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Morphometric Characterization and Interrelationship among Different Traits in Diverse Genotypes of Pole Type French Bean

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ABSTRACT

In the present investigation, morphological characterization, correlation and path coefficient analysis were calculated for yield and its contributing characters of twenty-nine pole type genotypes of French bean (*Phaseolus vulgaris* L.) at Vegetable Research Farm of Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan with the objective of discovering desirable traits that contribute to increased pod yield. Study reported considerable variation amongst the genotypes for the observed agro-morphological traits. The correlation results revealed that pod yield per plant had significant positive correlation with number of pods per plant, plant height, number of seeds per pod, harvest duration, pod length, seed yield per plant and pod weight both at phenotypic and genotypic level. Path analysis exposed that maximum positive direct effect towards pod yield per plant was contributed by number of pods per plant, pod weight, pod width, pod length, plant height and harvest duration. Number of pods per plant and pod weight are chief contributing traits influencing green pod yield and selection based on these traits may improve pod yield per plant in French bean having pole type growth habit.

Keywords Correlation, French bean, Path analysis, Morphological characterization, Pole type.

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is a diploid, herbaceous annual, belonging to family Leguminosae with a chromosome number 2n = 22. It's also known as kidney bean, string bean, haricot bean, snap bean, navy bean, wax bean, garden bean and large dry seed type varieties are called as "Rajmash" in India. French bean originated in Central America and the Peruvian Andes of South America, from where it spread throughout Europe in the 16th and 17th centuries. It was brought to India from Europe in the 17th

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century (Prakash and Ram 2014). It is a nutritious vegetable consumed as tender pods, dry beans and shelled beans (Kumar *et al*. 2014). It is capable of overcoming malnutrition's problems. Hundred gram of French bean includes 1.7 g of protein, 1.8 g of fiber, 4.5 g of carbohydrate, and 0.1 g of fat, as well as various vitamins and minerals. It is anti-diarrhea and anti-constipation because of its depurative and carminative qualities.

Himachal Pradesh is blessed with a diverse range of agro-climatic zones, ranging from subtropical to arid temperate desert, and it stands out among other states in terms of bean germplasm. Variability exists in the gene pool of the French bean. Variability creates an opportunity to use the genetic pool for future difficult breeding goals. To fulfil the increasing need of the changing production ecology, phenotypic and genotypic dissection of current germplasm is required on a regular basis in order to identify genetically varied lines with desirable features.

Understanding the diversity in pod yield and its relationship to other agronomic parameters in French bean genotypes is important for the varietal development program. Further, using path analysis to measure the direct and indirect effects of features on pod yield would aid in the discovery of reliable traits that contribute to yield. Several authors have studied the interrelationship of characters in French bean (Sharma *et al*. 2019, Thirugnanavel *et al.* 2019, Kalauni and Dhakal 2020 and Singh *et al*. 2020). Short duration, high yielding, biotic and abiotic stress tolerant cultivars of French bean are needed to meet the difficulties of climate change. Therefore, an exploration and characterization study were conducted to collect the available gene pool of indigenous pole type French bean from rural pockets of Himachal Pradesh and thereafter phenotyping of genotypes for morphological and yield traits along with correlation and path analysis study to advocate trait guided selection for better yield.

MATERIALS AND METHODS

The present investigation was carried out in the experimental farm of the Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP during the *kharif* season of the year 2020. The Farm is situated at 30^{o}86' North of latitude and 77^{o}17' East of longitude at an elevation of 1,275 m above mean sea level. During the cropping season, the average temperature ranged from 20.4 to 25.10^{0}C, with relative humidity ranging from 55 to 81% . The total rainfall during the growing season varied from 0.0 to 278.1 mm. Twenty - nine indigenous genotypes of pole type French bean were collected from districts viz., Shimla, Solan and Sirmour. Samples collected comprised of freshly harvested seeds (1 kg each or less depending upon the availability). These collected genotypes were grown at the spacing of 90 cm between the rows and 60 cm between plants in Randomized Complete Block Design (RCBD) with three replications. All the recommended cultural practices were followed to raise the crop. Correlation coefficients was computed according to the method given by Al-Jibouri *et al*. (1958). Path coefficient analysis was carried out by Dewey and Lu (1959).

RESULTS AND DISCUSSION

There was considerable variation amongst the pole type French bean genotypes for five qualitative traits studied. The twenty-nine pole type French bean genotypes were grouped individually into three categories as creamy white, purple and light purple. Prakash *et al*. (2015) classified 25 French bean genotypes into three groups viz., white, purple and pink. The genotypes were classified based on pod color as green group which contains 14 genotypes, second is yellow green group which contains 10 genotypes, third is green with purple streaks which contains 3 genotypes and fourth is purple group which contains 2 genotypes. Kumar *et al*. (2014) evaluated forty-four genotypes of French bean of having pod color viz., black pigmented all over, green, dark green and light green. Kalauni *et al*. (2019) classified 6 French bean accessions of having normal green, green with red stripes and light green at immature stage of pods (Table 1).

The green pods of different genotypes were categorized as straight, slightly curved and curved depending on their pod shape. Pandey *et al.* (2011) observed slightly curved, straight and curved pod

Table 1. Qualitative morphometric characteristics of indigenous pole type French bean genotypes.

Genotypes	Flower color	Pod color	Pod shape	Stringiness	Seedcoat color
LCPB-1	Purple	Purple group 79A	Straight	String less	Orange white group (159-A)
LCPB-2	Light purple	Green group 143C	Straight	String less	Greyed orange group (165-D)
LCPB-3	Purple	Purple group 79C	Straight	Stringy	Orange white group (159-A)
LCPB-4	Creamy white	Yellow green group 144D	Slightly curved	Stringy	Greyed orange group (165-B)
LCPB-5	Creamy white	Green group 137D	Slightly curved	Stringy	Greyed orange group (165-B)
LCPB-6	Light purple	Yellow green group 144C	Slightly curved	String less	Greyed orange group (168-D)
LCPB-7	Purple	Green with purple streaks	Straight	Stringy	Orange white group (159-A), Red purple group (59-A)
LCPB-8	Creamy white	Green group 141C	Curved	String less	Orange white group (159-A)
LCPB-9	Creamy white	Green group 137D	Slightly curved	Stringy	Greyed orange group (165-D)
LCPB-10	Creamy white	Yellow green group 144D	Straight	String less	White group (155-D)
LCPB-11	Creamy white	Yellow green group 145D	Straight	String less	White group (155-D)
LCPB-12	Purple	Green group 137C	Straight	String less	Red purple group (185-A)
LCPB-13	Purple	Green with purple streaks	Straight	String less	Orange white group (159-A), Red purple group (59-A)
LCPB-14	Creamy white	Green group 141C	Straight	Stringy	Red purple group (187-B)
LCPB-15	Creamy white	Green group 143C	Straight	Stringy	White group (155-D)
LCPB-16	Light purple	Yellow green group 144A	Straight	Stringy	Red purple group (187-B)
LCPB-17	Light purple	Green group 137D	Straight	Stringy	Red purple group (187-B), Greyed orange group (164-D)
LCPB-18	Purple	Green group 141C	Straight	Stringy	Greyed orange group (165-D)
LCPB-19	Purple	Green with purple streaks	Straight	Stringy	Orange white group (159-A), Red purple group (59-A)
LCPB-20	Light purple	Green group 137D	Straight	Stringy	Red purple group (187-B), Greyed orange group (164-D)
LCPB-21	Purple	Yellow green group 145C	Slightly curved	Stringy	Orange white group (159-A), Greyed purple group (185-A)
LCPB-22	Purple	Yellow green group 144B	Straight	String less	Greyed orange group (165-D), Black group (202-A)
LCPB-23	Creamy white	Green group 137D	Curved	String less	Greyed orange group (167-A)
LCPB-24	Creamy white	Green group 141C	Slightly curved	Stringy	Red purple group (187-B)
LCPB-25	Creamy white	Green group 137D	Straight	String less	White group (155-D)
SVM-1	Light purple	Green group 137C	Slightly curved	String less	Greyed orange group (168-D)
Kentucky Wonder	Creamy white	Yellow green group 145C	Slightly curved	String less	Greyed orange group (165-D)
Pusa Himlata	Creamy white	Yellow green group 144B	Straight	String less	White group (155-D)
Lakshmi (Check)	Creamy white	Yellow green group 144B	Straight	String less	White group (155-D)

curvature of French bean genotypes. Stringless genotypes are preferred in market because of having a better vegetable quality and selection should be done for those genotypes which are having high yield and less stringiness. French bean genotypes were classified based on stringiness as stringless and stringy. Fifteen pole type French bean genotypes were string less and fourteen genotypes were grouped under slightly stringy. The genotypes were grouped individually into six categories of seedcoat color as orange white, greyed orange, greyed purple, red purple, black and white. Twenty-two genotypes were categorized in single color coat pattern and seven in bi-color coat pattern. Kumar *et al*. (2014) also classified 44 pole type French bean genotypes into different groups viz., cream, white, red, brown, maroon, creamish yellow, yellow and black (Table 1).

Understanding the relationship between yield and yield components is fundamental to determining plant selection strategies. The genotypic and phenotypic correlation coefficients are used to measure the strength and direction of the association between the traits. The genotypic correlation coefficients were larger than the phenotypic correlation coefficients, representing the inherent association among the

Table 2. Phenotypic and genotypic coefficients of correlation among different traits in French bean.

Traits		DT50% F	DTFP	HD	NPPP	PL (cm)	PW (mm)	PWt (g)	PH (cm)	NSPP	SL (mm)	SW (mm)	100 SW (g)	SYPP (g)	PYPP (g)
DT50%F	P	**1.000**	0.810*	-0.391*	-0.182	0.002	0.182	0.018	-0.099	-0.142	-0.482*	0.074	-0.255*	-0.045	-0.186
	G	**1.000**	0.845*	-0.406*	-0.174	-0.020	0.188	-0.001	-0.116	-0.205	-0.496*	0.121	-0.265*	-0.046	-0.199
DTFP	P		**1.000**	-0.378*	-0.164	-0.164	0.031	0.029	-0.120	-0.276*	-0.427*	0.284*	-0.236*	-0.180	-0.155
	G		**1.000**	-0.385*	-0.172	-0.174	0.029	0.032	-0.127	-0.306*	-0.447*	0.366*	-0.246*	-0.181	-0.157
HD	P			**1.000**	0.405*	0.256*	0.051	-0.013	0.322*	0.493*	-0.078	-0.306*	-0.038	0.455*	0.383*
	G			**1.000**	0.422*	0.279*	0.048	-0.013	0.340*	0.530*	-0.085	-0.394*	-0.036	0.461*	0.389*
NPPP	P				**1.000**	0.361*	-0.270*	-0.150	0.558*	0.398*	-0.031	0.057	-0.060	0.328*	0.858*
	G				**1.000**	0.390*	-0.286*	-0.151	0.610*	0.470*	-0.024	0.109	-0.066	0.347	0.896*
PL (cm)	P					**1.000**	-0.049	-0.047	0.193	0.347*	-0.082	-0.195	0.027	0.195	0.309*
	G					**1.000**	-0.052	-0.056	0.201	0.408*	-0.093	-0.312*	0.031	0.217*	0.332*
PW (mm)	P						**1.000**	0.158	0.091	0.032	-0.182	-0.346*	0.354*	0.298*	-0.187
	G						**1.000**	0.164	0.102	0.040	-0.187	-0.450*	0.367*	0.301*	-0.189
PWt (g)	P							**1.000**	0.028	-0.044	0.071	-0.048	0.005	-0.049	0.255*
	G							**1.000**	0.017	-0.048	0.089	-0.112	0.007	-0.053	0.278*
PH (cm)	P								**1.000**	0.171	-0.005	-0.017	0.192	0.422*	0.594*
	G								**1.000**	0.178	-0.011	0.016	0.194	0.439*	0.622*
NSPP	P									**1.000**	-0.048	-0.219*	0.013	0.312*	0.394*
	G									**1.000**	-0.047	-0.255*	0.018	0.334*	0.420*
SL (mm)	P										**1.000**	0.134	0.409*	-0.182	0.084
	G										**1.000**	0.169	0.423*	-0.186	0.091
SW (mm)	P											**1.000**	0.075	-0.252*	0.110
	G											**1.000**	0.103	-0.322*	0.138
100 SW (g)	P												**1.000**	0.501*	0.093
	G												**1.000**	0.511*	0.094
SYPP (g)	P													**1.000**	0.277*
	G													**1.000**	0.280*
PYPP (g)	P														**1.000**
	G														**1.000**

*Significant at 5% level of significance.

DT50%F= Days to 50 % flowering, DTFP= Days to first picking, HD= Harvest duration, NPPP= Number of pods per plant, PL= Pod length, PW= Pod width, PWt= Pod weight, PH= Plant height, NSPP= Number of seeds per pod, SL= Seed length, SW= Seed width, 100 SW= Hundred seed weight, SYPP= Seed yield per plant, PYPP= Pod yield per plant.

characters studied (Table 2). Pod yield per plant had positive significant correlation with number of pods per plant (0.858, 0.896), plant height (0.594, 0.622), number of seeds per pod (0.394, 0.420), harvest duration (0.383, 0.389), pod length (0.309, 0.332), seed yield per plant (0.277, 0.280) and pod weight (0.255, 0.278) both at phenotypic and genotypic level. Relationship of these yield and yield components thus assumes an exceptional status as the basis for selecting desirable genotypes with high yield latent. Such positive interrelation between pod yield and these traits has also been reported by Panchbhaiya and Kumar (2015), Lyngdoh *et al*. (2017) and Topwal *et al*. (2018) in French bean. Number of pods per plant showed highly significant and positive phenotypic and genotypic correlation with pod yield per plant, seeds per pod, plant height and pod length. Harvest duration recorded highest significant positive correlation (phenotypic and genotypic) with seeds per pod, seed yield per plant, pods per plant, pod yield per plant, plant height and pod length. This could be explained by the fact that pole genotypes with more number of pods and seeds per plant had a longer harvest time, resulting in a higher harvest index.

Correlation study does not give an idea on the cause of association only provides information about the association and generally data gained is misleading relating to identification of yield components. The cause of such an association can be determined via path analysis. The path coefficient study was used to divide the correlation coefficient of all component

Table 3. Path coefficient analysis showing the direct and indirect effects of traits on pod yield per plant at genotypic level.

Traits	DT 50%F	DTFP	HD	NPPP	PL (cm)	PW (mm)	PWt (g)	PH (cm)	NSPP	SL (mm)	SW (mm)	100 SW (g)	SYPP (g)	rg with PYPP (g)
DT50%F	-0.0776	-0.0106	-0.0066	-0.1626	-0.0010	0.0239	-0.0006	-0.0019	0.0023	-0.0020	0.0218	0.0165	-0.0002	-0.199
DTFP	-0.0656	-0.0125	-0.0062	-0.1609	-0.0084	0.0037	0.0134	-0.0021	0.0034	-0.0018	0.0659	0.0153	-0.0007	-0.157
HD	0.0315	0.0048	0.0162	0.3940	0.0134	0.0061	-0.0053	0.0056	-0.0059	-0.0003	-0.0710	-0.0023	0.0018	0.389*
NPPP	0.0135	0.0022	0.0068	0.9327	0.0188	-0.0364	-0.0632	0.0102	-0.0052	0.0001	0.0196	-0.0041	0.0014	0.896*
PL (cm)	0.0016	0.0022	0.0045	0.3640	0.0482	-0.0067	-0.0235	0.0033	-0.0045	0.0004	-0.0562	-0.0020	0.0009	0.332*
PW (mm)	-0.0146	-0.0004	0.0008	-0.2666	-0.0025	0.1274	0.0686	0.0017	-0.0004	-0.0007	-0.0810	-0.0228	0.0012	-0.189
PWt (g)	0.0001	-0.0004	-0.0002	-0.1405	-0.0027	0.0208	0.4193	0.0003	0.0005	0.0004	-0.0202	0.0004	-0.0002	0.278*
PH (cm)	0.0090	0.0016	0.0055	0.5693	0.0097	0.0130	0.0070	0.0165	-0.0020	0.00004	0.0029	-0.0121	0.0018	0.622*
NSPP	0.0159	0.0038	0.0086	0.4388	0.0197	0.0051	-0.0200	0.0029	-0.0111	-0.0002	-0.0460	0.0011	0.0013	0.420*
SL (mm)	0.0385	0.0056	-0.0014	0.0220	0.0045	-0.0238	0.0374	0.0002	0.0005	0.0040	0.0305	-0.0263	-0.0007	0.091
SW (mm)	-0.0094	-0.0046	-0.0064	0.1013	-0.0150	-0.0573	-0.0469	0.0003	0.0028	0.0007	0.1801	-0.0064	-0.0013	0.138
100 SW (g)	0.0206	0.0031	0.0006	0.0611	0.0015	0.0467	-0.0028	0.0032	0.0002	0.0017	0.0186	-0.0622	0.0021	0.094
SYPP (g)	0.0035	0.0023	0.0075	0.3234	0.0105	0.0384	-0.0222	0.0072	-0.0037	-0.0007	-0.0581	-0.0318	0.0040	0.280*

rg = Genotypic correlation coefficient.
Diagonal figures represent the direct effect.
Residual effect = 0.00609.
Where,
DT50%F= Days to 50 % flowering, DTFP= Days to first picking, HD= Harvest duration, NPPP= Number of pods per plant, PL= Pod length, PW= Pod width, PWt= Pod weight, PH= Plant height, NSPP= Number of seeds per pod, SL= Seed length, SW= Seed width, 100 SW= Hundred seed weight, SYPP= Seed yield per plant, PYPP= Pod yield per plant.

qualities observed with pod yield into direct and indirect effects. Path coefficient analysis recorded pods per plant (0.9327) exhibited high positive direct effect on pod yield per plant followed by pod weight (0.4193), seed width (0.1801), pod width (0.1274), pod length (0.0482), plant height (0.0165) and harvest duration (0.0162) (Table 3). Focus should be on these traits during selection but more importance should be given on the pods per plant. The remaining traits viz., seed length (0.0040) and seed yield per plant (0.0040) also exhibited positive direct effect but of lower extent. It shows that if other aspects are held constant, an increase in these traits individually will reflect in the increased yield. Days to 50% flowering (-0.0776) followed by 100 seed weight (-0.0622), days to 1^{st} picking (-0.0125) and seeds per pod (-0.0111) had negative direct effect on pod yield per plant. This may be as the genetic stock used for study consists the diverse genotypes with different pod dimensions. The results obtained in this study was confirmed by Lad *et al*. (2017), Lyngdoh *et al*. (2017), Ramandeep *et al*. (2017) who also revealed high positive direct effect of pods per plant on pod yield per plant in French bean. Devi *et al*. (2015), Prakash *et al*. (2015) and Alemu *et al*. (2017) reported direct effect of pod weight towards pod yield per plant. Aklade *et al*. (2018) and Patil *et al.* (2018) also reported direct and highly significant influence of pod length and pod width on pod yield per plant in French bean. Ahmed and Kamaluddin (2013) and Kumar *et al.* (2014) exhibited direct effects of plant height on pod yield per plant.

CONCLUSION

The study reported considerable variation amongst the genotypes for the observed agro-morphological traits. Number of pods per plant and pod weight was found to be the chief contributing traits influencing green pod yield and selection based on these traits may improve pod yield per plant in French bean having pole type growth habit. The correlation results revealed that pod yield per plant had significant positive correlation with number of pods per plant, plant height, number of seeds per pod, harvest duration, pod length, seed yield per plant and pod weight both at phenotypic and genotypic level, indicating that selection of these characters would lead to improvement in yield. It was also observed that number of pods per plant had high positive correlation with plant height. Path analysis exposed that maximum positive direct effect towards pod yield per plant was contributed by number of pods per plant, pod weight, pod width, pod length, plant height and harvest duration. This will help the breeder in making effective selection for improving the pod yield which would further lead to the development of superior varieties with higher yield potential in pole type French bean.

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