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Short Communication

Correlation and path analysis studies in French bean (*Phaseolus vulgaris)* for yield and yield attributing traits

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French bean (*Phaseolus vulgaris* L.), a type of common bean, is an important legume vegetable crops grown for its tender pods, and is also known as snap bean, garden bean, green bean, edible podded bean, string bean, fresh bean or vegetable bean. The pods of French beans (green, yellow and purple in colour) are harvested when they are rapidly growing, fleshy, tender (not tough and stringy), bright in colour, and the seeds are small and underdeveloped (8 to 10 days after flowering). After that period, excessive seed development reduces quality and the pod becomes fibrous, pithy and tough, and loses its bright colour (Singh and Singh 2015). It is a nutritious legume vegetable as 100 g of tender pods contain 1.7 g protein, 4.5 g carbohydrates, 221 I.U. Vitamin - A, 11 mg vitamin-C and 50 mg calcium. Successful crop improvement programme depends on the nature and magnitude of genetic variability, the degree of transmission of the traits, their correlation and direct and indirect effect on yield, is of greater help in deciding the parents and segregants in the breeding programme. Correlation being an association of two variables and since all the genes affecting the phenotype of the two variables may not be completely linked, the correlation is seldom complete and must be tested for its significance to confirm whether observed correlation is real or by chance. The study of correlation helps breeder in determination of the relationship between various characters and give him a good understanding of the contribution of each character in the genetic makeup of the plant. The correlation measures the relationship between various plant traits and determines the component characters on which selection can be based for genetic improvement in yield. Hence, information regarding the nature and extent of association of morphological characters would be helpful in developing ideal plant type in addition to the improvement of yield. As some times correlation coefficients are not sufficient, in order to get a true picture, the partitioning of correlation coefficients into direct and indirect effects become important. The path analysis provides an effective means of finding out direct and indirect causes of association and permits a critical examination of given correlation and measure the relative importance of each factor. Such information reveals the possibility of simultaneous improvement of various attributes and also helps in increasing the efficiency of selection of complex inherited traits. Therefore, studies were undertaken to work out correlation and path coefficients among different characters.

Twenty-four genotypes were evaluated at the Vegetable Research Farm, Department of Vegetable Science, Punjab Agricultural University, Ludhiana, Punjab during spring season of 2015. The experiment was performed in Randomized Block Design (RBD) with three replications with plot size of 2.8 m^2. Spacing was maintained to 45 cm and 15 cm between rows and plants. Data collected for randomly taken ten plants of each genotype for nine quantitative traits *viz.* days to 50% germination, days to 50% flowering, days to first picking, pod length (cm), pod width (cm), average pod weight (g), number of pods per plant, plant height (cm) and green pod yield per plant (g) along with four quality parameters *viz.* dry matter content, total sugar content, crude protein content and crude fiber content were. Analysis of variance and error variance was tested for homogeneity (Gomez and Gomez, 1984). Correlation coefficients at genotypic and phenotypic levels were calculated according to Al-Jibouri et al. (1958) and path coefficient analysis was done as suggested by Dewey and Lu (1959).

The variance for all the characters was found to be significant, indicating the real difference present in the

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material Delete this table and number other tables accordingly. Phenotypic and genotypic correlations are presented in Table 1. Genotypic coefficients of correlation, in general, were greater in magnitude than the corresponding phenotypic ones, indicating that there was in inherent association among the various characters studies and phenotypic expression of correlation was lessened under the influence of environment. There was highly significant and positive correlation of green pod yield per plant with pod weight (0.585, 0.513), pod length (0.455, 0.408) and pod width (0.395, 0.358) at both genotypic and phenotypic level, respectively indicating mutual association of these traits. It could be suggested from correlation estimates that yield could be improved through selection based on either of these characters. These findings are in agreement with those of Kulaz et al. (2013). The number of pods per plant, crude protein content and crude fiber content were also observed to be positively but not significantly correlated with green pod yield at both genotypic and phenotypic level (Table 1). Similar results were given by Roy et al. (2006) and Verma et al. (2014) who reported positive correlation of green pod yield with protein content and crude fiber content. The characters *viz.* days to 50% germination and days to 50% flowering were found to be negatively correlated with green pod yield indicating that green pod yield was quite high if the 50% germination and flowering appears early and vice-versa. These characters also attributed negative correlation with green pod yield in the study of Devi et al (2015).

Path coefficient analysis determines causal pathways of association. The direct and indirect effects of various characters affecting total yield at genotypic level presented in Table 2. Partitioning total genotypic association between total yield and other characters revealed that maximum direct contribution was made by pod weight (0.892) followed by number of pods (0.575), total sugar content (0.286), crude protein content (0.278) and days to first picking (0.192). High positive indirect effect was found in case of pod weight via pod length (0.607), pod width (0.469%) and days to first picking (0.395). Similar finding were observed in the study of Roy et al. (2006), and Verma et al. (2014).

Table 1: Phenotypic and genotypic correlation among different traits in French bean

Character		Days to 50% germination	Plant height	Days to 50% flowering	Days to first picking	Number of pods per plant	Pod weight	Pod length	Pod width	Dry matter	Total sugar content	Crude protein content	Crude fiber content	Green pod yield per plant
Days to 50% germination	G	1.000	0.150	0.366**	0.326**	-0.343**	-0.055	-0.324**	0.020	-0.277*	-0.145	-0.047	-0.214	-0.081
	P	1.000	0.111	0.345**	0.247*	-0.236*	-0.045	-0.298**	0.020	-0.268*	-0.130	-0.039	-0.186	-0.053
Plant height	G		1.000	0.033	0.059	0.215	-0.006	0.154	0.285*	-0.168	-0.603**	-0.051	0.031	0.121
	P		1.000	0.030	0.024	0.184	-0.008	0.138	0.267*	-0.141	-0.571**	-0.044	0.029	0.103
Days to 50% flowering	G			1.000	1.137**	0.265*	-0.269*	-0.471**	-0.110	-0.173	-0.021	-0.216	0.311*	-0.052
	P			1.000	0.674**	0.199	0239*	-0.407**	-0.093	-0.171	-0.021	-0.199	0.281	-0.028
Days to first picking	G				1.000	0.347*	-0.443**	-0.643**	-0.250	-0.211	-0.052	0.269	0.367	.0.095
	P				1.000	0.277*	-0.267*	-0.398**	-0.135	-0.169	0.040	-0.182	0.257	0.132
Number of pods	G					1.000	-0.158	0.123	-0.098	-0.259*	0.077	-0.629**	0.191	0.075
	P					1.000	-0.079	0.044	-0.068	-0.229	0.068	-0.503*	0.161	0.031
Pod weight	G						1.000	0.680**	0.525**	0.254*	-0.219	-0.011	0.075	0.585*
	P						1.000	0.612**	0.493**	0.242*	-0.208	-0.009	0.081	0.513**
Pod length	G							1.000	0.631**	0.260*	-0.070	-0.005	-0.123	0.455**
	P							1.000	0.582**	0.274	-0.059	-0.006	-0.119	0.408**
Pod width	G								1.000	0.224	-0.377**	0.162	-0.116	0 .395**
	P								1.000	0.199	-0.367**	0.166	-0.107	0.358**
Dry matter content	G									1.000	0.206	0.417**	-0.047	0.084
	P									1.000	0.196	0.381**	-0.045	0.055
Total sugar content	G										1.000	-0.191	-0.228	-0.095
	P										1.000	-.0168	-0.217	-0.099
Crude protein content	G											1.000	-0.137	0.097
	P											1.000	-0.131	0.077
Crude fiber content	G												1.000	0.168
	P												1.000	0.149
Green pod yield per plant	G													1.000
	P													1.000

Critical value of 'r' at 5%= 0.2335 and that at 1%= 0.3040 (* and ** at 5% and 1% level of significance, respectively)

Table 2: Direct and indirect values of genotypic path coefficient for various characters of French bean

Variable	Days to 50% germination	Plant height	Days to 50% flowering	Days to first picking	Number of pods per plant	Pod weight	Pod length	Pod width	Dry matter	Total sugar content	Crude protein content	Crude fiber content	Correlation with green pod yield per plant
Days to 50% germination	**0.061**	0.012	-0.025	0.063	-0.198	-0.050	0.019	0.003	0.013	-0.042	-0.033	-0.022	-0.081
Plant height	0.009	**0.078**	-0.002	0.011	0.012	-0.005	-0.009	0.042	0.079	-0.172	-0.036	0.003	0.122
Days to 50% flowering	0.022	0.002	**-0.070**	0.219	0.153	-0.240	0.0281	-0.017	0.081	-0.006	-0.152	0.032	-0.052
Days to first picking	0.020	0.005	-0.080	**0.192**	0.200	0.395	-0.384	-0.037	0.099	0.015	-0.019	0.378	-.0.095
Number of pods per plant	-0.021	0.017	-0.019	0.067	**0.575**	-0.014	-0.007	-0.015	0.122	0.223	-0.444	0.020	0.076
Pod weight	-0.003	-0.001	0.019	-0.085	-0.091	**0.892**	-0.041	0.078	-0.120	-0.063	-0.008	0.008	0.586*
Pod length	-0.012	0.012	0.033	-0.124	0.071	0.607	**-0.060**	0.094	-0.122	-0.020	-0.004	-0.013	0.455**
Pod width	0.001	0.223	0.008	-0.048	-0.056	0.469	-0.037	**0.149**	-0.105	-0.108	0.114	-0.012	0.395**
Dry matter content	-0.017	-0.13	0.012	-0.041	-0.149	0.227	-0.016	0.033	**-0.470**	0.060	0.294	-0.005	0.085
Total sugar content	-0.009	-0.047	0.002	0.010	0.045	-0.200	0.004	-0.56	-0.097	**0.286**	-0.134	-0.234	-0.095
Crude protein content	-0.003	-0.004	0.153	-0.052	-0.362	-0.010	0.003	0.024	-0.200	-0.006	**0.278**	-0.014	0.098
Crude fiber content	-0.131	0.002	-0.022	0.071	0.101	0.067	0.007	-0.017	0.221	-0.065	-0.097	**0.103**	0.168

*and ** indicate significant at values of P=0.05 and 0.01, respectively
Residual value = 0.264

The results suggested that the character, namely, pod weight, number of pods, total sugar content, crude protein content and days to first picking were the most important and hence selection on the basis of these characters might result in the improvement of the crop. The estimated residual effect was low (0.264), at genotypic bases, which indicated that about 74% of the variability in pod yield per plant was contributed by the plant characters under study. This residual effect (0.264) towards pod yield in the present study might to be due to other characters or environmental factors and or sampling errors.

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