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Genetic Variation of Fababean (*Vicia faba* L.) Germplasm Collection in Eastern India

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ABSTRACT

Variability in 66 accessions of faba bean (*Vicia faba* L.) was assessed for different agro-morphological and quality parameters. Variability parameters, correlation coefficients, clustering and PCA were performed for yield and its contributing parameters. A very good variability was found in number of branches per plant ranged from 5.4 to 14.4, number of nods per main branch from 10.22 to 26.31, no. of pods in main branch varies from 8.61 to 19.65, 1000-seed weight from 271.69 to 390.31and seed yield per plant varied from 31.32 to 100.3.The protein content (%) of the genotypes varies widely from 26.31 to 31.52.Positive and significant correlation coefficients were also obtained between grain yield and 1000-seed weight (r = 0.33**) and number of pods in main branch (r = 0.01*). Principal Component Analysis shows that PC5 explained 62.8% of the total variance and was most closely associated with number of pods per cluster.

Keywords: Faba bean, variability, correlation coefficient, PCA, grain yield

INTRODUCTION

Faba bean (*Vicia faba* L.) is grown over a wide geographical range, such as the Middle East, north Africa, the Mediterranean Region, maritime Europe, southern China and Australia, or a spring sown crop where winters are severe such as continental Europe, northern China and Canada ((Singh *et al*., 2013a, Cubero, 1973 and Abul-Naas *et al*., 1989). It is grown under either rainfed or irrigated conditions (Singh *et al*., 2013a).The average world production of faba bean for 2009-2011 was 4.1 million metric tonnes (mmt) and about 25% of world faba bean production is internationally traded, with Egypt being the major importer and France, U.K. and Australia the major exporters. Genetic diversity within faba bean programs is important as this would enable better characterisation of the various agro-morphological traits, sources of resistance to diseases for the sustainable development of new varieties, and also enable marker based selection to be adopted in breeding programs to increase efficiency of selection and reduce the confounding effect of environmental variation that reduces heritability and slows genetic gain (Ladizinsky, 1998).Therefore, the main objective of this work was to characterize and evaluate the faba bean genetic resources present in India. Major emphasis in the study included the characterization of phenotypic variation in the collection. As a result, we hope to assist breeders in identifying the important trait specific useful materials.

MATERIALS AND METHODS

The experiment was conducted at National Bureau of Plant Genetic Resources, New Delhi during Rabi season in 2012-13 and 2013-14. The material of the study consists of 66fababean germplasm accessions. The experiment was laid out in Augmented Block Design with 66 accessions and 2 checks (Vikrant and PRT 12). Each genotype was sown in three rows of 4m length plot and having spacing of 50cm between lines and 15cm between plants. Normal cultural practices were followed to raise a good crop. Hand weeding method was used to control weeds. Border effect was removed by taking observations on middle plants in a row. A morphological characterization was carried out in these accessions and observations were recorded for five randomly selected plants in each accession traits as per descriptors for faba bean crop developed by IBPGR (1982).The characteristics evaluated are listed in Table 1.The mean data were used in this paper for correlation and cluster analysis. The data for the quantitative characters were analysed by determining mean, minimum, maximum and coefficient of variation (CV%).The ANOVA was computed by using SAS 9.3 (2001) computer software package.

RESULTS AND DISCUSSION

All the evaluated parameters for the quantitative characters in respect of 66 accessions are shown in table 2. With respect to phenology of plant, the variations in these traits were defined as low, intermediate, and high, depending on the ranges of the traits and coefficient of variation (CV). Wide variation was observed in nine traits, including plant height, leaflet length, leaflet width, no. of node per main branch, no. of pod per cluster, flower length, pod length, pod width and no. of ovules per pod as depicted by CV values showed low rangesand low CV values (<20 %). Because of low variations, improvement of these traits may be limited especially those with economic importance such as pod length and no. of pod per cluster

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Table 1: Morphological traits recorded in the faba bean accessions during 2012-13 and 2013-14

Traits Recorded	Code	Description
Plant height (cm)	PH	Measured at near maturity from ground to the tip of the plant
Number of branches per plant	P B	Total number of branched originated from the basal nodes
No. of Node/main branch	NB	Number of nodes up to and including first flowering node
Leaflet Length (cm)	LL	Length of basal pair of leaflet at secondary node
Leaflet width (cm)	L W	Width of basal pair of leaflet at secondary node
Flower Length (cm)	F L	Length of standard
No. of Pod in main branch	P M B	Number of pods on main branch
No. of Pod per Cluster	P C	Total number of pods counted per node
Pod length (cm)	PL	Length between the peduncle to the beak of pod
Pod width (cm)	PW	Width measured from suture to suture of pod
No. of ovules per Pod	OP	Number of ovules with seeds counted per Pod
Seed yield per plant (g)	G Y	Dry seed weight from individual plant
1000 -seed weight	SW	Weight of 1000 dry seeds

(Mulualem *et al*., 2013).

The results revealed that there was good variability in number of branches per plant ranged from 5.40 to 14.40, number of nods per main branch from 10.22 to 26.31, no. of pods in main branch varies from 8.61 to 19.65, 1000-seed weight (g) from 271.69 to 390.31and seed yield per plant (g) varied from 31.32 to 100.32 and were intermediate (CVs between 20 and 30 %). The result more or less agreed with that reported by Swarup and Changle (1962).

Results for quality parameters obtained in this study (Table 2) revealed that the fat content (%) ranged from 1.26 to 2.19.Faba bean contains high quality protein. The protein content of the genotypes varies widely from 26.31% to 31.52%. Phytochemical analysis was also done with respect to available carbohydrate and total starch. There was very good variability within the germplasm for protein content ranging from 16.90 to 31.52%. It is a good source of both soluble and insoluble dietary fiber. Results presented in table 3 confirmed wide variation in dietary fiber ranged from 19 to 22.93%, available carbohydrate 32.19 to 47.17%, total starch ranged from 34.92 to 41.86%. Total phenols were varied from 10.89 to 13.67 mg/g and total flavonol content was ranged from 0.25 to 0.34 mg/g. These values were corresponds to the earlier reported by Singh *et al.* (2014) for these traits.

Complete correlation coefficients among traits under investigation are presented in Table 4. The objective was to explore which traits are well associated and meaningful for breeding. Correlation result, suggested that increased plant height coupled with more number of branches per plant (r = 0.35**) and enhanced chlorophyll content (r = 0.34**) trait should be paid attention while breeding for enhanced seed yield. The estimates of correlation coefficient for leaf length had positive and significant correlations with leaflet width (r = 0.79**), number of node/main branch (r = 0.40**), flower length (r = 0.25*). Number of node/main branch had high negative correlation coefficients with plant height (r = -0.28**), but had positive and significant correlations with leaflet length (r = 0.40**) and leaflet width (r = 0.24*). The estimates of correlation coefficient for grain yield was well associated with number of pods per cluster (r = 0.23*) and 1000- seed weight (r = 0.28*).

This indicated that genotypes having large flowers, leaflet length, leaflet width and more number of nods per branch are high yielding. Bianco *et al.* (1979) also revealed the positive relationships between yield and plant height, number of branches and pods/plant, number of seeds/pod and 1000-seed weight. These findings indicate that selection for each or both of number of pods, nodes and biomass would be accompanied by high yielding ability under such conditions.

Multivariate analysis of the accessions revealed that the first five Principal components (PC1 to PC5) gave Eigen-values > 1.0 and cumulatively accounted for 62.8% of the total variation. The negative contribution of PCs in explaining the variation for each character is given in table 3. Principal components (PC) analyses showed that the first five PCs accounted for 62.8% of the total variance.PC1 explained 17.0% of the total variance with greater influence on leaflet length, leaf width and number of nods per main branch. PC2 accounted for 15.9% of the total variance and was positively correlated to number of branches per plant, pod length, pod width and number of ovules per pod. PC3 explained 11.7% variance with plant height and chlorophyll content.

PC4 explained 10.2% of the total variance and was most closely associated with 100-seed weight and grain yield while PC5 accounted for 8% the total variance and was very closely associated with flower length and number of pods per cluster. The results clearly showed that PC1 was closely associated with the vegetative traits, PC2 for yield contributing characters and PC5 explained the variance for the floral traits. Veasey *et al*. (2001) conducted principal component analysis in *Sesbania* and obtained similar trend.

CONCLUSION

The present study showed the wide ranges of variations for most of the agro-morphological and quality traits among faba bean genotypes and opportunities of the genetic gain through selection or hybridization. The germplasm collection has wide variability in total protein content, dietary fiber and available carbohyderate content. The correlation analysis showed the positive correlation of grain yield with most variations attributed to number of pods per cluster on the main stem and 1000 seed weight. The above traits are highly recommended for use in faba bean characterisation, conservation and for crop improvement programme.

Table 2: Variation in Mean, Range and Coefficient of variation (%) for different agro-morphological traits and different quality parameters within faba bean germplasm

Traits	Mean	Range		CV
		Min.	Max.	
Agro-morphological traits				
PH	92.44	83.53	104.93	5.05
LL	6.74	5.21	8.28	10.37
LW	2.87	2.20	3.71	10.19
PB	9.07	5.40	14.40	20.75
NB	17.28	10.22	26.31	19.62
FL	2.73	2.36	3.06	5.42
CHL	9.58	4.93	23.83	35.95
PC	2.53	2.13	3.00	5.61
PMB	13.48	8.61	19.65	20.03
PL	4.28	3.29	5.42	10.08
PW	8.72	7.76	10.85	6.30
OP	3.44	3.07	4.00	5.87
SW	27 1.69	1 27 .30	390.31	18.88
GY	73.78	31.32	100.32	20.54
Quality Parameters				
Moisture (%)	9.05	8.10	10.46	11.12
Ash (%)	3.14	2.42	3.60	14.86
Fat (%)	1.66	1.26	2.19	25.11
Protien (%)	26.31	16.90	31.52	25.89
Dietary Fiber (%)	21.38	19.00	22.93	7.44
Available carbohyderate (%)	38.46	32.19	47.17	16.75
Total soluable sugar (%)	8.95	7.69	9.48	7.26
Total starch (%)	37.42	34.92	41.86	7.48
Phosphorus (%)	0.18	0.15	0.25	19.41
Phytate	0.65	0.52	0.87	19.41
Total phenol (mg/g)	12.57	10.89	13.67	8.61
Total flavonol (mg/g)	0.28	0.25	0.34	14.05

Table 3: Vector loading, eigen value and percentage of variation explained by first five principal components and correlations between PC scores and agronomic traits

Traits	PC1	PC2	PC3	PC4	PC5
PH	-0.22	0.31	**0.40**	0.10	0.01
LL	**0.55**	-0.07	0.20	0.05	0.10
LW	**0.48**	-0.01	0.32	-0.06	0.15
PB	-0.14	**0.39**	0.16	0.21	-0.04
NB	**0.42**	-0.09	-0.10	0.17	0.03
FL	0.20	-0.01	0.34	0.28	**-0.52**
CHL	-0.18	0.08	**0.53**	0.20	0.2 8
PC	-0.05	-0.18	-0.06	0.21	**0.76**
PMB	-0.24	**-0.30**	0.02	0.14	-0.14
PL	0.08	**0.53**	-0.19	0.00	0.11
PW	0.28	**0.38**	-0.25	-0.06	0.01
OP	-0.03	**0.41**	-0.13	-0.02	0.06
SW	-0.02	-0.07	-0.38	**0.52**	-0.13
GY	0.05	0.06	-0.10	**0.67**	0.03
Eigenvalue	**2.39**	**2.23**	**1.63**	**1.43**	**1 .12**
Percent	**17.05**	**15.91**	**11.67**	**10.21**	**7.99**
Cum Percent	**17.05**	**32.96**	**44.64**	**54.84**	**62.83**

*, ** Significant at 5% and 1% probability, respectively

Dendrogram

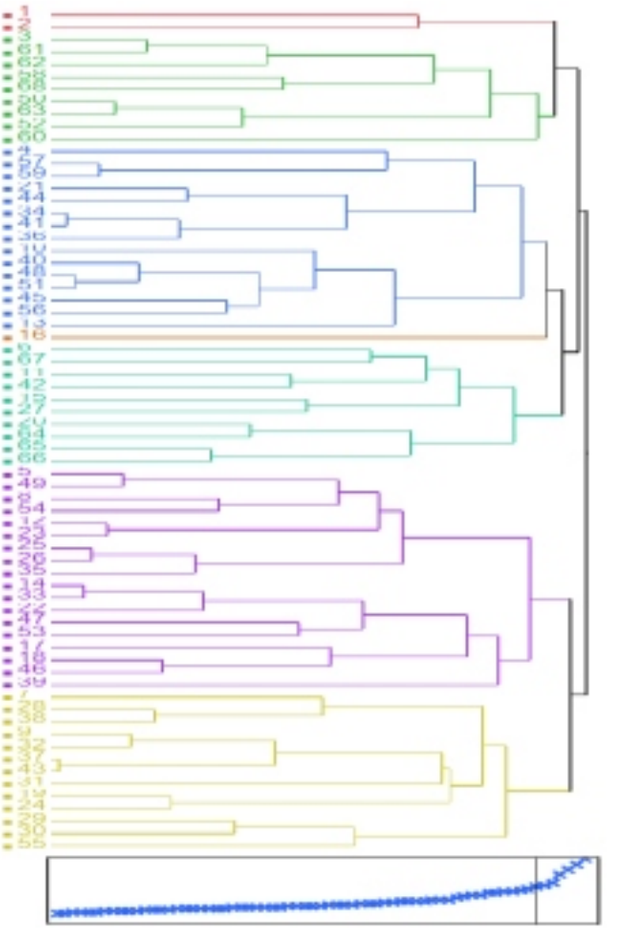

Fig. 2 Dendrogram generated through wards cluster technique

Table 4: Correlations between different agro-morphological traits for faba bean germplasm lines collected from different parts of India

Traits	PH	LL	LW	PB	NB	FL	CHL	PC	PMB	PL	PW	OP	SW
LL	-0.16												
LW	-0.06	0.79**											
PB	0.35**	-0.20	-0.06										
NB	-0.28*	0.40**	0.24*	-0.12									
FL	0.09	0.25*	0.17	0.07	0.23*								
CHL	0.34**	-0.06	0.04	0.21	-0.18	0.12							
PC	-0.07	0.00	-0.04	-0.07	0.10	-0.18	0.12						
PMB	-0.05	-0.13	-0.15	-0.09	-0.19	-0.03	0.03	0.07					
PL	0.18	0.02	0.03	0.30**	-0.03	-0.09	-0.05	-0.11	-0.27				
PW	-0.03	0.17	0.13	0.18	0.19	0.00	-0.24*	-0.11	-0.33**	0.48**			
OP	0.14	-0.05	-0.07	0.15	-0.06	-0.09	0.07	-0.14	-0.14	0.47*	0.18		
SW	-0.18	-0.01	-0.13	-0.01	0.03	-0.04	-0.16	0.11	0.13	0.02	-0.10	0.02	
GY	0.04	0.06	-0.04	0.10	0.13	0.10	0.09	0.23*	0.01	0.05	0.09	0.01	0.28*

*, ** Significant at 5 and 1% probability, respectively

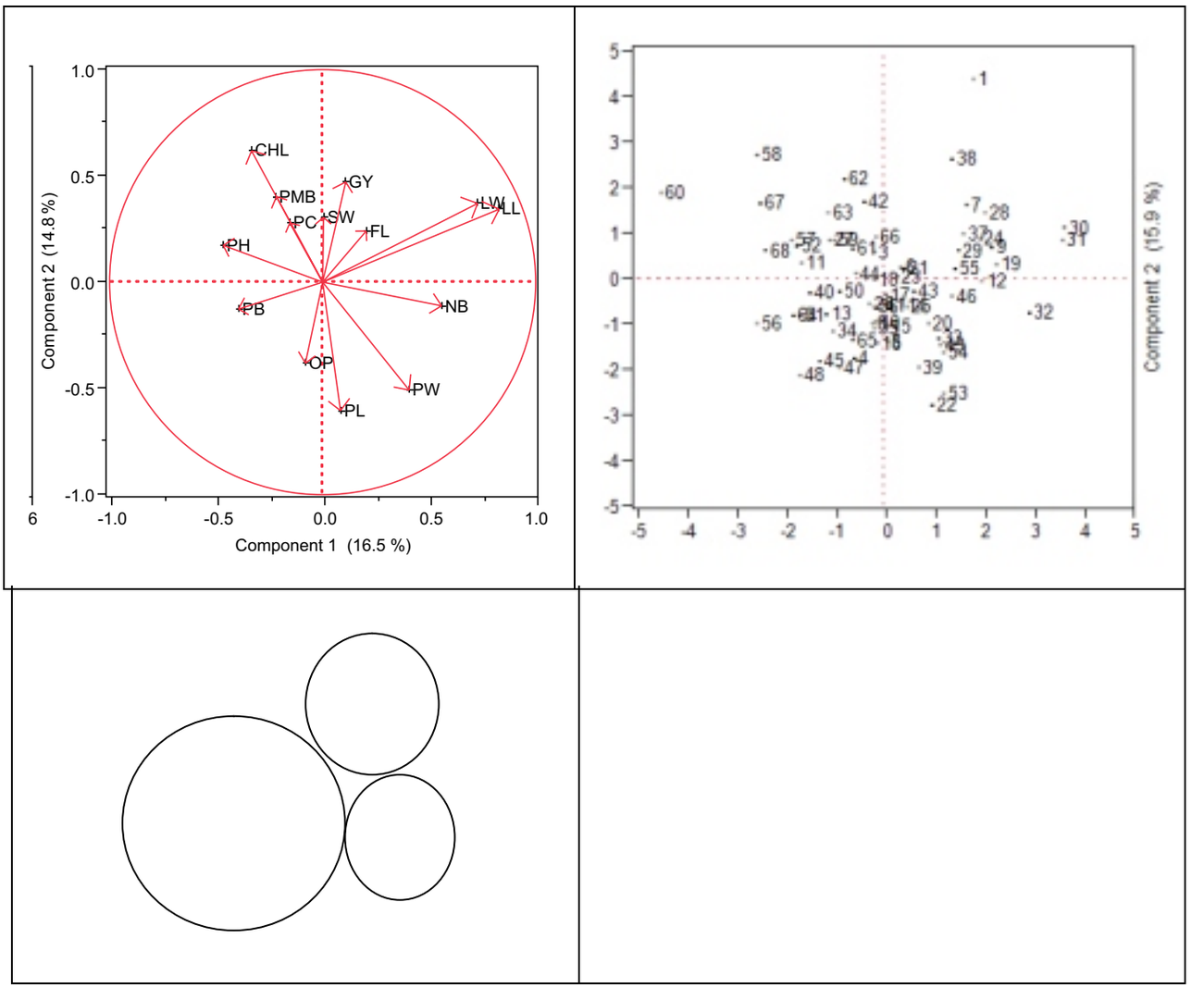

Fig. 1: Two dimension plot of Principal Component Analysis (PCA) clustering based on morphological similarity of *Vicia faba* germplasm in India**:** *PL=pod length, PW= pod width, NB= number of nodes on main branch, LL= Leaf length, LW= leaf width, FL= flower length, GY= grain yield/plant, GW= 1000-grain weight, PC= no.of pods per cluster, PMB= no. of pods on main branch, PH= plant height, PB= no. of branches per plant, OP= no. of ovules with seeds per pod*

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