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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 twenty one 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 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.

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

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Introduction

French bean (*Phaseolus vulgaris* L., 2n = 2x=22) is an important legume vegetable belonging to family Fabaceae. It has many synonyms like snap bean, kidney bean, haricot bean and also called raj mash in hindi. According to Vavilov (1950) the primary center of origin of French bean is Southern Mexico and Central America. It is originated from wild species *Phaseolus aborigineus* L. Beans are essentially used for their tender green pods. The dried pods are used as pulse and provide valuable protein to the human diet. Immature pods are marketed fresh, canned or frozen. These pods are dried and fried like potato chips and can be cooked. Green pods can be used to strengthen diuretic, flushing of toxins from the body and also infused in the treatment of diabetics.

The nutritive value of the crop per 100 g of green pod is 1.7 g protein, 0.1 g fat, 4.5 g carbohydrate, 1.8 g fiber and is also rich in minerals and vitamins. French bean possesses medicinal properties which are useful against diabetes, certain cardiac problems and a good natural cure for bladder burn. It has both carminative and reparative properties against constipation and diarrhoea respectively (Duke 1981). In India, it is mainly grown in Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Bihar, Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu.

Yield is a complex character controlled by large number of contributing characters and their interactions. A study of correlation between different quantitative characters provides an idea of association that could be effectively exploited to formulate selection strategies for improving yield and quality of a crop. In order to have clear picture of yield components for effective selection program, it would be desirable to consider the relative magnitude of association of various characters with yield. The path coefficient technique developed by Wright (1921) helps it estimating direct and indirect contribution of various components in building up the total correlation towards yield. On the basis of these studies, the quantum importance of individual character is marked to facilitate the selection program for better gains.

Materials and Methods

The 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*, 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 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, 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 (r_p) and genotypic (r_g) level were estimated by employing formula given by Al-Jibourie 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.

Table 1. Phenotypic correlation coefficient among growth, earliness and yield parameters in French bean genotypes. 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. 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 ten pods, 19. Dry matter content of pods, 20. No. of root nodules per plant, 21. Pod yield per plant.

	1	2	3	4	5	6	7	8	9	10	11
1	1.000	0.702**	0.432**	0.419**	0.417**	0.453**	0.439**	-0.274*	-0.504**	-0.369**	0.510**
2		1.000	0.272*	0.272*	0.276*	0.386**	0.360**	-0.360**	-0.515**	-0.340**	0.541**
3			1.000	0.476**	0.492**	0.460**	0.415**	-0.116	-0.114	-0.298*	0.254*
4				1.000	0.687**	0.647**	0.642**	-0.238*	-0.397**	-0.280*	0.176
5					1.000	0.736**	0.752**	-0.296*	- 0.352**	-0.291*	0.320**
6						1.000	0.877**	-0.337**	-0.362**	-0.210	0.268*
7							1.000	-0.366**	-0.386**	-0.305**	0.305**
8								1.000	0.392**	0.296*	-0.128
9									1.000	0.329**	-0.312**
10										1.000	-0.030
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	-0.345**	0.419**	0.420**	0.233*	-0.050	0.167	0.492**	0.463**	0.372**	0.439**
2	-0.279*	0.337**	0.441**	0.257*	-0.125	0.114	0.454**	0.448**	0.375**	0.373**
3	-0.177	0.349**	0.375**	0.261*	0.005	0.200	0.382**	0.206	0.549**	0.396**
4	-0.168	0.319**	0.337**	0.291*	0.273*	0.422**	0.429**	0.52**	0.455**	0.593**
5	-0.168	0.303**	0.273*	0.372**	0.323**	0.506**	0.350**	0.635**	0.571**	0.615**
6	-0.125	0.417**	0.421**	0.463**	0.318**	0.571**	0.414**	0.509**	0.610**	0.714**
7	-0.132	0.399**	0.363**	0.327**	0.322**	0.466**	0.464**	0.486**	0.606**	0.651**
8	0.001	-0.284*	-0.232*	-0.205	-0.128	-0.264*	-0.292*	-0.453**	-0.392**	-0.385**
9	0.317**	-0.227	-0.338**	-0.244*	-0.131	-0.312**	-0.412**	-0.571**	-0.288*	-0.479**
10	0.153	-0.077	-0.218	-0.186	-0.145	-0.227	-0.292*	-0.265*	-0.392**	-0.370**
11	-0.500**	0.390**	0.451**	0.046	-0.135	-0.031	0.460**	0.377**	0.172	0.256*
12	1.000	-0.339**	-0.448**	-0.136	0.124	-0.034	-0.379**	-0.141	0.069	-0.245*
13		1.000	0.449**	0.155	-0.057	0.096	0.571**	0.263*	0.203	0.435**
14			1.000	0.137	0.040	0.142	0.576**	0.311**	0.269*	0.465**
15				1.000	-0.031	0.727**	0.085	0.310**	0.312**	0.612**
16					1.000	0.655**	-0.099	0.115	0.124	0.434**
17						1.000	0.014	0.340**	0.319**	0.771**
18							1.000	0.387**	0.333**	0.638**
19								1.000	0.509**	0.519**
20									1.000	0.476**
21										1.000

Lenka and Mishra (1973) have suggested scales for path coefficients analysis.

Results and Discussion

The observed difference between the genotypic and phenotypic correlation coefficients was narrow for various traits indicated the lesset influence of environment in the expression and presence of strong inherent association among the traits. Hence, only genotypic correlations (Tables 1, 2) 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),

Table 2. Genotypic correlation coefficient among growth, earliness and yield parameters in French bean genotypes. 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. 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 ten pods, 19. Dry matter content of pods, 20. No. of root nodules per plant, 21. Pod yield per plant.

	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**

Table 2. Continued.

	1	2	3	4	5	6	7	8	9	10	11
10										1.000	-0.020
11											1.000
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											

Table 2. 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**	-0.447**	-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

Angadi et al. (2012) and Gangadhara (2012) in French bean. A significant at p =0.01 and positive association of days to first flowering was noticed with days to 50% flowering, days to first pod maturity and showed significant and negative correlation with yield. 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). But it showed significant and negative correlation with pod width (-0.499). These results were obtained by Kamaluddin and Ahmed (2011), SyedMudasir et al. (2012), Singh et al. (2014) and Verma et al. (2014) 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), SyedMudasir 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. (2014) in French bean. Dry matter content of pods had positive and significant (at p=0.01) association with number of root nodules per plant (0.639) and yield per plant (0.717). Similar results were also obtained by Verma et al. (2014) in French bean and Aditya et al. (2011) in soya bean.

As the genotypic associations are inherent, the path analysis is discussed only at genotypic level. Path analysis studies revealed that pod length (Tables 3, 4), (Fig. 1) had low and direct positive effect (0.121) on total yield per plant. The findings of Verma et al. (2014) in French bean, Ravinaik et al. (2014) in dolichos bean were in conformity with present findings. 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

Table 3. Genotypic path coefficient analysis among growth, earliness and yield parameters in French bean genotypes. Residual effect (R) = 0.04 bold and diagonal values indicated direct effect. 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 ten pods, 19. Dry matter content of pods, 20. No. of root nodules per plant, 21. Pod yield per plant.

	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	0.0001
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 3. 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****

had negligible and direct positive effect on total yield per plant. It also had negligible and indirect positive effect through number of clusters per plant, number of pods per plant, weight of ten pods and dry matter content of pods. The findings of Singh et al. (2014) and Verma et al. (2014) in French bean.

Table 4. Phenotypic path coefficient analysis among growth, earliness and yield parameters in French bean genotypes. Residual effect (R) = 0.09 bold and diagonal values indicate direct effect. 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 ten pods, 19. Dry matter content of pods, 20. No. of root nodules per plant, 21. Pod yield per plant.

	1	2	3	4	5	6	7	8	9	10	11
1	**0.031**	0.009	0.005	0.005	0.005	0.005	0.005	-0.003	-0.006	-0.004	0.006
2	-0.012	**-0.017**	-0.004	-0.004	-0.004	-0.006	-0.006	0.006	0.009	0.006	-0.009
3	-0.0007	-0.004	**-0.018**	-0.008	-0.008	-0.008	-0.007	0.002	0.002	0.005	-0.004
4	-0.003	-0.001	-0.003	**-0.007**	-0.004	-0.004	-0.004	0.001	0.002	0.002	-0.001
5	-0.004	-0.002	-0.004	-0.006	**-0.009**	-0.007	-0.007	0.002	0.003	0.002	-0.003
6	0.039	0.033	0.040	0.056	0.064	**0.087**	0.076	- 0.029	-0.031	-0.018	0.0234
7	-0.029	-0.024	-0.027	-0.042	-0.050	-0.058	**-0.066**	0.024	0.025	0.020	-0.020
8	-0.002	0.002	-0.0009	-0.001	-0.002	-0.002	-0.002	**0.007**	0.002	0.002	-0.0009
9	-0.0013	-0.014	-0.003	-0.010	-0.009	-0.009	-0.010	0.010	**0.027**	0.008	-0.008
10	0.008	0.008	0.007	0.006	0.007	0.005	0.007	-0.007	-0.007	**-0.024**	0.0007
11	0.001	0.0001	0.0001	0.000	0.0001	0.0001	0.0001	0.000	-0.000	0.000	**0.0003**
12	-0.001	-0.001	-0.0009	-0.0008	-0.000	- 0.000	-0.0007	0.000	0.0001	0.0008	-0.0025
13	0.004	0.003	0.003	0.003	0.002	0.003	0.003	-0.002	-0.002	-0.0007	0.003
14	-0.005	-0.005	0.004	-0.004	-0.003	-0.005	-0.004	0.003	0.004	0.002	-0.005
15	0.035	0.039	0.040	0.044	0.057	0.071	0.050	-0.031	-0.037	-0.028	0.007
16	-0.007	-0.017	0.0008	0.038	0.045	0.045	0.045	-0.018	-0.018	-0.020	-0.019
17	0.090	0.061	0.108	0.227	0.272	0.307	0.250	-0.142	-0.167	-0.122	-0.017
18	0.310	0.286	0.241	0.270	0.220	0.261	0.293	-0.184	-0.260	-0.184	0.290
19	0.016	0.016	0.007	0.018	0.022	0.018	0.017	-0.16	-0.020	-0.009	0.013
20	0.007	0.007	0.011	0.009	0.011	-0.012	0.012	-0.007	-0.005	-0.007	0.003

Table 4. Continued.

	12	13	14	15	16	17	18	19	20	r_p
1	-0.004	0.005	0.005	0.0030	-0.0007	0.002	0.006	0.0061	0.004	0.439**
2	0.004	-0.005	-0.007	-0.004	0.002	-0.002	-0.008	-0.007	-0.006	0.373**
3	0.003	-0.006	-0.006	-0.004	-0.0001	-0.003	-0.006	-0.003	-0.009	0.396**
4	0.001	-0.002	-0.002	-0.002	-0.001	-0.003	-0.003	-0.003	-0.003	0.593**
5	0.001	-0.002	-0.002	-0.003	-0.003	-0.004	-0.003	-0.006	-0.005	0.615**
6	-0.010	0.036	0.036	0.0405	0.027	0.049	0.036	0.0444	0.053	0.714**
7	0.008	-0.026	-0.024	-0.021	-0.021	-0.031	-0.031	-0.032	-0.0405	0.651**
8	0.000	-0.002	-0.001	-0.001	-0.0009	-0.002	-0.002	-0.003	-0.002	-0.385**
9	0.008	-0.006	-0.009	-0.006	-0.0036	-0.008	-0.011	-0.0155	-0.007	-0.479**
10	-0.003	0.001	0.005	0.004	0.0035	0.005	0.007	0.0064	0.009	-0.370**
11	-0.000	0.000	0.000	0.000	0.000	0.000	0.0001	0.0001	0.000	0.256**
12	**0.005**	-0.001	-0.002	-0.0007	0.0006	-0.0002	-0.001	-0.0007	0.0003	-0.245*
13	-0.003	**0.009**	0.004	0.0015	-0.0005	0.0009	0.005	0.002	0.001	0.435**
14	0.005	-0.005	**-0.012**	-0.001	-0.0005	-0.001	-0.007	-0.0040	-0.003	0.465**
15	-0.021	0.023	0.0211	**0.153**	-0.004	0.115	0.013	0.0475	0.048	0.612**
16	0.017	-0.007	0.005	-0.004	**0.142**	0.093	-0.014	0.0164	0.017	0.434**
17	-0.018	0.051	-0.076	0.390	0.352	**0.537**	0.008	-0.182	0.1718	0.771**
18	-0.239	0.360	0.363	0.053	-0.063	0.0093	**0.630**	0.244	0.210	0.638**
19	-0.005	0.009	0.11	0.011	0.0041	0.012	0.0139	**0.036**	0.018	0.519**
20	0.001	0.0041	0.005	0.006	0.002	0.006	0.006	0.010	**0.0200**	0.476**

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.

Number of pods per plant had low and direct negative effect on total yield per plant. It had low and

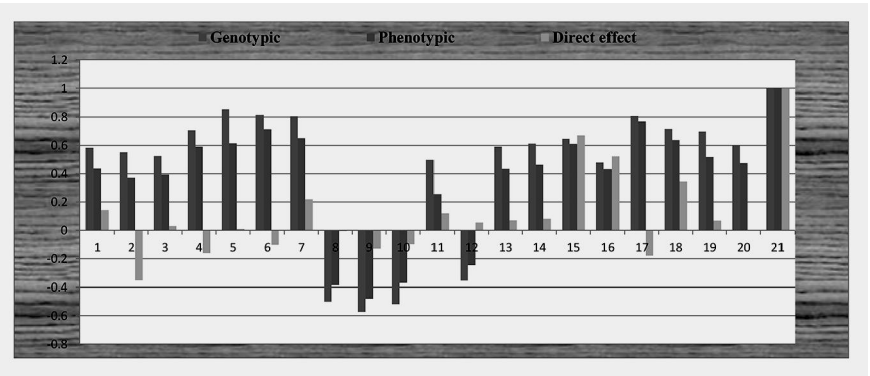

Fig. 1. Genotypic and phenotypic correlation of different characters and direct phenotypic effect with yield per plant in French bean genotypes. 1. Plant height at 25 DAS, 2. Plant height at 50 DAS, 3. No. of primary branches at 50 DAS, 4. Plant spread (N-S) at 50 DAS, 5. Plant spread (E-W) at 50 DAS, 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 ten pods, 19. Dry matter content of pods, 20. No. of root nodules per plant, 21. Pod yield per plant.

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.

Conclusion

From this study it can be concluded that the 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.

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