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Research Note

Genetic variability and factor analysis in common bean (*Phaseolus vulgaris* L.) germplasm collection for yield related traits

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Abstract

The present study was undertaken in Kharif 2011 and 2012 at Research Farm of Regional Research station of SKUAST-K at Wadura. The divergence of beans collection comprising 300 genotypes including 297 test germplasm accessions and three checks namely Shalimar Rajmash-1, Contender and Selection-3 was studied using factor analysis. We considered eight quantitative traits related to seed yield namely days to flowering, days to maturity, plant height, number of pods/plant, pod length, seeds/pod, 100-seed weight and seed yield/plant. Analysis of variance revealed that there were significant differences between checks and accessions, between accessions and between checks for all the traits. It indicated presence of substantial amount of variation among the test entries. The factor analysis was based on Pearson correlation matrix and Euclidean distances. Total variance explained with the four PC's was more than 70%. Latent roots (Eigen values) are between 2.318 for the first and 0.112 for the eight. The first component explained 28.976 % of total variation, the second component explained 16.989 %, while as the third and fourth component explained 14.751 and 12.972 % respectively. Days to flowering and days to maturity were the important traits in the first two principal components. 100-seed weight was the important trait in third principal component while the pod length and seeds per pod were important traits in fourth principal component. Combined use of the three seven PC (principal components) could yield a successful selection of genotypes suitable for donors of one or more important traits in breeding.

Key words: *Phaseolus vulgaris*, divergence, quantitative traits, PCA

Common bean is one of the most important summer season pulse crop in India. It is regarded as “Grain of hope” as it is an important component of subsistence agriculture and feeds about 300 million people in tropics and 100 million people in Africa alone. Besides it is emerging as an important income generation especially in Central America. Globally, with 21 million tonnes produced from about 26 million hectares, it accounts for about half of the total pulse production. In India common bean is grown over an area of about 6 million hectares with a production of about 2.5 million tones (FOA, 2010). In the state of Jammu and Kashmir, it is a niche crop valued for its taste and nutritional qualities as a cheap source of protein. The major farming systems having common bean as a component crop are characterized by growing of local landraces that are invariably low yielding, more often disappointingly low, but possess specific adaptation traits that confer niche value. Plant diversity is an important phenomenon on which further progress in crop improvement relies. In a crop like common bean where breeding for a particular set of growing conditions holds promise, it is highly imperative to conserve and use the local populations, since in them the relationships among yield components are balanced and in harmony with the effects of the specific climatic and edaphic factors (Vasic *et al*, 2008). The principal component analysis (PCA), one of Multivariate Analysis methods elucidates among a set of the traits which ones are decisive in genotypic differentiation (Kovacic, 1994). PCA enables easier understanding of impacts and connections among different traits by identifying them and explaining their roles. This method is a powerful multiple method to apply for evaluating yield component (Guertin and Bailey, 1982), identify biological relationships among traits (Acquaah *et al*., 1992), decrease associated-traits to a few factors (Johnson and Wichern, 1996) and description of correlations among variables. Factor analysis has the potential of enhancing our knowledge of causal relationship of variables and can help to know the nature and sequences of traits to be selected for breeding program (Khameneh *et al.,* 2012). The method has been used by many workers in elucidating genotypic differentiations in gene bank collections (Antunes *et al.*, 1981; Acquaah *et al.*, 1992; Brithers and Kelly, 1993 and Vasic *et al.*, 2008). With this background the present investigation was carried out.

The present study was undertaken in Kharif 2011 and 2012 at Research Farm of Regional Research station of SKUAST-K at Wadura (34^{o} 17' North and 74^{o} 33 E at altitude of 1594 m amsl). The divergence of beans collection comprising 300 genotypes including 297 test germplasm accessions and three checks namely Shalimar Rajmash-1, Contender and Selection-3. The material is a part of the common bean collection maintained in *Phaseolus* GeneBank at Regional Research Station of SKUAST-K. The design consisted of 11 blocks containing 30 genotypes in each with 27 new entries and three check entries. Augmented design was followed with three checks. Each genotype was represented by a plot size of 2 x 2 meter dimensions with 5 lines. The plants were space planted for optimal expression of traits and lack of prior knowledge about growth habit of the genotypes. Data was collected from five randomly selected competitive plants on various morphological, maturity, yield and yield contributing traits as per the descriptors developed by CIAT, Colombia, USDA-ARS and other organizations. The analysis of variance was done using WINDOSTAT advanced biometrics software. We considered eight quantitative traits related to seed yield namely days to flowering, days to maturity, plant height, number of pods/plant, pod length, seeds/pod, 100-seed weight and seed yield/plant. The factor analysis was based on Pearson correlation matrix and Euclidean distances. Latent roots or Eigen values for all principal components were shown. The variability of the collection in was interpreted based on the seven principal components. Non-rotated and rotated values of Latent vectors (Component weights, Factor loadings) were shown. The Varimax method (Kaiser and Wilkins, 1990) was used for the rotation of principal components. Both the unrotated and the varimex rotated PCA values were calculated by the statistical package statistiXL.

The substantial variation observed in the present study could be a result of genetic factors as well as the eco-geographic adaptation or both. However, the stability of performance needs to be studied across locations as well as years. Mean performances of the accessions and checks presented in Table . The range of performance was much wider in case of accessions than checks. In fact, the highest performances for individual traits were recorded in case of the accessions. Shahin *et al* (2007) and Sofi *et al* (2011) also reported broad variation pattern in the tested genotypes for morphological, maturity and yield traits. Razvi *et al*. (2012) evaluated some local landraces using morphological parameters and RAPD markers and found significant variation among different ecotypes. Analysis of variance for augmented design (Table 2) revealed that there were significant differences between checks and accessions, between accessions and between checks for all the 24 morphological and eight quantitative characters for which the material was evaluated. It indicated presence of substantial amount of variation among the test entries. The variation can be a result of genetic factors as well as the eco-geographic adaptation or both.

A comprehensive understanding of grain yield components and their effect on the yield is usually obtained using correlation and path analysis. Path analysis shows any yield component compensations when two or more variables either positively increase the yield and/or negatively decrease the yield. In case of studies where a large number of traits are considered simultaneously assuming to have significant effects on yield or other economic traits through direct and indirect effects, it creates a peculiar situation by coming up with a selection index comprising large number of traits. The factor analysis is a method of reducing the large number of correlated traits that define the yield into a small number of uncorrelated factors. The factor analysis divided all the studied variables into main factors.

The number of Principal Components calculated from correlation matrix is 8 which is equal to number of observed traits. PCA concentrated more variability in first principal components. Total variance explained with the first four PC's was more than 70 The criteria followed for selecting the number of principal components (PC) to be included in the future analysis was based on the height of Eigen values of PC or needed summary communality in percentage (Kovacic, 1994). The fact that Eigen values are above 1 indicates that the evaluated principle component weight values are reliable (Mohammadi and Prasanna, 2003). In the principal components where the values of Latent roots (Eigen values) was reduced to less than unity, which in present study occurred after the fourth Principal Component together accounting for more than 70 % of total variance in our common bean collection, the rest of the components were not considered (Table 3). Latent roots (Eigen values) are between 2.318 for the first and 0.112 for the eight. The first component explained 28.976 % of total variation, the second component explained 16.989 %, while as the third and fourth component explained 14.751 and 12.972 % respectively.

Days to flowering and days to maturity were the important traits in the first two principal components. The Trait 100-seed weight was the important trait in third principal component while the pod length and seeds per pod were important traits in fourth principal component. The first four principal components were expressed on the basis of non-rotated values. Certain traits have a high coefficient of correlation with only one Principal Component while as some has lower correlation level with more PC. This is usually overcome by rotation of all the components to have a more clear distribution of particular traits in them, and traits were more closely tied to particular Principal Components (Table 4 and 5).

It is obvious that the variables effective in the first factor had a high level of loading coefficients and contribute much more on the response structure. All of these variables showed significant and positive correlations with grain yield**.** The first, third and fourth PC could be designated as components of productivity as they determine the limits of yield by virtue of containing yield component traits with pronounced loadings before and after rotation. The important traits in these components were number of pods per plant, pod length, seeds per pod and 100-seed weight. Similar results have been reported by Salehi *et al.*, (2008), Vasic *et al.*, (2001) and Vasic *et al.*, (2008) in common bean using multivariate analysis. These traits with the exception of pod length also share positive correlation with seed yield. The second principal component can be designated as the component of maturity since it contains pronounced traits which determine the maturity level. In the highest correlation with this PC are days to flowering and days to maturity. Combined use of the three principal components could yield a successful selection of genotypes suitable for donors of one or more important traits in breeding.

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Table 1. Descriptive statistics of accessions and checks

Trait	Accessions		Checks		SE ±
	Mean	Range	Mean	Range	
Days to flowering	51.78	32 – 91	42.83	32 - 50	0.94
Days to maturity	108.01	78 – 144	98.23	97 - 102	0.79
Plant height	116.79	23.50 - 383.43	70.56	67.89 - 77.90	4.74
Pods per plant	10.51	3.00 - 38.50	9.74	8.22 - 12.78	0.35
Pod length	13.73	6.25 - 17.70	13.89	12.88 - 14.60	3.30
Seeds per pod	3.68	1.37 - 8.25	4.79	4.76 - 5.22	0.06
100-seed weight	32.85	13.56 - 65.64	37.79	35.80 - 42.51	0.52
Seed yield per plant	12.28	2.80 - 51.77	16.93	12.56 - 23.27	0.47

Table 2 . Analysis of variance for eight quantitative traits

Source of Variation	df	Days to flowering	Days to maturity	Plant height	Pods/ plant	Pod length	Seeds/ pod	100 –seed weight	Seed yield/ plant
Blocks (ignoring Treatments)	10	486.74**	220.69**	16149.26**	50.76**	3037.55**	1.19**	318.98**	86.45**
Treatments (ignoring Blocks)	299	268.80**	169.42**	6122.54**	38.21**	3312.88**	0.89**	70.10**	71.79**
Checks + Varieties v/s Varieties	300	266.89**	170.58**	6167.86**	37.96**	3337.41**	0.89**	69.59**	71.04**
Blocks (eliminating Checks + Varieties)	10	6.25	5.26**	81.10**	1.06**	0.41**	0.14**	3.11**	7.57**
Entries (ignoring Blocks)	296	284.70**	176.54**	6654.21**	39.85**	3491.39**	0.93**	80.56**	74.39**
Checks	2	526.93**	12.23**	3.82**	71.69**	1.71**	0.49**	139.21**	175.33**
Varieties	296	275.91**	1687.82**	6513.85**	39.70**	3451.39**	0.81**	77.96**	71.25**
Checks v/s Varieties	1	2165.43**	2581.33**	57711.51**	16.04**	11.09**	33.52**	659.87**	583.60**
Error	20	5.56	10.53	31.23	0.65	0.43	0.05	4.22	1.66

Table 3. Eigen values (Latent roots) and variability of non-rotated values of Principal Components

Principal Component	Latent roots (Eigen values)	Percent variation explained	Cumulative Percentage
PC1	2.318	28.976	28.976
PC2	1.359	16.989	45.965
PC3	1.180	14.751	60.711
PC4	1.038	12.972	73.688
PC5	0.910	11.378	85.066
PC6	0.717	8.910	94.027
PC7	0.366	4.574	98.601
PC8	0.112	1.399	100

Table 4 Non-rotated component loadings (values of principal component traits of common bean)

Variable	PC 1	PC 2	PC 3	PC 4
Days to Flowering	**0.614**	**0.573**	-0.080	0.060
Days to maturity	**0.563**	**0.647**	0.240	-0.034
Plant height	-0.337	0.245	**-0.702**	0.060
Number of pods/ plant	**-0.717**	0.499	0.041	-0.355
Pod length	0.119	0.313	0.116	**0.652**
Seeds/ pod	-0.442	-0.025	-0.207	**0.664**
100-seed weight	-0.309	-0.126	**0.722**	0.190
Seed yield per plant	**-0.832**	0.435	0.210	-0.028
Latent roots	2.318	1.359	1.180	1.038
Percent of variation explained	28.976	16.989	14.751	12.972
Cumulative percentage	28.976	45.965	60.711	73.688
Varimex rotated component loadings				
Days to Flowering	0.169	**0.807**	-0.182	0.041
Days to maturity	0.013	**0.883**	0.104	-0.045
Plant height	-0.272	-0.127	-0.732	0.207
Number of pods/ plant	**-0.929**	-0.046	-0.108	-0.116
Pod length	0.057	0.330	0.114	**0.652**
Seeds/ pod	-0.124	-0.326	-0.137	**0.735**
100-seed weight	-0.230	-0.175	**0.743**	0.181
Seed yield per plant	**-0.926**	-0.141	0.100	0.201
Latent roots	2.318	1.359	1.180	1.038
Percent of variation explained	28.976	16.989	14.751	12.972
Cumulative percentage	28.976	45.965	60.711	73.688