CORRELATIVE ANALYSIS OF THE RELATIONSHIPS AMONG DIFFERENT YIELD TRAITS IN DRY BEAN

A.V. POP, S. CIULCA

Banat's University of Agricultural Sciences and Veterinary Medicine Timisoara
E-mail: alyn301 @yahoo.com

Abstract: *Common bean is an interesting crop from the point of view of the consumer, farmer and processor. Consequently, breeding program objectives must be designed to address the needs of the farmers who will use the cultivars. An important challenge for dry bean breeders working with certain market classes is the negative association between seed size and seed yield potential. Correlation is a pragmatic approach to develop selection criteria for accumulating optimum combination of yield contributing traits in a simple genotype. To increase yield, the study of direct and indirect effects of yield and its components provide the basis for its successful breeding program and thus increase of bean yield can be more effective ely tackled on the basis of performance of yield components and selection for closely associated traits. The objective of this study was to evaluate the interrelationships between different yield traits in dry bean genotypes from Romania with the purpose to dignify the possibilities of combining these traits in an optimum proportion to improve the yield. For these genotypes about 98 % of the grains yield variability can be explained by the influence of the seven quantitative traits. The number of pods/plant has the highest distinctly significant contribution (54 %) on achieving yield, followed by pod weight with a contribution of 30 % on the total variability. Given the partial and semi partial correlations coefficients between grains weight/plant and other traits, it is noted that the individual relation of each trait is strongly controlled by the influences of the other traits included in the study. Grains weight/pod and grains number/plant have a positive and significant indirect influence on the contribution of other traits to yield achievement. Pod weight affects in a considerable and negative extent the contribution of different traits to yield achievement. It is recommended to obtain and cultivate bean genotypes that possess an optimal number of 4-5 seeds / pod, associated with a pod length of 8-9 cm, which provides more than 30 grains / plant.*

Key words: dry bean, correlations, grains yield,

INTRODUCTION

Common bean is an interesting crop from the point of view of the consumer, farmer and processor (ESCRIBANO *et al* 1997). Each region has different production practices and a unique set of biotic and abiotic constraints. Consequently, breeding program objectives must be designed to address the needs of the farmers who will use the cultivars (SANTALLA et al. 2001; SINGH 2001; KELLY 2001).

An important challenge for dry bean breeders working with certain market classes is the negative association between seed size and seed yield potential (WELSH et al. 1995; WHITE and GONZALEZ 1990). KELLY *et al*. (1998) noted that a lack of desirable alleles for seed yield in dry beans may limit breeding progress. SINGH (2001) noted that most of the genetic variability in common bean has not yet been exploited by breeding programs.

Correlation is a pragmatic approach to develop selection criteria for accumulating optimum combination of yield contributing traits in a simple genotype. The quantification and interpretation of these correlations can result in mistakes on selection strategies, since a high correlation can be the result of a third trait or a group of traits affecting these traits.

To increase yield, the study of direct and indirect effects of yield and its components provide the basis for its successful breeding program and thus increase of bean yield can be more effective ely tackled on the basis of performance of yield components and selection for closely associated traits. In this scenario, multiple regression, partial correlations and path analysis are tools that available to the breeder for better understanding the causes involved in the associations between traits and to partition the existing correlation in direct and indirect effects, through a main variable (MOLINA-CANO *et al.* 1997).

The objective of this study was to evaluate the interrelationships between different yield traits in dry bean genotypes from Romania with the purpose to dignify the possibilities of combining these traits in an optimum proportion to improve the yield.

MATERIAL AND METHODS

The studied material was composed by six varieties and nine lines of dry bean with determinate growth. The experimental design was a randomized complete block (RCB) with three replications, during 2010-2011. From each plot 20 plants were evaluated for the following yield traits: pods number/plant; pod lenght; pod weight; grain number/pod; valves weight; grains weight/pod; grains number/plant; grains weight/plant.

Phenotypic correlations between two traits x and y were calculated by using method of CIULCA (2006). Also, the interrelationships between different traits were analyzed using partial and semipartial correlation coefficient, and path coefficient (HILL, 1974) using:

$$r_{xi} = P_{xi} + \sum_f P_{xj} \times r_{ij}$$

where: i = one of the cause which govern X; j = other causes; P_{ij} = *path* coefficient; r_{ij} = correlation coefficient between i and j; r_{xi} = correlation coefficient between x and i.

The obtained results concerning the spike yield were statistically processed using variance analysis for multiple regressions with seven independent variables.

RESULTS AND DISCUSSIONS

Analysis of variance for multiple regressions regarding the influence of different quantitative traits on grains weight/plant (Table 1) shows that 98 % of the yield variability is due to the influence of the seven traits. Among these, we see that the number of pods has a major and significant contribution (54 %) to achieve grains yield/plant, followed by pod weight which influences an extent of 30% the variability of this trait, while the length pod has a contribution of about 10%.

Table 1

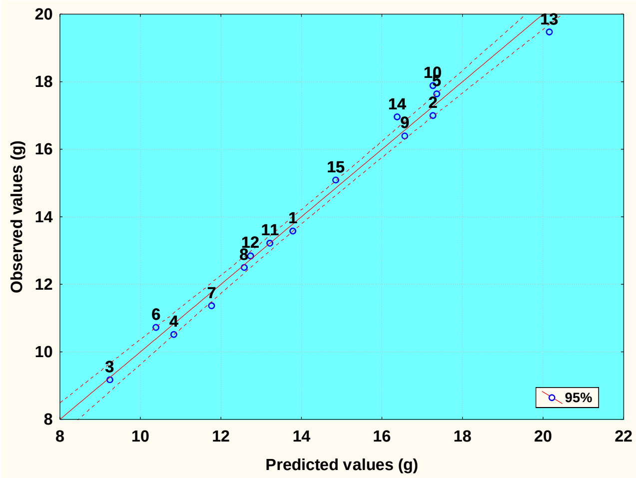
Variance components of multiple regressions between grains weight/plant and other studied traits in dry bean genotypes

Variability sources	SS	DF	MS	F Test
Regresie	137,26	7	19,61	72,76**
Pods number/plant (x_1)	73,82	1	73,82	273,91**
Pod length (x_2)	14,16	1	14,16	52,56**
Pod weight (x_3)	41,33	1	41,33	153,39**
Grains number/pod (x_4)	0,27	1	0,27	1,02**
Valves weight (x_5)	6,41	1	6,41	23,80**
Grains weight/pod (x_6)	0,37	1	0,37	1,39
Grains number/plant (x_7)	0,88	1	0,88	3,27
Residual	1,88	7	0,27	
Total	139,15	14		

$y = -2,28\ -0,006x_1\ -0,053x_2\ -3,737x_3\ -0,24x_4\ +1,024x_5 +3,762x_6 +0,725x_7$;

$R^2 = 0,9864$; $R^2_a = 0,9729$; $R = 0,9932$ SDE= 0,519 g; DW = 2,41; SC = -0,237

The regression model for analyzing the relationship between grains weight / plant and the other traits shows a strong statistical assurance, by assessing this trait with an error of ± 0,519 g. Given the fact that the Durbin-Watson index is greater than 1.4 follows that the possible errors accompanying the experimental results are not auto correlated, and the traits order in regression equation does not affect the estimated values of grains weight/ plant.



1-Star; 2-Diva; 3-Vera; 4-Avans; 5-Ami; 6-Ardeleana; 7- F 1235/91; 8- F 23C/93; 9- F 835/95; 10- F 962/97; 11- F 831/95; 12- F 957/96; 13- F 822/95; 14- F 1247/92; 15- F 504/96.

Fig 1. Observed and predicted values of grains weight/plant according to multiple regression model for dry bean genotypes

According to Fig. 1 it is noted that Ami variety and lines F 962/97, F 1247/92 , F504/96 submit values of grains weight / plant significantly higher than those estimated based on regression model. Also in the case of lines F 822/95 and F 1235/91, the estimated values of yield / plant are significantly lower than those experimentally observed.

Table 2

Correlation coefficients values between yield traits studied in dry bean genotypes

Traits	2	3	4	5	6	7	8
1. Pods number/plant	r =0.260	r =0.216	r =-0.001	r =0.132	r =0.217	r =0.832 ***	r =0.728 **
2. Pod length		r =0.472	r =0.714 **	r =0.354	r =0.444	r =0.627 *	r =0.498
3. Pod weight			r =0.184	r =0.708 **	r =0.970 ***	r =0.283	r =0.772 ***
4. Grains number/pod				r =0.115	r =0.170	r =0.540*	r =0.181
5. Valves weight					r =0.515*	r =0.157	r =0.383
6. Grains weight/pod						r =0.282	r =0.806 ***
7. Grains number/plant							r = 0.721 **
8. Grains weight/plant							

$r_{5\%} = 0.514$; $r_{1\%} = 0.683$; $r_{0.1\%} = 0.760$

Based on data from Table 2 it is noted that the number of pods per plant has a strong positive and statistically assured correlation with the number and weight of grains/plant. It is also notes that the increasing of pod length is associated with a significantly proportional increase of the grains number/pod, with a straight and significant impact on the grains number/plant. The pod weight is strongly correlated with grains weight/pod, but without a significant influence on the grains number/pod.

Analysis of correlation coefficients and covariances indicates that there is a linear relationship between most of the studied traits, so that the extent to which the different traits influencing each other is predictable.

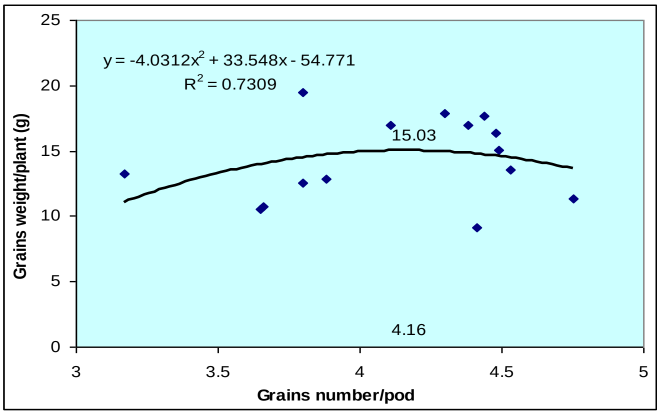


Fig. 1. Regressions between grains weight/plant and grains number/pod in dry bean genotypes

As a whole at the studied genotypes (Fig. 1), due to a nonlinear relationship it is found that the grains number/pod has a positive effect on plant yield to the value of approx. 4.16, where the grains reach a maximum weight of 15.03 g. Due to the higher number of grains/pod, there is a negative correlation between the two traits, which causes a reduction of yield.

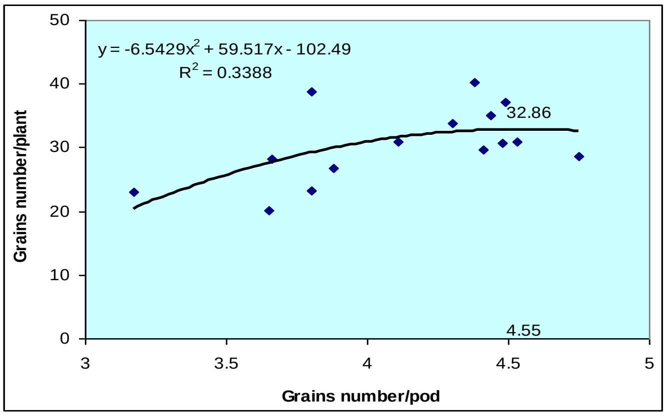


Fig. 2. Regressions between grains number/plant and grains number/pod in dry bean genotypes

Taking into account Figure 2, it is found that the number of grains/pod has a positive effect on grains weight up to the level of about 4.55, where it reaches a maximum value of about 33 grains/plant. In terms of pods with more than 5 grains, there is a negative correlation between the two traits, so that the number of grains/plant decreases.

Given the partial and semi partial correlations coefficients between grains weight/plant and other studied traits Table 3), it is noted that the individual relation of each trait is strongly controlled by the influences of the other traits included in the study.

To establish the extent to which the studied traits contribute to increase plant productivity, the information obtained through correlation were supplemented by "path" coefficients analysis. The "path" coefficients method is based on releasing these correlations in their components, to a direct connection and one or more indirect connection if there are correlations, or causal connections between several traits.

Table 3

Partial and semi partial correlation coefficients between grains weight/plant and other studied traits in dry bean genotypes

Traits	Tolerance ($1- R^2$)	R^2	R	Partial correlations	Semi partial correlations
Pods number/plant	0.0178	0.9822	0.9911	-0.007	-0.001
Pod length	0.2691	0.7309	0.8549	-0.229	-0.027
Pod weight	0.0002	0.9998	0.9999	-0.430	-0.055
Grains number/pod	0.0466	0.9534	0.9764	-0.407	-0.052
Valves weight	0.0027	0.9973	0.9986	0.415	0.053
Grains weight/pod	0.0003	0.9997	0.9998	0.504	0.068
Grains number/pod	0.0120	0.9880	0.9940	0.564	0.080

Thus, in case of the number of pods per plant and pods length it finds the lowest direct effect on yield / plant. Grains weight/pod and grains number/plant have a positive and significant indirect influence on the contribution of other traits to yield achievement. Pod weight affects in a considerable and negative extent the contribution of different traits to yield achievement. The relation between yield/plant and pod length, respectively valves weight are controlled by a powerful effect of suppressor variables, since the values of partial correlation coefficients are higher than those of simple correlation.

CONCLUSIONS

For these genotypes about 98 % of the grains yield variability can be explained by the influence of the seven quantitative traits. The number of pods/plant has the highest distinctly significant contribution (54 %) on achieving yield, followed by pod weight with a contribution of 30 % on the total variability.

Given the partial and semi partial correlations coefficients between grains weight/plant and other traits, it is noted that the individual relation of each trait is strongly controlled by the influences of the other traits included in the study. Grains weight/pod and grains number/plant have a positive and significant indirect influence on the contribution of other traits to yield achievement. Pod weight affects in a considerable and negative extent the contribution of different traits to yield achievement. It is recommended to obtain and cultivate bean genotypes that possess an optimal number of 4-5 seeds / pod, associated with a pod length of 8-9 cm, which provides more than 30 grains/plant.

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