ISSN: 0974 - 0376

The Ecoscan : Special issue, Vol. VII: 41-46: 2015
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES
www.theecoscan.in

STUDY ON GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS WITH GREEN POD YIELD AND YIELD ATTRIBUTING TRAITS IN FRENCH BEAN (*PHASEOLUS VULGARIS* L.)

Bhaganna Haralayya *et al.*,

KEYWORDS

French bean
Genetic Variability
Correlation
Path analysis

Proceedings of National Conference on
Harmony with Nature in Context of
Bioresources and Environmental Health
(HORMONY - 2015)
November 23 - 25, 2015, Aurangabad,
organized by
Department of Zoology,
Dr. Babasaheb Ambedkar Marathwada University
Aurangabad (Maharashtra) 431 004
in association with
National Environmentalists Association, India
www.neaindia.org

The Ecoscan
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES

BHAGANNA HARALAYYA*[1], P. M. SALIMATH[1], NAGARAJAPPA ADIVAPPAR[2], I. S. ASHA AND S. GANGAPRASAD[1]
[1]Department of Genetics and Plant Breeding, College of Agriculture, UAHS, Shivamogga - 577 225
[2]Department of Horticulture, College of Agriculture, UAHS, Shivamogga - 577 225
e-mail:bhagannaharalayya@gmail.com

ABSTRACT

The present study was conducted on French bean to study the genetic variability, correlation among the yield components their direct and indirect effects on green pod yield. 36 French bean genotypes are used in these experiments which are collected from IIHR, Bangalore. These genotypes were planted in LSD with two replications during summer, 2014 at College of Agriculture, Shivamogga. The study indicated the existence of considerable amount of genetic variability for all the traits in all the genotypes used in the experiment. The PCV and GCV was observed for number of pods per plant (34.10 &33.48) followed by plant height (31.96 &31.45) and 100 seed weight (22.50 and 22.30).The high positive and significant correlation with green pod yield was noticed by Plant height (0.234) followed by pod length (0.3871) and number of pods per plant (0.3131). The Path coefficient analysis revealed that pod length had highest direct positive contribution (0.314) towards green pod yield per plant followed by plant height (0.194), days to 50% flowering (0.148) and flower to pod setting ratio (0.107). Suggesting that these parameters may be considered as prime traits during the course of selection to have the higher potential of yield in case of French bean.

***Corresponding author**

INTRODUCTION

Legumes represent the second largest family of higher plants, second only to grasses in agricultural importance (Doyle and Luckow, 2003). Resource poor farmers across the developing world depend on grain legumes to sustain the health of their families and livestock and to enhance their economic wellbeing. Pulses are the principal source of dietary protein among vegetarians and are an integral part of daily diet because of their high protein content and good amino-acid balance in several forms world-wide. On account of balanced aminoacid composition of cereals and protein blend, which matches with the milk protein, pulses are often called as life line of human beings. There is large disparity in yield of cereals and legumes. But as contrast to the impressive achievement in cereals, pulse production in our country remained almost stagnant with slight increase in productivity. There is also progressive decline in per capita availability of pulses from 70g per day in 1960-61 to less than 34g today as against 80g per day recommended by W.H.O. (2010). It is estimated that the country's population will touch nearly 1.68 billion by 2030 AD. The country would then require a minimum of 32.00 million ton of pulses with an anticipated growth rate of 4.2 %. The global pulse production in 2009 was over 18 million ton over an area of 26 million hectares, and an average productivity of 701 kg/ha (FAO, 2009). In India, the total pulse production during 2007-08 was 15.12 million ton on 23.86 million hectares with an average productivity of 638 kg/ha (Agriculture Statistics at a glance, 2009). French bean, (*Phaseolus vulgaris* L.) 2n=2x=22, belongs to the family *Fabaceace*. It is also known as kidney bean, snap bean, garden bean, string bean, hari cot bean, parotaparsha bean, wax bean, navy bean, dwarf beanand seed type varieties are called Rajma in India (Duke, 1981). It is one of the most important leguminous vegetable crop grown for its tender fleshy green pods, shelled green seeds and also dry beans.French bean originated from Central America and Peruvian Andes in South America (Vavilov, 1950; Yarnell, 1956). French bean is grown in the world in an area of 15.35 m ha with production of 20.74 mt (Anon., 2012). But in India, it is grown in an area of about 2.2 m ha with 6.2 mt of production and 2.8 Mt/ha productivity.

The entire success of plant breeding programme of any crop largely depends on the wide range of variability present in that crop. It is the range of genetic variability in respect of important economic characters present in the population upon which is based on the effectiveness of selection. Environment has a profound influence upon the economically important characters, which are quantitatively inherited. Hence, it is difficult to decide upon whether the observed variability is heritable or due to environment and it is therefore, necessary to partition the same into its heritable and non-heritable components with suitable parameters like genetic coefficient, heritability estimates and genetic advance. Selection procedure is more difficult in a trait, where heritability is low or is not precisely measurable. Indirect selection in such a situation is more effective and study of correlation among different economic traits are therefore, essential for an effective selection programme because selection for one or more trait results in correlated response for several other traits (Searle,1965) .The knowledge of genotypic and phenotypic correlation between yield and its contributing characters is very essential. Correlation studies measure only mutual association between two traits and it does not imply the cause and effect of relationship. Path coefficient analysis has been found useful direct and indirect causes of association and allows a detailed examination of specific forces acting to produce a given correlation and measures the relative importance of each causal factor. The paper deals with the above aspect.

MATERIALS AND METHODS

The experimental material for the present study comprised of 36 genotypes collected from Indian Institute of Horticultural Research (IIHR), Bangalore. The present investigation was carried out at College of Agriculture, Shivamogga. This comes under Southern transition Agro-climatic zone of Karnataka (Zone number 7). Geographically, College of Agriculture, Shivamogga is located at 13.91^0 North latitude and 75.56^0 East longitudes with an altitude of 650 m above the mean sea level. The experiment was laid out in simple lattice design with two replications during summer 2014. Every genotype in each replication was grown in a plot of 2×2 meter with a spacing of 45 cm between rows and 15 cm between plants. The seeds were hand-dibbled at given spacing in the respective blocks and crop was grown with other practices as per the recommendation. Observations were recorded on five competitive and randomly selected plants in each replications for all the genotypes viz., plant height (cm), number of vegetative branches per plant, number of flowering branches per plant, number of pods per plant, number of seeds per pod, pod length (cm), pod width (cm), days to maturity, days to 50% flowering, days to first flowering and 100 seeds weight; the average from these five plants was worked out for the statistical computation. Genotypic and Phenotypic co-efficient of variation were computed according to Burton and Devane (1953), Genetic advance was computed by using the formula given by Robinson *et al.* (1949). The correlation coefficients among all possible character combinations at phenotypic (rp) and genotypic (rg) level were estimated by using the formula given by Al-Jibouri *et al.* (1958). Path coefficient analysis was carried out using phenotypic correlation values of yield components on yield as suggested by Wright (1921) and illustrated by Dewey and Lu (1959).

RESULTS AND DISCUSSION

From the analysis of variance, it was observed that mean squares due to genotypes were significant for all the traits, indicating there by the presence of genetic variability in the experimental material (Table 1).The materials taken under study was having the sufficient magnitude of variability, which is very much desirable to the breeder for identification of suitable high yielding genotypes to be used in crop improvement programme to enhance the green pod yield of French bean. The extent of variability was measured in terms of mean, range,

Table 1: Analysis of variance for different characters in French bean

Sources of Variation	df	DFFl.	50% FLG	Fl:P	Pl.Ht	DMAT	No. VB	No. Fl.B	No. PPP	No. SPP	PL	PW	TWt.	GPYl.
Replication	1	19.53	18.70	0.47	88.62	3.511	0.52	0.29	27.92	0.68	1.33	0.02	12.35	4154.92
Genotypes	35	1.16**	4.06**	0.12**	599.23**	4.23**	0.95**	8.55**	54.58**	1.90**	7.61**	0.07**	129.57**	457.90**
Error	35	1.01	1.26	0.04	9.70	0.64	0.06	0.39	1.00	0.08	0.11	0.005	0.64	222.78
S. Em		0.70	0.78	0.14	2.17	0.55	0.17	0.43	0.69	0.20	0.23	0.04	0.56	10.40
CV		2.12	2.81	10.20	5.70	1.69	6.09	8.17	6.48	4.97	2.68	6.07	2.24	10.70
CD @ 5%		2.04	2.28	0.41	6.32	1.62	0.51	1.27	2.03	0.58	0.67	0.14	1.63	30.30
CD @ 1%		2.73	3.06	0.55	8.48	2.18	0.69	1.70	2.70	0.78	0.90	0.19	2.18	40.65

* Significance at 5 per cent ** Significance at 1 per cent df = Degrees of freedom
Where, DFFl. = Days to first flowering; No.VB = Number of vegetative branches; PW = Pod width (cm); 50%FLG = Days to 50 per cent flower No.Fl.B = Number of flowering branches TWt. = Test weight (g); Fl:P = Flower to pod set ratio ; No. PPP = Number of pods per plant ; GPYl. = Green pod yield (g); Pl.Ht. = Plant height (cm) No. SPP = Number of seeds per pod; DMAT = Days to maturity; PL = Pod length (cm)

Table 2: Genetic parameters for 13 characters in French bean

Sl No.	Character	Mean	Range Min	Max	Vp	Vg	Ve	GCV(%)	PCV(%)	h^2(%)	GA	GAM(%)
1	DFFl.	36.85	35.40	38.90	1.09	0.07	1.01	0.76	2.83	6.42	0.15	0.42
2	50% FLG	39.92	37.80	46.40	2.66	1.40	1.26	2.96	4.09	52.63	1.76	4.42
3	Fl:P	1.98	1.54	2.52	0.08	0.04	0.04	10.54	14.67	50.00	0.30	15.59
4	Pl.Ht	54.58	42.70	93.34	304.47	294.76	9.70	31.45	31.96	96.81	34.79	63.75
5	DMAT	47.15	41.90	49.10	2.43	1.79	0.64	2.84	3.31	73.66	2.37	5.02
6	No.VB	4.16	3.30	6.20	0.51	0.44	0.06	16.04	17.16	86.27	1.28	30.90
7	No.Fl.B	7.67	5.95	12.89	4.47	4.08	0.39	26.32	27.56	91.27	3.97	51.78
8	No.PPP	15.45	9.90	27.85	27.79	26.78	1.00	33.48	34.10	96.36	10.46	67.72
9	No.SPP	5.78	4.40	8.0	0.99	0.91	0.08	16.48	17.22	91.91	1.88	32.51
10	PL	12.41	10.40	17.25	3.86	3.75	0.11	15.61	15.84	97.15	3.93	31.69
11	PW	1.16	0.94	1.35	0.01	0.006	0.005	6.65	9.01	60.00	0.11	10.11
12	TWt.	35.86	20.66	50.95	65.11	64.46	0.64	22.38	22.50	99.00	16.45	45.89
13	GPYl.	139.40	99.50	165.00	340.34	117.56	222.78	7.77	13.23	34.54	13.12	9.41

Where, DFFl. = Days to first flowering; No.VB = Number of vegetative branches; PW = Pod width (cm); 50%FLG = Days to 50 per cent flower; No.Fl.B = Number of flowering branches; TWt. = Test weight (g); Fl:P = Flower to pod set ratio ; No.PPP = Number of pods per plant; GPYl. = Green pod yield (g); Pl.Ht. = Plant height (cm); No.SPP = Number of seeds per pod; DMAT = Days to maturity ; PL = Pod length (cm)

Table 3: Correlation coefficients among different yield components in French bean

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
X_1	1.0000												
X_2	0.3948**	1.0000											
X_3	0.3472**	0.4134**	1.0000										
X_4	0.3575**	0.0456	0.0667	1.0000									
X_5	0.2434*	0.0375	0.2579*	0.0837	1.0000								
X_6	0.1069	0.1508	0.1942	-0.2419*	-0.1603	1.0000							
X_7	0.1533	-0.1594	-0.2149	-0.2197	-0.1504	0.5068**	1.0000						
X_8	0.3981**	0.1246	0.1067	0.8492**	-0.0250	-0.3014*	-0.2612*	1.0000					
X_9	0.1341	0.1728	0.4024**	-0.0935	-0.0511	-0.0501	-0.0977	-0.0272	1.0000				
X_{10}	0.0624	0.1534	0.3858**	-0.1958	-0.0601	-0.0810	-0.1691	-0.1331	0.9361**	1.0000			
X_{11}	0.2040	0.2345*	0.2490*	-0.0725	-0.0434	0.1982	0.1104	0.0389	0.2947*	0.2425*	1.0000		
X_{12}	-0.0267	0.0459	0.2186	-0.2946*	-0.0413	0.2395*	0.1179	-0.3446**	-0.0530	-0.0288	0.0601	1.0000	
X_{13}	-0.1122	0.0937	-0.0307	0.2340*	-0.2967*	-0.0803	-0.1252	0.3131**	0.2464*	0.3871**	-0.0649	-0.1337	1.0000

* Significance at 5 per cent ** Significance at 1 per cent

Where, X_1 = Days to first flowering; X_2 = Days to 50 per cent flower; X_3 = Flower to pod set ratio; X_4 = Plant height (cm); X_5 = Days to maturity; X_6 = Number of vegetative branches; X_7 = Number of flowering branches; X_8 = Number of pods per plant; X_9 = Number of seeds per pod; X_{10} = Pod length (cm); X_{11} = Pod width (cm); X_{12} = Test weight (g); X_{13} = Green pod yield (g)

phenotypic co-efficient of variation, genotypic coefficient of variation, heritability, genetic advance and genetic advance as per cent mean (Table 2).Plant height varied from 42.70 to 93.34 cm with general mean 54.58cm as in Table 2 showed that all the genotypes are having the semi-dwarf stature, number of vegetative branches per plant varied from 3.30 to 6.20 with general mean 4.16 suggesting that very few genotypes are closer to the higher range of traits, number of flowering branches per plant varied from 5.95 to 12.89 having general mean 7.69 indicating that most of the genotypes were having the moderate flowering branches per plant, number of pods per plant varied from 9.90 to 27.85 with general mean 15.45 which revealed that majority of genotypes were having the high number of pods per plant,pod length ranged from 10.40 to 17.25 cm having general mean 12.41 cm, number of seeds per pod varied from 4.40 to 8.0 pod and most of genotypes were having the fiveseeds per pod as evident from general mean, , 100 seed weight ranged from 20.66 g to 50.95 g with general mean 35.86 g suggesting most of genotypes were having moderate test weight.

On perusal of Table 2, it was revealed that for all the characters phenotypic coefficient of variation (PCV) was slightly higher than the genotypic coefficient of variation (GCV), so it is evident that in expression of the characters mainly governed by the genotypes itself along with meagre effect of environment. This finding also get corroborated with Venkateswarlu (2001), Dikshit *et al.* (2002), Reddy *et al.* (2003) and Tejbir *et al.* (2009). A perusal of the table, revealed that high heritability estimates coupled with high genetic advance was observed for pod length, number of seeds per pod and 100 seed weight, indicating the preponderance of additive and fixable genetic variance; suggesting that this trait may be subjected to any selection scheme to develop the stable genotypes and selection pressure may be exercised in early generation. High heritability coupled with moderate genetic advance for 100 seed weight as well as high heritability coupled with low genetic advance indicating the presence of additive as well as non-additive gene action. For these traits improvement can be made opting the two to three cycles of recurrent selection followed by pedigree or single seed descent methods of breeding. These findings were corroborated with Dadepeer *et al.* (2009), Dhananjay *et al.* (2009) and Rahim *et al.* (2010).

Correlation of 13 characters was represented in the Table 3.In the present study days to first flowering negatively correlated with green pod yield. This result is in agreement with Aghora (1999). Days to 50 per cent flowering showed positive association with green pod yield, these results agrees with Ahmed and Kamaluddin (2013). In the present study flower to pod set ratio had a positive association with days to first flowering, days to 50 per cent flowering, days to maturity, number of seeds per pod, pod length (cm), pod width, plant height, number of primary branches and number of pods per plant and test weight. It suggests that if the flower numbers are more there will be a more number of pods that will positively associated with other yield contributing traits. Plant height exhibited significant positive association with green pod yield per plant. Similar results are reported by Shinde and Dumbre (2001) and Angadi *et al.* (2012). It also had positive correlation with days to first flowering, number of pods per plant. The green pod yield can be improved through increasing plant height, because it exhibited a positive association with days to first flowering and number of pods per plant. Days to maturity exhibited negative and significant association with green pod yield, similar result was reported by Prakash and Ram (1981).The number of primary branches showed negative and non significant association with green pod yield. The contrast results are reported by Aghora (1999) they shown positive and significant association with green pod yield. It had a positive and significant association with number of secondary branches and test weight. Number of pods per plant exhibited significant positive association with green pod yield and these results are in consonance with those of Islam *et al.* (2011). The number of seeds per pod exhibited a positive significant association with green pod yield; these results are on par with Angadi *et al.* (2012), Arun *et al.* (2014). It also observed significant and positive association with flower to pod, pod length and pod width as reported Arun *et al.* (2014).The pod length showed significant and positive association with green pod yield. These results are in agreement with Arun *et al.* (2014). It also exhibited positive association with number of

Table 4: Direct (diagonal) and indirect effects of yield components on green pod yield per plant in French bean

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
X_1	-0.092	-0.036	-0.032	-0.033	-0.022	-0.009	-0.014	-0.036	-0.012	-0.005	-0.018	0.002
X_2	0.058	0.148	0.061	0.006	0.005	0.022	-0.023	0.018	0.025	0.022	0.034	0.006
X_3	0.037	0.044	0.107	0.007	0.027	0.020	-0.023	0.065	0.118	0.041	0.026	0.023
X_4	0.069	0.008	0.013	0.194	0.016	-0.047	-0.042	0.165	-0.018	-0.038	-0.014	-0.057
X_5	-0.085	-0.013	-0.090	-0.029	-0.352	0.056	0.053	0.008	0.018	0.021	0.015	0.014
X_6	-0.010	-0.015	-0.019	0.104	0.016	-0.102	-0.051	0.030	0.005	0.008	-0.020	-0.024
X_7	-0.002	0.002	0.003	0.083	0.002	-0.007	-0.014	0.182	0.076	0.002	-0.001	-0.001
X_8	-0.054	-0.017	-0.014	-0.117	0.003	0.041	0.036	-0.137	0.078	0.183	-0.005	0.047
X_9	-0.044	-0.057	-0.133	0.031	0.017	0.016	0.032	0.009	-0.332	-0.311	-0.098	0.017
X_{10}	0.019	0.048	0.121	-0.061	-0.018	-0.025	-0.053	-0.041	0.294	0.314	0.076	-0.009
X_{11}	-0.010	-0.011	-0.012	0.003	0.002	-0.010	-0.005	-0.002	-0.014	-0.012	-0.050	-0.003
X_{12}	0.004	-0.006	-0.032	0.044	0.006	-0.036	-0.017	0.051	0.008	0.004	-0.009	-0.150
Correlation with yield X_{13}	-0.112	0.093	-0.030	0.234	-0.296	-0.080	-0.125	0.313	0.246	0.387	-0.064	-0.133

Residual effect = 0.1896

Where, X_1 = Days to first flowering; X_2 = Days to 50 per cent flower; X_3 = Flower to pod set ratio; X_4 = Plant height (cm); X_5 = Days to maturity; X_6 = Number of vegetative branches; X_7 = Number of flowering branches; X_8 = Number of pods per plant; X_9 = Number of seeds per pod; X_{10} = Pod length (cm); X_{11} = Pod width (cm); X_{12} = Test weight (g); X_{13} = Green pod yield (g)

seeds per pod, pod width and flower to pod set ratio. It suggests that by improving pod length we can improve the pod yield.

The study of direct and indirect effects through path analysis was done and the results obtained from the study were represented in the Table 4. Days to 50 per cent flowering, flower to pod set ratio, plant height and pod length showed high positive and direct effect on green pod yield, these results are similar with Subhadeep-Nath and Korla (2004) and Ahmed and Kamluddin (2013). In crop like French bean, among yield component traits flower to pod set ratio is a major trait why because it had a high positive direct effect to green pod yield. It had a high positive indirect effect to green pod yield through days to 50 per cent flowering, plant height, number of secondary branches and pod length. This trait could be used as an index trait while selecting for green pod yield.Even though days to first flowering, days to maturity, number of primary branches, number of secondary branches, number of pods per plant, number of seeds per pod, pod width and test weight had negative direct effect on green pod yield but they showed positive indirect effect on green pod yield through other characters. These results are similar with Venkateswarlu (2001) and Ambularmathi *et al.* (2004). The number of pods per plant shows high positive indirect effect through pod length, flower to pod set ratio; therefore, this character plays an important role in green pod yield improvement. Similarly for the character pod length which exhibited high positive indirect effect through number of pods per plant on green pod yield. Plant height also exhibited high positive indirect effect through number of primary branches per plant.

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