned as follow (Ariena *et al.*, 1986):

I) To indicate the relative importance of certain factors contributing to yield reduction by any factor,
ii) to unravel opposing effects between variables along different paths of influence, which may obscure the importance of certain factors along those paths and
iii) to determine which variables need to be measured to enable faba bean's biological yield.

In other words, path analysis is used when we want to determine the amount of direct and indirect effects of the variables on the effect component. For this reason Adams (1967), Duarte and Adams, (1972), Gebeyehou *et al.* (1982), Williams *et al.* (1990), Dofing and Knight (1992) and Güler *et al.* (2001) determined the direct and indirect effects of various plant characters on yield and yield components by using path analysis in durum wheat, navy pea, field beans, winter barley cultivars and small grains. Katiyar and Singh (1990) determined that numbers of pod plant^{-1}, harvest index, grain pod^{-1} and grain weight were the major yield components for selection in faba bean. As in previous studies, plant breeder could find well-qualified varieties or certain characters by using path analysis at the terminal selection stage of breeding. In this research, relationships between yield and yield components were investigated to determine which characters directly affected yield primarily and how much faba bean yield variation was apparent in faba bean.

Materials and Methods

The study was carried out at the Experimental Fields of the Department of Field Crops, Faculty of Agriculture, University of Ankara, Turkey during 1999-2000. This study was conducted on brown soils (Table 1). This research was conducted with one faba bean cultivar i.e. Filiz 99 and two advanced breeding lines i.e. H_1=PN 55 K.No 584-066 Reine Blance and H_2=PN 54 K.No 7954 x 964-92B. Cultivar of Filiz 99 was provided from the Seed Testing and Registration Institute, Ankara, Turkey. Lines were taken from the Osman Tosun Gene Bank of the Department of the Field Crops, University of Ankara, Turkey. Sowing was made by hand in 2 m long rows with 0.3 m row spacing (approx. 20 seeds/m^{-2}) on 21th March, 1999. The field experiment was established as a randomized complete block design (RCBD) with 3 replications. Measurements and observations of investigated characters were done on five plants which had been randomly chosen from the mid-row of each plot. The following measurements and observations were made: plant height (cm); pod length (cm); first pod height plant^{-1} (cm); pod number plant^{-1}; grain number pod^{-1} and biological yield (g). Plant height was measured before harvesting and other characters were determined at or after harvest. The effects of investigated characters on biological yield, pod length, first pod height and pod number plant^{-1} and grain number pod^{-1} were determined by using the path analysis (Dewey and Lu, 1959; Duarte and Adams, 1972; Hondelmann and Strauss, 1990; Williams *et al.*, 1990; Dofing and Knight 1992) separately for one faba bean cultivar and two advanced breeding lines. After the test of homogeneity of the variance-covariance matrix of the faba bean genotypes, the calculations related to path analysis were done with 3 blocks and genotypes. In order to determine the relationships among investigated characters, biological yield and correlation coefficients were firstly calculated. In our study path analysis were calculated as follows Li (1975):

Table 1: Soil properties of the research location

Organic matters (%)	1.270
$CaCO_3$ level (%)	7.510
pH	8.290
EC	0.1965 (mmhos/cm^{-1})
Sand (%)	37.65
Clay (%)	23.32
Silt (%)	39.04
Available N (%)	0.064
P (ppm)	12.05
K (ppm)	240.00

$$\text{Biological Yield (Y)} = P_{yx1}X_1 + P_{yx2}X_2 + P_{yx3}X_3 + P_{yx4}X_4 + P_{yx5}X_5 + \text{Error}$$

Where $P_{yxi} = \sigma_{xi}/\sigma_y$ (P_{yxi} is path coefficient of x_i variable, σ_{xi} is the variation (std. deviation) in Y (dependent variable) which was caused by X_i, σ_y is total variation (std. deviation) in Y (dependent variable) which was caused by all X_is. Also, indirect effect of X_i's on biological yield has been calculated. For example the indirect effect of X_i (IE_{yxi}) via X_k on Y can be calculated by the following equation:

$$IE_{yxi} = r_{xixk}P_{yxk} \text{ (I=1...to...k)}$$

k = the number of independent variable (Here, k =5)

Path coefficients were then calculated to understand the direct effects of the characters on biological yield. The path coefficient is known as a standardized partial-regression coefficient (Dofing and Knight, 1992) and separates the direct and indirect effects of a correlation coefficient. Therefore, path analysis plays an important role in determining the degree of relationship between yield and yield components. Path coefficient analysis has been used successfully to determine the relationships among yield and yield components in crested wheat grass, (*Agropyron desertorum*) (Fisch.) Schult., common wheat, (*Triticum aestivum* L.), barley (*Hordeum vulgare*), field beans (*Phaseolus vulgaris*), *Euphorbia lathyris* and Chickpea (*Cicer arietinum*) (Duarte and Adams, 1972), Hondelmann and Strauss, 1990; Garcia del Moral *et al.*, 1985, Dofing and Knight 1992, Torrie and Teng, 1993, Güler *et al.*, 2001.

Results and Discussion

Positive and significant relationships were found statistically between grain number pod^{-1} and pod number plant^{-1}; between biological yield and plant height and

Table 2: Climatic data of the research location

Months	Rainfall	Temperature (°C)	Relative humidity
September 1999	20.8	18.8	55.0
October	43.3	13.9	64.0
November	31.1	6.7	68.0
December	38.9	5.0	73.0
January 2000	47.3	-3.4	79.7
February	42.6	-1.1	77.7
March	41.4	4.5	63.3
April	75.6	13.1	66.3
May	17.3	15.5	59.5
June	34.6	19.8	60.8
July	-	26.5	37.7

Table 3: Descriptive statistics of the variables in investigated faba bean genotypes

Variable	N	Mean	Median	Standart error of mean
Plant hight	34	1.971	2.00	0.834
Pod length plant^{-1} (cm)	34	7.062	7.50	2.914
First pod height plant^{-1} (cm)	34	12.926	12.500	4.739
Pod number plant^{-1} (cm)	34	4.647	4.00	3.014
Grain number pod^{-1}	34	9.150	8.50	6.380
Biological yield (g)	34	790.8	540.0	474.4

between biological yield and grain number pod^{-1} (Table 3). Negative and non-significant relationships were determinated statistically between pod length plant^{-1} and plant height; between first pod height plant^{-1} and plant height; between pod number plant^{-1} and plant height; between pod number and first pod height plant^{-1}; between grain number and first pod height plant^{-1}; between biological yield and pod length plant^{-1}; between biological yield and first pod height plant^{-1} (Table 4). The direct effect of characteristics on biological yield were to be non-significant except for: the direct effects of the plant height on plant height, pod length plant^{-1}, grain number pod^{-1}(Table 5). The direct effect of the plant height on biological yield has the highest value (path coefficient (p.c.)= 0.510**) of the direct effects which were statistically significant and the ratio of the direct effect of the plant height on biological yield is 26.00%. In other words, 26.00% of the variation in biological yield the ratio of the direct effect of plant height on biological yield comes from the direct effects of plant height on biological yield. Thus, increases in the plant height raises biological yield significantly. The direct effect of pod length plant^{-1} on biological yield was negative and statistically significant (p.c.=-0.331*) and the ratio of the direct effect of pod length plant^{-1} on biological yield is 10.96%. Similarly, increases in the pod length plant^{-1} raises biological yield significantly. The direct effect of the pod number plant^{-1} on biological yield is positive and statistically non-significant (p.c.=0.124) and the ratio of the direct effect of the number plant^{-1} on biological yield is 1.53%. That means, increases in the number plant^{-1} not obviously raises biological yield significantly. The direct effect of the grain number pod^{-1} on biological yield is positive and statistically significant (p.c.=0.420**) and the ratio of the direct effect of the grain number pod^{-1} on biological yield is 17.64%. In addition, outside of the diagonally line (Table 5), numbers are shown indirect effects of upon each other. For example, -0.009 is the indirect effect of pod length plant^{-1} via plant height on biological yield. Similarly, 0.238 is the indirect effect of pod number plant^{-1} via grain number pod^{-1} on biological yield.

Discussion

The relations (simple correlations and path coefficients) among the investigated characters were recorded statistically significant (Table 4, 5). Obtained linear relations among investigated characters (correlations) are insufficient in used faba bean genotypes in our research. However, grain number pod^{-1} could be a useful selection criteria for this study because jointed or bilateral relations with this character has been given almost biggest value.

Kuraczyk *et al*. (1989), indicated that seed yield structure was studied by path analysis of 18 yield characteristics of faba bean varieties', number of pods plant^{-1} and number of seeds from the main stem in var. major had the most significant effect on seed yield plant^{-1}. Katiyar and Singh (1990) stated that in 40 indigenious and exotic strains positive and significant association among grain yield and number of pods plant^{-1} or harvest index, pods plant^{-1} was positively correlated with grain pod^{-1} and harvest index, number of grains pod^{-1} was negatively correlated with grain weight, number of pods plant^{-1}, harvest index, grain pod^{-1} and grain weight were the main yield attributes for which selection could be effective. Gyanendra *et al.* (1993), determined that genotypic and phenotypic coefficients of variation were high for seed yield, 100-seed weight and plant weight, seed yield and seed pod^{-1}, but moderate for days to maturity and plant height, seeds pod^{-1} and 100-seed weight. Also, researchers reported that plant height had the highest positive direct effect on seed yield, followed by number of seeds pod^{-1}. Singh (1994), indicated that contribution to yield made by 8 yield components in 40 inbred lines of faba bean and according to his study the ideotype would be early flowering with numerous pods and seeds plant^{-1} and high seed weight. These results are generally similar to previous study findings. Except the grain number pod^{-1}, indirect effects of all dependent variables via grain number pod^{-1}were found high. The total determination coefficient related to biological yield was 0.636 (63.60%). In this case, 63.60% in biological yield variation was due to characters indicated as significant (Table 4). It may be possible to get increases of 63.60 in biological yield by suit selection techniques (primary recurrent selection) on the mentioned

Table 4: Correlation coefficients among the characteristics in investigated faba bean genotypes

Characters	Plant height	Pod length plant^{-1}	First pod height plant^{-1}	Pod number plant^{-1}	Grain number pod^{-1}
Plant height					
Pod length plant^{-1}	-0.018				
First pod height plant^{-1}	0.082	-0.133			
Pod number plant^{-1}	-0.025	-0.200	-0.220		
Grain number pod^{-1}	0.252	0.290	-0.150	0.567**	
Biological yield	0.515**	-0.188	-0.045	0.291	0.528**

* Significant at P<0.05 ** Significant at P<0.01

Table 5: Path coefficients among the characteristics in investigated faba bean genotypes

Characters	Plant height (cm)	Pod length plant^{-1} (cm)	First pod height plant^{-1} (cm)	Pod number plant^{-1}	Grain number pod^{-1}
Plant height	0.510**	0.006	-0.003	-0.003	0.106
Pod length plant^{-1}	-0.009	-0.331*	0.005	0.025	0.122
First pod height plant^{-1}	0.042	0.044	-0.040	-0.027	-0.063
Pod number plant^{-1}	-0.013	-0.066	0.009	0.124	0.238
Grain number pod^{-1}	-0.128	-0.096	0.006	0.070	0.420**

* Significant at P<0.05 ** Significant at P<0.01 Underline indicates direct effects

characteristics in faba bean cultivars. Also, it was essential that the amount of direct and indirect effect of the causal components on the effect component were determined. Hence, the production feasibility of a wide array of leguminous crops, including faba bean, breeding programme was established at the Department of Field Crops, Faculty of Agriculture, University of Ankara, Ankara, Turkey. In the light of the research findings, this breeding programme can be carry out in a very easily and fast way under the field condition without requirement of large labor force, time and money.

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