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Short Communication

Correlation and Path Analysis Studies for Growth, Yield and Quality Traits in French Bean (*Phaseolus vulgaris* L.)

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Abstract An experiment of correlation and path analysis studies in French bean (*Phaseolus vulgaris* L.) for 21 characters were studied in 36 genotypes collected from IIHR, Hesaraghatta, conducted during *rabi* season of the year 2015-16. 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 10 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 10 pods and pod length had exhibited true association with direct effect on yield per plant.

Keywords French bean, Genotypic correlation, Phenotypic correlation, Genotyic path analysis, Phenotypic path analysis.

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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 center 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.

Materials and Methods

The experiment material consists of 36 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* 2015-2016 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% 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, num-

Table 1. Genotypic correlation coefficient among growth, earliness and yield parameters in French bean genotypes. 1. Plant height at 25 DAS, 2. Plant height at 50 DAS, 3. No. of primary branches at 50 DAS, 4. Plant spread (N-S) at 50 DAS, 5. Plant spread (E-W) at 50 DAS, 6. Plant spread (N-S) at 25 DAS, 7. Plant spread (E-W) at 25 DAS, 8. Days to first flowering, 9. Days to 50% flowering, 10. Days to first pod picking, 11. Pod length, 12. Pod width, 13. Pod flesh thickness, 14. No. of seeds per pod, 15. No. of clusters per plant, 16. No. of pods per cluster, 17. No. of pods per plant, 18. Weight of 10 pods, 19. Dry matter content of pods, 20. No. of root nodules per plant, 21. Pod yield per plant. Critical r_g value at 1% -0.301, critical r_g value at 5% -0.231, **-indicates significant at p=0.01, *-indicates significant at p=0.05.

	1	2	3	4	5	6	7	8	9	10	11
1	**1.000**	0.957**	0.645**	0.553**	0.613**	0.622**	0.685**	-0.492**	-0.692**	-0.575**	0.794**
2		**1.000**	0.447**	0.342**	0.486**	0.582**	0.552**	-0.422**	-0.684**	-0.530**	0.682**
3			**1.000**	0.661**	0.641**	0.584**	0.642**	-0.341**	-0.184	-0.342**	0.298*
4				**1.000**	0.895**	0.822**	0.830**	-0.370**	-0.465**	-0.428**	0.328**
5					**1.000**	0.917**	0.904**	-0.431**	-0.490**	-0.304**	0.376**
6						**1.000**	0.997**	-0.477**	-0.483**	-0.310**	0.470**
7							**1.000**	-0.396**	-0.503**	-0.374**	0.469**
8								**1.000**	0.479**	0.476**	-0.022
9									**1.000**	0.452**	-0.507**
10										**1.000**	-0.020
11											**1.000**
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											

Table 1. Continued.

	12	13	14	15	16	17	18	19	20	21
1	-0.485**	0.661**	0.621**	0.374**	-0.177	0.198	0.793**	0.576**	0.496**	0.585**
2	-0.304**	0.448**	0.537**	0.421**	-0.030	0.314**	0.573**	0.673**	0.471**	0.552**
3	-0.151	0.519**	0.462**	0.389**	-0.100	0.236*	0.622**	0.465**	0.707**	0.525**
4	-0.266*	0.470**	0.429**	0.371**	0.448**	0.596**	0.465**	0.617**	0.543**	0.707**
5	-0.176	0.551**	0.386**	0.639**	0.441**	0.793**	0.493**	0.802**	0.665**	0.857**
6	-0.212	0.571**	0.568**	0.542**	0.329**	0.631**	0.625**	0.694**	0.774**	0.815**
7	-0.244*	0.532**	0.499**	0.413**	0.433**	0.603**	0.631**	0.679**	0.757**	0.807**
8	0.023	-0.407**	-0.292*	-0.272*	-0.230	-0.373**	-0.377**	-0.677**	-0.416**	-0.499**
9	0.390**	-0.277*	-0.438**	-0.243*	-0.231*	-0.375**	-0.510**	-0.743**	-0.324**	-0.573**
10	0.109	-0.096	-0.268*	-0.291*	-0.315**	-0.426**	-0.363**	-0447**	-0.478**	-0.517**
11	-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**

ber of pods per plant, weight of 10 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 phe-

Table 2. Genotypic path coefficient analysis among growth, earliness and yield parameters in French bean genotypes. 1. Plant height at 25 DAS, 2. Plant height at 50 DAS, 3. No. of primary branches at 50 DAS, 4. Plant spread (N-S) at 50 DAS, 5. Plant spread (E-W) at 50 DAS, 6. Plant spread (N-S) at 25 DAS, 7. Plant spread (E-W) at 25 DAS, 8. Days to first flowering, 9. Days to 50% flowering, 10. Days to first pod picking, 11. Pod length, 12. Pod width, 13. Pod flesh thickness, 14. No.of seeds per pod, 15. No. of clusters per plant, 16. No. of pods per cluster, 17. No. of pods per plant, 18. Weight of 10 pods, 19. Dry mattercontent of pods, 20. No. of root nodules per plant, 21. Pod yield per plant. Residual effect (R) = 0.04 Bold and diagonal values indicate direct effect.

	1	2	3	4	5	6	7	8	9	10	11
1	**0.144**	0.138	0.093	0.079	0.088	0.089	0.098	-0.071	-0.099	-0.083	0.114
2	-0.337	**-0.352**	-0.157	-0.120	-0.171	-0.205	-0.194	0.149	0.241	0.187	-0.240
3	0.019	0.013	**0.030**	0.020	0.019	0.018	0.019	-0.010	-0.005	-0.010	0.009
4	-0.088	-0.055	-0.106	**-0.160**	-0.143	-0.131	-0.133	0.059	0.074	0.068	-0.052
5	0.007	0.005	0.007	0.010	**0.011**	0.011	0.010	-0.005	-0.005	-0.003	0.004
6	-0.063	-0.059	-0.059	-0.083	-0.093	**-0.102**	-0.101	0.048	0.049	0.031	-0.048
7	0.151	0.121	0.141	0.183	0.199	0.219	**0.220**	-0.087	-0.110	-0.082	0.103
8	0.002	0.002	0.001	0.001	0.002	0.002	0.002	**-0.005**	-0.002	-0.002	0.001
9	0.089	0.088	0.023	0.060	0.063	0.062	0.064	-0.061	**-0.128**	-0.058	0.065
10	0.056	0.052	0.033	0.042	0.029	0.030	0.036	-0.046	-0.044	**-0.098**	0.002
11	0.096	0.082	0.036	0.039	0.045	0.056	0.056	-0.002	-0.061	-0.002	**0.121**
12	-0.027	-0.017	-0.008	-0.015	-0.009	-0.011	-0.013	0.001	0.022	0.006	-0.030
13	0.047	0.032	0.037	0.033	0.039	0.040	0.038	-0.029	-0.019	-0.006	0.043
14	0.051	0.044	0.038	0.035	0.031	0.047	0.041	-0.024	-0.036	-0.022	0.044
15	0.252	0.283	0.262	0.250	0.430	0.364	0.278	-0.183	-0.164	-0.195	0.166
16	-0.092	-0.016	-0.052	0.234	0.231	0.172	0.226	-0.120	-0.120	-0.164	-0.102
17	-0.035	-0.056	-0.042	-0.106	-0.142	-0.113	-0.108	0.066	0.067	0.076	-0.019
18	0.274	0.197	0.215	0.160	0.170	0.216	0.218	-0.130	-0.176	-0.125	0.275
19	0.040	0.047	0.032	0.043	0.056	0.048	0.047	-0.047	-0.052	-0.031	0.043
20	-.0.001	-0.0009	-0.001	-0.001	-0.001	-0.001	-0.001	0.008	0.0006	0.0009	-0.000

Table 2. Continued.

	12	13	14	15	16	17	18	19	20	r_g
1	-0.070	0.095	0.089	0.054	-0.025	0.028	0.114	0.083	0.071	0.585**
2	0.107	-0.158	-0.189	-0.148	0.010	-0.111	-0.202	-0.237	-0.166	0.552**
3	-0.004	0.016	0.014	0.012	-0.003	0.007	0.019	0.014	0.021	0.525**
4	0.042	-0.075	-0.068	-0.059	-0.071	-0.095	-0.074	-0.099	-0.087	0.707**
5	-0.002	0.006	0.004	0.007	0.005	0.009	0.005	0.009	0.008	0.857**
6	0.0216	-0.058	-0.058	-0.055	-0.033	-0.064	-0.063	0.070	-0.079	0.815**
7	-0.053	0.117	0.110	0.091	0.095	0.133	0.139	0.149	0.166	0.807**
8	-0.0001	0.002	0.001	0.001	0.001	0.001	0.001	0.003	0.002	-0.499**
9	-0.050	0.035	0.056	0.031	0.029	0.048	0.065	0.095	0.041	-0.573**
10	-0.010	0.009	0.026	0.028	0.031	0.041	0.035	0.0440	0.047	-0.517**
11	-0.065	0.074	0.064	0.029	-0.023	0.013	0.096	0.074	0.013	0.499**
12	**0.056**	-0.024	-0.026	-0.01	0.007	-0.005	-0.030	-0.010	0.006	-0.354**
13	-0.031	**0.071**	0.045	0.018	-0.005	0.010	0.063	0.022	0.021	0.594**
14	-0.039	0.053	**0.082**	0.018	0.007	0.019	0.065	0.040	0.026	0.614**
15	-0.141	0.170	0.153	**0.673**	0.020	0.511	0.103	0.246	0.276	0.648**
16	0.073	-0.041	0.044	0.016	**0.523**	0.349	0.020	0.141	0.122	0.481**
17	0.016	-0.026	-0.043	-0.136	-0.119	**-0.179**	-0.029	-0.086	-0.083	0.809**
18	-0.189	0.305	0.273	0.053	0.013	0.056	**0.345**	0.211	0.149	0.717**
19	-0.013	0.022	0.034	0.025	0.018	0.034	0.0429	**0.070**	0.044	0.700**
20	-0.0002	-0.000	-0.000	-0.0008	-0.0005	-0.0009	-0.000	-0.001	**-0.001**	**0.601****

notypic (r_p) and genotypic (r_g) 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 tdirect and indirect effect of the morphological traits on plant yield. Lenka and Mishra

(1973) have suggested scales for path co-efficients analysis.

Results and Discussion

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 10 pods. Similar, results were reported by Verma et al. (2014), Kumar et al. (2014), Angadi et al. (2012) and Gangadhara (2012) in French bean. Days to 50% 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 SyedMudasir 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 10 pods, dry matter content of pods, number of root nodules per plant and yield per plant. The readings in 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 clusterbean 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 dolichos 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), SyedMudasir et al. (2012), Singh et al. (2014) and Jayprakash et al. (2015) in French bean.

Weight of 10 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. (2014) 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 as in 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 Aditya et al. (2011) in Soyabean.

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 10 pods. Similar, results were recorded by Verma et al. (2014) and Singh et al. (2014) in french bean. Weight of 10 pods had high and direct positive effect (0.345) on total yield per plant. The similar 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 cluster per plant, number of pods per clusters per plant and weight of 10 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.

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