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Character Association, Direct and Indirect Effects Studies for Growth, Yield and Quality Traits in French Bean (*Phaseolus vulgaris* L.)

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A B S T R A C T

An experiment of Correlation and Path analysis studies in French Bean (*Phaseolus vulgaris* L.) for twenty one characters were studied in 36 genotypes collected from IIHR, Hesaraghatta, conducted at department of vegetable science, College of Horticulture, Bagalkot duing *rabi* season. Correlation studies revealed total yield per plant was found to be positively and significantly (at p=0.01) associated with characters like plant height at, number of primary branches, plant spread, pod length, pod flesh thickness, number of seeds per pod, number of clusters per plant, number of pods per cluster, number of pods per plant, weight of ten pods, dry matter content of pods and number of root nodules per plant. Path analysis studies revealed that significant positive association at genotypic level was observed with number of clusters per plant, number of pods per cluster, weight of ten pods and pod length had exhibited true association with direct effect on yield per plant.

Introduction

French bean (*Phaseolus vulgaris* L., 2n= 2x= 22) is an important legume, protein rich vegetable belonging to family *Fabaceae*. It is also known as string bean, snap bean, kidney bean, Navy bean and Rajma bean. The primary centre of origin of french bean is Southern Mexico and Central America.

This vegetable is very profitable cool season legume crop mainly grown for their tender green pods, shelled green and dry beans. The dried pods are used as pulse and provide valuable protein to the human diet. Immature pods are marketed as fresh, canned or frozen. The present study was undertaken with an objective of assessing Correlation and path analysis studies in 36 bush type French bean genotypes.

The experiment material consists of thirty six bush type genotypes of french bean collected from Indian institute of Horticultural Research, Hesaraghatta, Bangalore. The experiment was conducted in a RCBD with two replications during *rabi*, at Department of vegetable science, college of horticulture, Bagalkot. Fifty plants of each genotype were grown per replication with a spacing of 60 cm between rows and 15 cm between plants. In each replication, five plants were selected randomly for recording observation. The characters *viz.,* plant height,

number of primary branches per plant, plant spread, days to first flowering, days to first flowering, days to 50 per cent flowering, days to first pod picking, pod length, pod width, pod flesh thickness, number of seeds per pod, number of clusters per plant, number of pods per cluster, number of pods per plant, weight of ten pods, dry matter content of pods, pod yield per plant and number of root nodules per plant. The correlation co-efficient among all important character combinations at phenotypic (rp) and genotypic (rg) level were estimated by employing formula given by Al-Jibouri *et al.,* (1958). Whereas path co-efficient analysis suggested by Wright (1921) and Dewey and Lu (1957) was carried out to know the direct and indirect effect of the morphological traits on plant yield. Lenka and Mishra (1973) have suggested scales for path coefficients analysis.

The Results of Correlation i.e., observed difference between the genotypic and phenotypic correlation coefficients was narrow for various traits indicated the lesser influence of environment in the expression and presence of strong inherent association among the traits. Hence, only genotypic correlations (Table 1) are discussed.

Plant height at 25 and 50 DAS had positive and significant correlation at p=0.01 with, number of primary branches at 50 DAS, pod length, pod flesh thickness, number of seeds per pod, number of clusters per plant and weight of ten pods. Similar results were reported by Verma *et al.,* (2014) and Kumar *et al.,* (2014); Angadi *et al.,* (2012) and Gangadhara (2012) in French bean.

Days to 50 per cent flowering (Table 1) was positively and significantly (at p=0.01) correlated with days to first pod maturity (0.452), pod width (0.390). It showed significant and negative correlation with yield per plant (-0.573). The findings of Syed mudasir *et al.,* (2012); Verma *et al.,* (2014) and Jayprakash *et al.,* (2015) in French bean, are in conformity with present findings.

Pod length had positive and highly significant association with pod flesh thickness (0.512), number of seeds per pod (0.608), number of clusters per plant (0.631) and yield per plant (0.553). These results were obtained by Kamaluddin and Ahmed (2011); Syed mudasir *et al.,* (2012) in French bean. Pod width had negative and highly significant correlation with pod flesh thickness (-0.436) and yield per plant (-0.354). Similar results were also obtained by Rai *et al.,* (2004) and Verma *et al.,* (2014) in french bean.

Number of seeds per pod had positive and highly significant association with weight of ten pods, dry matter content of pods, number of root nodules per plant and yield per plant The readings are accordance with Kamaluddin and Ahmed (2011) and Singh *et al.,* (2014) in French bean. The significant and positive correlation of number of clusters per plant was observed with number of pods per plant and yield per plant (0.648). Girish *et al.,* (2012) in cluster bean also obtained similar results.

Number of pods per cluster had positive and highly significant association with number of pods per plant (0.667) and yield per plant (0.481). Similar results were obtained by Chaudhari *et al.,* (2013) and Ravinaik *et al.,* (2014) in dolicos bean. The significant at p=0.01 and positive correlation of number of pods per plant was observed with yield per plant (0.809), dry matter content of pods (0.484) and number of root nodules per plant (0.465). These results are in conformity with the observations of Kamaluddin and Ahmed (2011); Syed Mudasir *et al.,* (2012); Singh *et al.,* (2014) and Jayprakash *et al.,* (2015) in french bean.

Weight of ten pods exhibited the positive and highly significant association with pod yield (0.717), dry matter content of pods (0.611) and number of root nodules per plant (0.433). These results obtained by Verma *et al.,* (2014) and Singh *et al.,* (2014b) in french bean.

As the genotypic associations are inherent, the path analysis is discussed only at genotypic level. Path analysis studies revealed that Pod length (Table 2) had low and direct positive effect (0.121) on total yield per plant. Pod width had negligible and direct positive effect on total yield per plant. The results were obtained by Kumar *et al.,* (2015) in cluster bean. Number of seeds per pod had negligible and direct positive effect on total yield per plant. The findings of Verma *et al.,* (2014) in french bean.

Number of clusters per plant had high and direct positive effect on total yield per plant. It also had high and indirect positive effect through number of pods per plant (0.511). Similar findings were recorded by Idress *et al.,* (2006) and Singh *et al.,* (2009) in mung bean. Number of pods per cluster had high and direct positive effect on total yield per plant. It had high and indirect positive effect through number of pods per plant (0.349). These results obtained by Mehra and Singh (2012) in french bean, Kumar *et al.,* (2015) in cluster bean.

Table.1 Genotypic correlation coefficient among growth, earliness and yield parameters in french bean genotypes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	**1.000**	0.957**	0.645**	0.553**	0.613**	0.622**	0.685**	-0.492**	-0.692**	-0.575**	0.794**	-0.485**	0.661**	0.621**	0.374**	-0.177	0.198	0.793**	0.576**	0.496**	0.585**
2		**1.000**	0.447**	0.342**	0.486**	0.582**	0.552**	-0.422**	-0.684**	-0.530**	0.682**	-0.304**	0.448**	0.537**	0.421**	-0.030	0.314**	0.573**	0.673**	0.471**	0.552**
3			**1.000**	0.661**	0.641**	0.584**	0.642**	-0.341**	-0.184	-0.342**	0.298*	-0.151	0.519**	0.462**	0.389**	-0.100	0.236*	0.622**	0.465**	0.707**	0.525**
4				**1.000**	0.895**	0.822**	0.830**	-0.370**	-0.465**	-0.428**	0.328**	-0.266*	0.470**	0.429**	0.371**	0.448**	0.596**	0.465**	0.617**	0.543**	0.707**
5					**1.000**	0.917**	0.904**	-0.431**	-0.490**	-0.304**	0.376**	-0.176	0.551**	0.386**	0.639**	0.441**	0.793**	0.493**	0.802**	0.665**	0.857**
6						**1.000**	0.997**	-0.477**	-0.483**	-0.310**	0.470**	-0.212	0.571**	0.568**	0.542**	0.329**	0.631**	0.625**	0.694**	0.774**	0.815**
7							**1.000**	-0.396**	-0.503**	-0.374**	0.469**	-0.244*	0.532**	0.499**	0.413**	0.433**	0.603**	0.631**	0.679**	0.757**	0.807**
8								**1.000**	0.479**	0.476**	-0.022	0.023	-0.407**	-0.292*	-0.272*	-0.230	-0.373**	-0.377**	-0.677**	-0.416**	-0.499**
9									**1.000**	0.452**	-0.507**	0.390**	-0.277*	-0.438**	-0.243*	-0.231*	-0.375**	-0.510**	-0.743*	-0.324**	-0.573**
10										**1.000**	-0.020	0.109	-0.096	-0.268*	-0.291*	-0.315**	-0.426**	-0.363**	-0.447**	-0.478**	-0.517**
11											1.000	-0.539**	0.612**	0.536**	0.247*	-0.196	0.107	0.796**	0.614**	0.110	0.499**
12												**1.000**	-0.436**	-0.477**	-0.210	0.140	-0.092	-0.549**	-0.189	0.108	-0.354**
13													**1.000**	0.641**	0.253*	-0.079	0.149	0.885**	0.315**	0.293*	0.594**
14														**1.000**	0.227	0.085	0.240*	0.790**	0.493**	0.317**	0.614**
15															1.000	0.031	0.760**	0.153	0.366**	0.410**	0.648**
16																**1.000**	0.667**	0.038	0.269*	0.234*	0.481**
17																	**1.000**	0.164	0.484**	0.465**	0.809**
18																		**1.000**	0.611**	0.433**	0.717**
19																			1.000	0.639**	0.700**
20																				**1.000**	0.601**
21																					**1.000**

Critical r_g value at 1 percent -0.301 critical r_g value at 5 percent – 0.231 **- indicates significant at P=0.01 *- indicates significant at P= 0.05

1. Plant height at 25 DAS	8. Days to first flowering	15. No. of clusters per plant
2. Plant height at 50 DAS	9. Days to 50 per cent flowering	16. No. of pods per cluster
3. No. of primary branches at 50 DAS	10. Days to first pod picking	17. No. of pods per plant
4. Plant spread (N-S) at 50 DAS	11. Pod length	18. Weight of ten pods
5. Plant spread (E-W) at 50 DAS	12. Pod width	19. Dry matter content of pods
6. Plant spread (N-S) at 25 DAS	13. Pod flesh thickness	20. No. of root nodules per plant
7. Plant spread (E-W) at 25 DAS	14. No. of seeds per pod	21. Pod yield per plant

Table.2 Genotypic path coefficient analysis among growth, earliness and yield parameters in french bean genotypes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	rG
1	**0.144**	0.138	0.093	0.079	0.088	0.089	0.098	-0.071	-0.099	-0.083	0.114	-0.070	0.095	0.089	0.054	-0.025	0.028	0.114	0.083	0.071	0.585**
2	-0.337	**-0.352**	-0.157	-0.120	-0.171	-0.205	-0.194	0.149	0.241	0.187	-0.240	0.107	-0.158	-0.189	-0.148	0.010	-0.111	-0.202	-0.237	-0.166	0.552**
3	0.019	0.013	**0.030**	0.020	0.019	0.018	0.019	-0.010	-0.005	-0.010	0.009	-0.004	0.016	0.014	0.012	-0.003	0.007	0.019	0.014	0.021	0.525**
4	-0.088	-0.055	-0.106	**-0.160**	-0.143	-0.131	-0.133	0.059	0.074	0.068	-0.052	0.042	-0.075	-0.068	-0.059	-0.071	-0.095	-0.074	-0.099	-0.087	0.707**
5	0.007	0.005	0.007	0.010	**0.011**	0.011	0.010	-0.005	-0.005	-0.003	0.004	-0.002	0.006	0.004	0.007	0.005	0.009	0.005	0.009	0.008	0.857**
6	-0.063	-0.059	-0.059	-0.083	-0.093	**-0.102**	-0.101	0.048	0.049	0.031	-0.048	0.0216	-0.058	-0.058	-0.055	-0.033	-0.064	-0.063	0.070	-0.079	0.815**
7	0.151	0.121	0.141	0.183	0.199	0.219	**0.220**	-0.087	-0.110	-0.082	0.103	-0.053	0.117	0.110	0.091	0.095	0.133	0.139	0.149	0.166	0.807**
8	0.002	0.002	0.001	0.001	0.002	0.002	0.002	**-0.005**	-0.002	-0.002	0.0001	-0.0001	0.002	0.001	0.001	0.001	0.001	0.001	0.003	0.002	-0.499**
9	0.089	0.088	0.023	0.060	0.063	0.062	0.064	-0.061	**-0.128**	-0.058	0.065	-0.050	0.035	0.056	0.031	0.029	0.048	0.065	0.095	0.041	-0.573**
10	0.056	0.052	0.033	0.042	0.029	0.030	0.036	-0.046	-0.044	**-0.098**	0.002	-0.010	0.009	0.026	0.028	0.031	0.041	0.035	0.0440	0.047	-0.517**
11	0.096	0.082	0.036	0.039	0.045	0.056	0.056	-0.002	-0.061	-0.002	**0.121**	-0.065	0.074	0.064	0.029	-0.023	0.013	0.096	0.074	0.013	0.499**
12	-0.027	-0.017	-0.008	-0.015	-0.009	-0.011	-0.013	0.001	0.022	0.006	-0.030	**0.056**	-0.024	-0.026	-0.01	0.007	-0.005	-0.030	-0.010	0.006	-0.354**
13	0.047	0.032	0.037	0.033	0.039	0.040	0.038	-0.029	-0.019	-0.006	0.043	-0.031	**0.071**	0.045	0.018	-0.005	0.010	0.063	0.022	0.021	0.594**
14	0.051	0.044	0.038	0.035	0.031	0.047	0.041	-0.024	-0.036	-0.022	0.044	-0.039	0.053	**0.082**	0.018	0.007	0.019	0.065	0.040	0.026	0.614**
15	0.252	0.283	0.262	0.250	0.430	0.364	0.278	-0.183	-0.164	-0.195	0.166	-0.141	0.170	0.153	**0.673**	0.020	0.511	0.103	0.246	0.276	0.648**
16	-0.092	-0.016	-0.052	0.234	0.231	0.172	0.226	-0.120	-0.120	-0.164	-0.102	0.073	-0.041	0.044	0.016	**0.523**	0.349	0.020	0.141	0.122	0.481**
17	-0.035	-0.056	-0.042	-0.106	-0.142	-0.113	-0.108	0.066	0.067	0.076	-0.019	0.016	-0.026	-0.043	-0.136	-0.119	**-0.179**	-0.029	-0.086	-0.083	0.809**
18	0.274	0.197	0.215	0.160	0.170	0.216	0.218	-0.130	-0.176	-0.125	0.275	-0.189	0.305	0.273	0.053	0.013	0.056	**0.345**	0.211	0.149	0.717**
19	0.040	0.047	0.032	0.043	0.056	0.048	0.047	-0.047	-0.052	-0.031	0.043	-0.013	0.022	0.034	0.025	0.018	0.034	0.0429	**0.070**	0.044	0.700**
20	-0.001	-0.0009	-0.001	-0.001	-0.001	-0.001	-0.001	0.008	0.0006	0.0009	-0.000	-0.0002	-0.000	-0.000	-0.0008	-0.0005	-0.0009	-0.000	-0.001	**-0.001**	**0.601****

Residual effect (R) = 0.04 Bold and diagonal values indicate direct effect .

1. Plant height at 25 DAS	8. Days to first flowering	15. No. of clusters per plant
2. Plant height at 50 DAS	9. Days to 50 per cent flowering	16. No. of pods per cluster
3. No. of primary branches at 50 DAS	10. Days to first pod picking	17. No. of pods per plant
4. Plant spread (N-S) at 50 DAS	11. Pod length	18. Weight of ten pods
5. Plant spread (E-W) at 50 DAS	12. Pod width	19. Dry matter content of pods
6. Plant spread (N-S) at 25 DAS	13. Pod flesh thickness	20. No. of root nodules per plant
7. Plant spread (E-W) at 25 DAS	14. No. of seeds per pod	21. Pod yield per plant

Number of pods per plant had low and direct negative effect on total yield per plant. It had low and indirect negative effect through weight of ten pods. Similar results were recorded by Verma *et al.,* (2014) and Singh *et al.,* (2014) in french bean. Weight of ten pods had high and direct positive effect (0.345) on total yield per plant. The results were obtained by Kumar *et al.,* (2014) and Verma *et al.,* (2014) in french bean.

Out of 36 genotypes evaluated characters like plant spread (E-W) at 25 DAS, number of clusters per plant, number of pods per cluster per plant and weight of ten pods had high direct and indirect effects on total yield per plant at genotypic level. Hence, more emphasis has to be given to these traits for improving the yield.

Author Contribution

D. R. Jhanavi: Investigation, formal analysis, writing—original draft. H. B. Patil: Validation, methodology, writing—reviewing. R.W. Anuradha:—Formal analysis, writing—review and editing. B. M. Ranjita: Investigation, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval: Not applicable.

Consent to Participate: Not applicable.

Consent to Publish: Not applicable.

Conflict of Interest: The authors declare no competing interests.

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