



Genetic variability and character association studies in French bean (*Phaseolus vulgaris*) in Nilgiri hills of Tamil Nadu

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ABSTRACT

In the present investigation, the genotypic and phenotypic coefficients of variation, heritability, correlation and path coefficient analysis were worked out for yield and its contributing characters of 77 French bean (*Phaseolus vulgaris* L.) genotypes at Horticultural Research Station, TNAU, Udahgamandalam, Nilgiris, Tamil Nadu, India in 2018 with the objective of identifying desirable traits contributing to higher yield in French bean. Phenotypic coefficient of variation was slightly higher than genotypic coefficient of variation for all the characters suggesting the presence of environmental influence to some extent in the expression of these characters. High heritability along with high genetic advance as per cent of mean was observed for plant height, pods per plant and seed yield per plant indicating that these characters would be amenable for phenotypic selection. A considerable amount of genetic variability was observed among all the genotypes for all the characters under study. Genotypic coefficients variance and Phenotypic coefficients variance were highest for seed yield per plant followed by biological yield and number of pods per plant. High genetic advance coupled with high heritability were observed for plant height, days to 50% flowering, number of primary branches per plant, pod length, pod girth, seeds per pod, number of pods per plant, biological yield and seed yield per plant. Combined results of correlation coefficient and path analysis revealed that pods per plant, pod length, pod girth, biological yield and seed yield are major component traits for improvement of grain yield. The present findings could be useful in selecting superior genotypes in French bean breeding programmes.

Key words: Coefficient of variation, French bean, GCV, Heritability, PCV

French bean, *Phaseolus vulgaris* L. (2n=2x=22) belonging to the family Leguminosae is known by various names, viz. common bean, Frase bean, green bean, haricot bean, kidney bean, rajma, snap bean. It is a dual-purpose legume grown as pulse as well as vegetable crop. It has the potential to meet out challenges of malnutrition. The yield of French bean is low in India as compared to other countries due to lack of high yielding varieties. The narrow genetic base of French bean cultivars provide the task to breeders to broaden the genetic diversity through collection of exotic cultivars, landraces and wild common beans or to create it through induced mutation. Several authors have studied the genetic variability in French bean (Choudhary

et al. 2016, Ramandeep et al. 2018). A critical assessment of nature, magnitude of variability and character association is a pre-requisite to make efficient breeding methods. Greater variability increases the genetic potential and gives wider scope for selection. Seed yield is a complex trait which is a final product affected by a large number of its components. The analysis of various yield contributing characters and their interrelationship can be of immense help in selecting desirable genotypes for high yield. Path analysis showing direct and indirect effects are effective to get high selection response simultaneously for several characters from the diverse populations. The information related to nature and extent of association among various yield attributes, direct and indirect effect of each component on yield are helpful in formulating effective breeding strategy. Thus, the present study was undertaken to identify traits contributing to higher yield in French bean.

MATERIALS AND METHODS

Seventy seven genotypes of French bean (*Phaseolus vulgaris* L.) were grown in a randomized block design with three replications during the year 2018 at Horticultural Research Station, TNAU, Udahgamandalam, Nilgiris, Tamil Nadu. The farm is located at 11.4° to 11.5°N latitude. The

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elevation is 1500 m amsl. The annual rainfall varies between 1600–1800 mm. The mean temperature ranged from 21°C to 32.2°C (Day); 9°C to 18°C (Night). The relative humidity ranged from 58 to 75%. Each genotype had 3 rows of 3 m length with a spacing of 60 × 30 cm. The crop was well managed for optimum growth and yield. The observations were recorded on five random plants from each plot for 24 characters described in Table 1. The coefficients of variability were calculated following the methodology given by Burton and De Vane (1953). Heritability and genetic advance under selection were calculated according to Lush (1949). Correlation coefficients were computed according to the method given by Searle (1961). Path coefficient analysis was carried out as per Dewey and Lu (1959).

RESULTS AND DISCUSSION

Phenotypic Coefficient Variance (PCV) and Genotypic Coefficient Variance (GCV): Analysis of variance revealed highly significant differences among the genotypes for all the traits studied. The estimated mean, range, phenotypic and genotypic coefficients of variability, heritability and expected genetic advance for all the traits are presented in Table 1 revealed sufficient variability present in the germplasm for all traits. This variability can be utilized effectively to develop high yielding genotypes through hybridization followed by selection. Phenotypic coefficient variance (PCV) for all traits except sulphur content were higher than their corresponding coefficients of genotypic coefficient variance (GCV) indicating the influence of environmental factors on the expression of these traits. The phenotypic coefficient of variation was high for seed yield per plant, iron content, zinc content, single pod weight, 100-seed weight, biological yield per plant, number of leaves per plant; plant height and number of pods per plant and days to harvest had low estimates of PCV. Similar trend was observed for genotypic coefficient of variation (GCV) for almost all the traits, though they were slightly low compared to PCV. These results were in conformity with the findings of Jhanavi *et al.* (2018), Anju *et al.* (2000), Junaif *et al.* (2010) and Ahmed (2011).

Heritability estimates: The heritability estimates help the breeders in selection based on the phenotypic performance. The heritability estimate (Table 1) was the highest for zinc and iron content (99.84%). The character days to 50% flowering (11.20) showed low heritability. High heritability for these traits was also reported earlier by Prakash *et al.* (2015) and Prasanth and Sreelatha (2014). Though high heritability indicates the effectiveness of selection on the basis of phenotypic performance, it does not show any indication of the amount of genetic progress for selecting the best individuals.

Genetic Advance (GA): High genetic advance was observed for seed yield per plant (98.04), iron content (93.08), zinc content (90.44) (Table 1). Protein content (18.43), seeds per pod (17.49) and leaf chlorophyll content (12.31) had moderate genetic advance.

Growth characters: Days taken to germination, plant

Table 1 Estimates of genetic parameters for growth, yield and yield attributes in French bean

Character	PCV	GCV	Heritability % (H)	GA % of mean
Days to germination	6.94	4.44	40.89	5.85
Plant height (cm)	28.58	26.43	89.45	50.33
No. of leaves/Plant	37.56	33.86	81.27	62.89
Leaf chlorophyll content	6.50	6.23	91.88	12.31
Days to 1st flowering	5.03	2.26	20.22	2.09
Days to 50% flowering	3.51	1.17	11.20	0.81
Days to 1st picking	3.49	3.31	89.81	6.46
Days to harvest	2.95	1.77	35.97	2.18
Primary branches/plant	16.72	12.74	58.07	20.01
No. of pods/plant	22.11	20.32	84.41	38.45
Pod length (cm)	19.17	15.08	61.88	24.44
Pod girth (cm)	14.77	8.34	31.87	9.70
Single pod weight (g)	40.06	38.22	91.05	75.13
Pod yield/plant (g)	45.35	44.84	97.75	91.33
Seeds per pod	18.27	12.45	46.47	17.49
100 seed weight (g)	40.03	38.83	94.11	77.60
Seed yield/plant (g)	49.74	48.66	95.68	98.04
Biological yield/plant (g)	38.10	37.22	95.42	74.90
Harvest Index (%)	33.67	33.26	97.57	67.68
Protein content (%)	9.32	9.13	96.02	18.43
Phosphorus content (%)	19.30	19.22	99.19	39.44
Sulphur content (%)	6.04	35.99	99.73	74.03
Zinc content (mg/kg)	43.98	43.94	99.84	90.44
Iron content (mg/kg)	45.25	45.22	99.84	93.08

height, number of pods per plant, single pod weight, 100 seed weight, seed yield per plant, biological yield per plant, phosphorus content, sulphur content, zinc content and iron content had high heritability coupled with high genetic advance indicating that these characters to be under additive genetic control and simple selection would be effective for their improvement. Leaf chlorophyll content, days to first picking and protein content showed high heritability estimates accompanied with moderate to low genetic advance as percentage of mean. This reflects the presence of non-additive gene effects. Selection based on such traits may not be rewarding. These findings are in conformity with Rai *et al.* (2006) and Prakash *et al.* (2014)

The estimation of correlation coefficient has been done at both phenotypic and genotypic levels. The results indicated that the values of genotypic correlation were higher than their phenotypic counterparts indicating the inherent relationship among the characters studied. Correlation studies showed that for most character pairs, genotypic and phenotypic

associations were in same direction. This indicated that though there was high degree of association between two variables at genotypic level, its phenotypic expression was deflated by the influence of environment. This indicated a greater role of non-genic factors in determining these associations, which reflected that the environment may deviate the expression of genotypic association.

Yield characters: Seed yield per plant exhibited highest significant positive association with 100-seed weight (0.861) followed by single pod weight (0.857), biological yield per plant (0.740), pod girth (0.537), no. of seeds per pod (0.457), plant height (0.448), no. of pods per plant (0.425), days to 50 % flowering (0.376), no. of leaves per plant (0.342), pod length (cm) (0.286), leaf chlorophyll content (0.269), zinc content (%) (0.229) and number of primary branches per plant (0.176). Whereas at phenotypic level seed yield per plant revealed highest significant positive association with 100-seed weight (0.822) followed by single pod weight (0.788), biological yield per plant (0.717), plant height (0.404), no. of pods per plant (0.399), no. of seeds per pod (0.342), no. of leaves per plant (0.300), pod girth (0.295), leaf chlorophyll content (0.253), pod length (cm) (0.250), zinc content (%) (0.225), number of primary branches per plant (0.165) and days to 50 % flowering (0.117). Thus, these characters turned out to be the major components of seed yield. Such positive interrelationship between seed yield and these attributes has also been reported by Singh *et al.* (2000).

Number of seeds per pod showed highly significant positive genotypic and phenotypic correlation with plant height, number of primary branches per plant, pod length, 100-seed weight, biological yield per plant, iron content and single pod weight, and negative significant association with days to first flowering, days to harvest and number of pods per plant. The 100-seed weight revealed positive and significant correlation with plant height, number of leaves per plant, pod length, pod girth, single pod weight, number of seeds per pod, biological yield per plant and zinc content at genotypic and phenotypic level. Biological yield per plant exhibited positive and significant correlation with plant height, number of leaves per plant, leaf chlorophyll content, number of pods per plant, pod length, pod girth, single pod weight, seeds per pod, 100-seed weight and zinc content, whereas negative and significant association for this character was observed with days taken to germination and days to harvest. Same findings were also reported by Singh *et al.* (2007). These results propound that any positive increase in such traits will improve the seed yield of French bean.

The information of correlation coefficient determines only the nature and degree of association existing between pairs of characters. Seed yield is dependent on several mutually associated component characters. Thus, a change in any one of the component may possibly affect the whole network of cause and effect of relationship tending to vitiate association of yield and yield components. Path analysis is valuable in partitioning the phenotypic correlation of component characters into direct and indirect effects which

might provide the true association of component characters, both in magnitude and direction (Singh *et al.* 2000).

The path coefficient analysis indicated that days taken to germination, plant height, number of pods per plant, single pod weight, 100-seed weight, biological yield and zinc content recorded maximum and positive magnitude to direct effects on seed yield per plant and their association with seed yield per plant were also highly significant and positive, indicating the facts that there exists a true and perfect association between these characters. This may indicate that the direct selection for these characters would likely be effective in increasing grain yield. Kamaluddin and Shahid (2011) reported that number of pods per plant, pod length and 100-seed weight had direct effects on seed yield per plant. Rai *et al.* (2006) revealed that number of pods per plant had maximum direct effect toward seed yield per plant and Dahiya *et al.* (2006) also reported that number of seeds per pod had direct and highly significant influence on seed yield per plant. On the contrary, the direct effects of no. of leaves per plant, days taken to 50% flowering, number of primary branches per plant, pod length, pod girth, protein content and sulphur content were negative and their correlation with seed yield per plant was

Table 2 Distribution of 77 genotypes of French beans in different clusters

Cluster number	Number of genotypes	Accession number/Name
I	3	EC- 24595, IC- 41650, EC- 755318.
II	7	IC- 311094, EC- 283180, EC- 271563, EC- 271493, EC- 398574, EC- 324995, EC- 324976.
III	9	EC- 284250, EC- 271489, EC- 271499, IC- 39078, EC- 755382, EC- 500335, EC- 500308, EC- 755305, SL- 9.
IV	12	IC- 271509, IC- 271523, IC- 271524, IC- 271530, EC- 500674, EC- 540876, EC- 755400, EC- 755337, EC- 755327, EC- 500307, EC- 755302, EC- 564791.
V	7	IC- 37154, IC- 37145, IC- 39073, IC- 41651, IC- 279995, EC- 500682, EC- 564794.
VI	8	IC- 328626, IC- 328558, IC- 328555, IC- 311674, EC- 284255, EC-284251, EC- 121013, EC- 564797.
VII	16	EC- 286067, EC- 284248, EC- 284247, EC- 283179, EC- 283175, EC- 271564, EC- 106613, EC- 109731, EC- 115962, EC- 116177, EC-271501, EC- 540850, EC- 755315, EC- 500328, EC- 398587, EC- 286071.
VIII	4	EC- 324986, MZ- 53, FB- 1, FB- 8.
IX	11	IC- 328406, EC- 271505, IC- 39067, IC- 280353, IC-280367, EC- 755441, EC- 755322, EC-755320, EC- 398533, EC- 325013, EC- 325010.

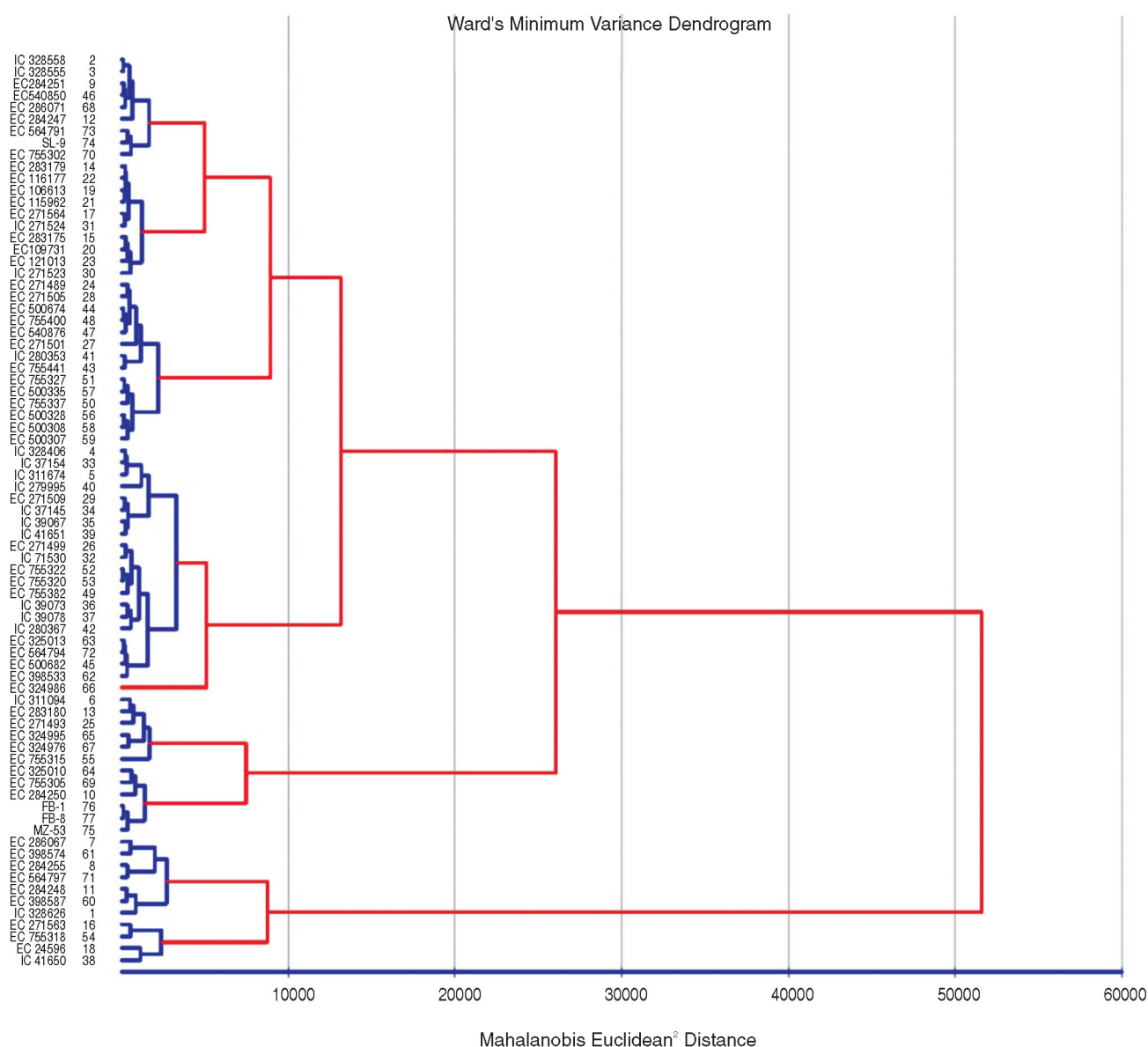


Fig 1 Mahalanobis D2 Distance

also highly significant and positive which is due to positive indirect effect on seed yield per plant. These findings suggest that indirect selection of these traits could be helpful for yield improvement of French bean. The phosphorus content recorded minimum negative direct effect but was significantly and positively correlated with seed yield per plant. Whereas, the trait number of primary branches per plant exhibited maximum negative and significant magnitude of direct effect on seed yield per plant. Days taken to harvest and days taken to 1st picking had high negative direct effect on seed yield per plant; their association with seed yield per plant was also highly significant and negative which is due to higher negative indirect contribution towards seed yield per plant.

The maximum negative indirect effect on seed yield per plant was exhibited by biological yield per plant through plant height while the second and the third maximum

negative indirect effects were exerted by days taken to harvest and number of seeds per pod through pod girth and days taken to harvest characters respectively. The seed yield is an important parameter among all the yield contributing as well as morphological traits. Improvement in seed yield in French bean could be brought through selection of component characters directly concerned with final yield like branches, pods per plant, pod length, pod girth, seeds per pod, 100-seed weight, days taken to harvest and first picking which showed positive direct effects.

Group constellation: Seventy-seven genotypes used in the present study were grouped into 9 clusters. The clustering pattern of the genotypes has been presented in Table 2. A total of sixteen genotypes fell into cluster VII followed by 12 genotypes in cluster IV, 11 genotypes in cluster IX, 9 genotypes in cluster III, 8 genotypes in cluster VI, 7 genotypes in cluster II and V, 4 genotypes in cluster

Table 3 Intracuster (diagonal) and intercluster D² values for nine clusters formed by 77 genotypes of French bean

Cluster	I Cluster	II Cluster	III Cluster	IV Cluster	V Cluster	VI Cluster	VII Cluster	VIII Cluster	IX Cluster
I Cluster	1012.23	1847.80	2886.63	2314.38	9642.96	3075.84	2852.83	3206.96	9161.00
II Cluster		776.50	1729.02	2683.62	11240.39	5407.92	4968.11	5145.53	11642.66
III Cluster			1108.74	2193.30	9251.88	7160.59	4309.27	8185.22	16602.96
IV Cluster				1331.14	5988.69	6824.17	3362.45	5975.24	14430.56
V Cluster					0.00	14501.18	6856.93	12780.58	25317.65
VI Cluster						1835.36	3784.00	4793.63	9650.18
VII Cluster							1274.88	6868.49	15571.57
VIII Cluster								2229.67	5394.22
IX Cluster									2677.66

VIII and 3 genotypes in cluster I.

Inter and intra cluster distances: The average intra and inter cluster D² values and average intra and inter cluster distance values are presented in Table 3 and Fig 1. Maximum intracuster distance was recorded in cluster IX (2677.66) followed by cluster VIII (2229.67), cluster VI (1835.36), cluster IV (1331.14), cluster VII (1274.88), cluster III (1108.74), cluster I (1012.23) and cluster II (776.50). Cluster V showed minimum intracuster distance (0.00).

The data presented in Table 3 shows that maximum intercluster distance was recorded between cluster V and cluster IX (25317.65) followed by cluster III and IX, cluster VII and IX cluster V and VI (14501.18). Minimum average intercluster distance was exhibited between cluster II and III (1729.02).

Based on the studies of genetic diversity, maximum inter cluster distance between cluster V consisting of genotypes IC- 37154, IC- 37145, IC- 39073, IC- 41651, IC- 279995, EC- 500682 and EC- 564794 and cluster IX having genotypes IC- 328406, EC- 271505, IC-39067, IC- 280353, IC- 280367, EC- 755441, EC- 755322, EC- 755320, EC- 398533, EC- 325013 and EC- 325010 indicating the possibilities of hybridization between the genotypes of these clusters for the development of high yielding varieties in French bean.

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REFERENCES

- Ahmed S. 2011. Variability, correlation and path analysis for seed yield and yield related traits in common beans. *Indian Journal of Horticulture* **68**(1): 61–5.
- Anju D, Sharma S, Singh K and Alok K. 2000. Variability studies in french bean (*Phaseolus vulgaris* L.). *Annals of Botany* **16**(2): 201–4.
- Burton G W and De Vane E H. 1953. Estimating heritability in tall fescue (*Festuca arundinacea*) from replicated clonal material. *Agronomy Journal* **45**: 478–81.
- Choudhary J, Kushwah S S, Singh O P and Naruka I S. 2016. Studies on genetic variability and character association in Indian bean (*Lablab purpureus* L.). *Legume Research* **39**: 336–42.
- Dahiya A, Sharma S K, Singh K P and Luthra O P. 2006. Path analysis of seed yield components in French bean (*Phaseolous vulgaris* L.). *Research Crops* **7**(1): 255–7.
- Dewey D R and Lu K H 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal* **51**: 515–8.
- Jhanavi D, Patil H, Justin P, Hadimani R H, Mulla S and Sarvamangala C. 2018. Genetic variability, heritability and genetic advance studies in french bean (*Phaseolus vulgaris* L.) genotypes. *Indian Journal of Agricultural Research* **52**(2): 162–6.
- Junaif N, Wani K, Khan S, Jabeen N, Mushtaq F, and Ummyiah H. 2010. Genetic variability in dwarf French bean (*Phaseolus vulgaris* L.). *Asian Journal of Horticulture* **5**(1): 117–8.
- Kamaluddin and Shahid Ahmed. 2011. Variability, correlation and path analysis for yield and yield related traits in common bean. *Indian Journal of Horticulture* **68**(1): 56–60.
- Lush J L. 1949. Heritability of quantitative characters in farm animals. Proceedings of 85th Congress on Genetics, Hereditas (Supplement): 356–75.
- Prakash J, Ram R and Meena M. 2015. Genetic variation and characters interrelationship studies for quantitative and qualitative traits in french bean (*Phaseolus vulgaris* L.) under Lucknow conditions. *Legume Research* **38**(4):425–33.
- Prasanth K and Sreelatha K. 2014. Variability and heritability studies for pod yield and its component characters in winged bean (*Psophocarpus tetragonolobus* L.). *Bioscan* **9**(4):1795–7.
- Rai N, Asati B, Singh A and Yadav D. 2006. Genetic variability, character association and path coefficient study in pole type French bean. *Indian Journal of Horticulture* **63**(2): 188–91.
- Ramandeep, Dhillon T S, Dhall R K and Gill B S. 2018. Genetic variability of yield and yield attributing traits in French bean (*Phaseolus vulgaris* L.). *Agricultural Research Journal* **55**(2): 219–23.
- Searle S R. 1961. Phenotypic, genotypic and environmental correlations. *Biometrics* **17**: 474–80.
- Singh B, Singh B and Ram H. 2000. Variability and correlation studies in bush type French bean (*Phaseolus vulgaris* L.) in relation to green pod yield. *Progressive Horticulture* **32**(2):176–82.
- Singh K P, Minakshi J and Minakshi B. 2007. Genetic variability in french bean (*Phaseolus vulgaris* L.). *Research on Crops* **8**: 636–7.