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STUDIES OF GENETIC VARIABILITY, CORRELATION AND PATH COEFFICIENT FOR VARIOUS CHARACTERS IN FRENCH BEAN

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ABSTRACT

The research was conducted during the *Rabi season* of 2019-2020 on 32 genotypes of French bean (*Phaseolus vulgaris* L.) to evaluate genetic variability, correlation coefficient and path coefficient. The genotypes were studied for 13 different characters of growth and yield attributing characters in Randomized Block Design with three replications for each genotype. All characters recorded higher PCV value over GCV thereby indicating the influence of environmental factors in their expression. High heritability observed in all the characters studied and high heritability coupled with high genetic advance found in the parameters *viz*. number of pods per plant, average pod weight, 100 seed weight and pod yield per plant. Correlation coefficient analysis showed pod yield had significant and positive correlation with number of pods per plant, pod length, average pod weight and 100 seed weight. Path analysis revealed that maximum positive direct effect *w.r.t* pod yield per plant was brought about by the parameters *viz.* 100 seed weight, days taken to marketable maturity, number of seeds per pod, number of pods per plant, average pod weight, pod width and pod length hence, should be given more importance for genetic improvement to bring about an increase in overall production of french bean through enhanced pod yield per plant.

Keywords: Correlation coefficient, French bean, Genetic variability, Heritability, Path analysis.

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) also called as kidney beans or snap beans belongs to the family Leguminoseae and most of whose members acquire the nitrogen they require through an association with Rhizobia, species of nitrogen-fixing bacteria. French bean has a chromosome number of 2n=22. The center of origin is

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believed to be in South Mexico and Central America (Jones, 1999). It is a herbaceous annual plant and cross-pollinated. All varieties of French bean bear alternate, green or purple leaves, which are divided into three oval, smooth-edged leaflets, each 6-15cm long and 3-11cm wide. The white, pink, or purple flowers are about 1cm long and they give way to pods 8-20cm long and 1- 1.5cm wide. The beans are smooth plump, kidney-shaped up to1.5cm long and range widely in color and are often mottled in two or more color. In India the production is at 1.977mt with an area of 0.197mha with a productivity of 10.35 t/ha whereas for the state of Nagaland, it has an area of 0.47 lakh ha with a production of 5.62 lakh tonnes and the productivity higher than the national productivity at 11.96 t/ha (NHB, 2018). French bean is said to have a high protein content (23.9%) and good source of vitamin A and C, Folic acid, Fibre and helps in reducing risk of cardiovascular diseases. French bean in Hindi is also known as Rajma (dried seeds) and in Nagaland it is called as Kholar. Nagaland is blessed with diverse agro-climatic condition just like India and has a scope for growing all types of vegetables. Likewise, Nagaland has the potential to be leading producer of French bean in the country if provided with high yielding and suitable cultivar for this region.

The potential of french bean as fresh vegetable is not exploited and is still insufficient to meet the domestic needs of the people. High yield can be achieved by selection of characters that have high heritability coupled with genetic advance. Selection of one trait invariably affects a number of associated traits which evokes the necessity of determining interrelationships of various yield components among them and with yield. Yield is a composite character and dependent upon a number of ascribes. For an effective selection, it is essential to have the association of various attributes with yield and yield attributing characters. Estimation of correlation coefficient among the yield contributing characters is necessary to understand the direction of selection and maximize yield in the shortest period. Path coefficient provides an efficient way of entangling direct and indirect causes of association of selection and measures the relative importance of each causal factor. Varietal performance of French bean varies from place to place due to the varied agro-climatic conditions and does not remain same for all the regions. Considering all the above mentioned facts, a pertinent need was felt to undertake an experiment on the performance of French bean genotypes by calculating the genotypic correlations and determining the indirect effects of component characters on yield in French bean under foothill condition of Nagaland. Thus, the present study was conducted as to identify the characters which need to be considered for yield related breeding aspects.

MATERIALS AND METHODS

The experiment was carried out in the experimental farm of School of Agricultural Sciences and Rural Development, Medziphema campus, Nagaland University, Nagaland during October, 2019 to January, 2020. The site of the experiment is situated at 20°45'43'N latitude and 93°53'04'E latitude at an elevation of 305m above

mean sea level bearing sub-tropical climate. The materials for the experiment comprising of 32 lines/genotypes of french bean is maintained *viz*. NUFB-1, NUFB-2, NUFB-3, NUFB-4, NUFB-5, NUFB-6, NUFB-7, NUFB-8, NUFB-9, NUFB-10, NUFB-11, NUFB-12, NUFB-13, NUFB-14, NUFB-15, NUFB-16, NUFB-17, NUFB-18, NUFB-19, NUFB-20, NUFB-21, NUFB-22, NUFB-23, NUFB-24, NUFB-25, NUFB-26, NUFB-27, NUFB-28, NUFB-29, NUFB-30, NUFB-31 and NUFB-32. All thirty two varieties were evaluated in Randomized Block Design (RBD) with three replications. Seeds were sown on 23rd of October, 2019 in the plot size of 2 m x 2 m at the depth of 5 cm with a spacing of 50cm x 10cm, recommended cultural practices and plant protection measures were followed. 10 plants are randomly selected from each plot of every replication and tagged for further data recording and mean value have been calculated. The observations were for days taken to flowering, days taken to 50% flowering, days taken to marketable maturity, number of pods per plant, pod length (cm), pod width (cm), number of seeds per pod, average pod weight (g), 100 seed weight (g), pod yield per plant (g), pod yield per plot (kg) and pod yield per hectare (q). The biochemical observations were taken for total soluble solids (%) using hand refractometer, ascorbic acid (mg/100g) by titration method, (Ranganna, 1995) and protein (%) by the Micro-Kjeldahl method is according to AOAC (2000). The data recorded for investigation were analyzed heritability in broad sense, genetic advance, genotypic and phenotypic correlation coefficients and path coefficient analysis using R- statistical software.

RESULTS AND DISCUSSION

Genetic variability, heritability and genetic advance

The variability analysis were done for the 13 characters where it was found that genotypic coefficient variability (GCV) for all the characters studied was lower when compared to their corresponding phenotypic coefficient variability (PCV) thereby indicating environmental influence over their expressions as shown in table 1. Similar findings were reported by Ghimire and Mandal, 2019 and Basavaraja et al., 2021. However, the difference between the GCV and PCV in the present investigation were found out to be minimal thereby suggesting that the environmental influence over the genotypes was near stable (Panchbhaiya et al., 2017). It is estimated that highest genotypic and phenotypic coefficient of variation was observed for pod yield per plant (34.93 and 34.98, respectively) followed by number of pod per plant (34.69 and 34.79, respectively) while lowest GCV and PCV were recorded for days taken to marketable maturity (6.98 and 7.16, respectively). It is not always true that high heritability would always exhibit high genetic advance. Hence, that heritability in combination with genetic advance would be more reliable for predicting effects of selection because genetic advance depends on amount of genetic variability; magnitude of masking effect of genetic expression (environmental influence) and intensity of selection. However, it is not necessary that a character showing high heritability will also exhibit high genetic advance (Johnson et al.,

1955). The present study, estimates of high heritability was exhibited by no. of pods per plant (99.45) followed by no. of seeds per pod (99.32) and highest genetic advance mean (%) were obtained from no. of pods per plant (71.22) followed by Pod yield /plant(g) (70.88) as shown in Table 1. High heritability, along with high genetic advance as percent over mean, indicated inheritance of those characters is controlled mainly by additive genes and selection based on phenotypic performance may prove useful which will further help in improvement of their performance and these traits may be used as selection criteria in French bean breeding program.

Correlation coefficient

It is necessary to know the correlation of yield with its economically important component for making selection in a breeding. It provides advantages of adequate selection i.e. more than one character at a time in advance generations. Correlations between character pairs are due to the linkage of genes or pleiotropy of genes. Therefore, selection of one trait influences the other linked or pleiotropically affected traits. Hence, direct selection for yield may not be effective. So, it would be necessary to have an adequate knowledge about the correlation studies in the plant improvement because they are helpful in making an effective selection. In general, the magnitude of genotypic correlation coefficient was lesser than the corresponding values of the phenotypic correlation coefficient. This indicates that the expressions of character associations had been influenced by the environment and the apparent association may not be largely due to genetic reason. The difference between genotypic and phenotypic correlation was low, indicating that the environmental effects did not have much influence on these characters.

The current study revealed that pod yield per plant showed significant and positive correlation association at genotypic and phenotypic level with number of pods per plant (0.7792 and 0.7794, respectively), pod length (0.4711 and 0.4729, respectively), number of seeds per pod (0.3985 and 0.4005, respectively), average seed weight (0.4323 and 0.4364, respectively) and 100 seed weight (0.4087 and 0.4107, respectively) as shown in Table 2 and Table 3. Similar findings, for number of seed per pod, 100 seed weight and pod length was given by Aklade et al. (2018), for pod length by Rai et al. (2006), for number of pods per plant by Samal et al. (1995) and for number of pods per plant, number of seeds per pod and pod length by Mishra et al. (2008).

Path coefficient analysis

Path coefficient analysis has been carried out to analyze the direct and indirect effect of causal factors which affect the yield. It is simply standardized partial regression coefficient which splits the correlation coefficient into the measures of the direct and indirect effects of a set of independent variables on the dependent variable. The present study on path coefficient analysis revealed that the maximum negative direct

Table 1. Genetic parameters for yield and yield attributing traits of 32 french bean genotypes.

Parameters	Mean	Range		Heritability (%)	Coefficient of variation		Genetic Advance	Genetic Advance value % means
		Min.	Max.		GCV (%)	PCV (%)		
Days taken to 1st flowering	46.13	37.98	54.30	96.61	8.56	8.70	7.99	17.32
Days taken to 50% flowering	50.54	39.98	58.33	96.86	8.92	9.07	9.14	18.09
Days taken to marketable maturity	58.43	49.98	66.37	94.98	6.98	7.16	8.18	14.01
No. of pods per plant	9.39	4.00	16.18	99.45	34.69	34.79	6.69	71.27
Pod length	13.63	9.06	18.14	99.19	18.37	18.45	5.14	37.70
pod width	1.50	1.11	1.93	98.43	13.99	14.10	0.43	28.60
No.of seeds per pod	5.60	3.98	8.12	99.32	20.08	20.15	2.31	41.22
Average pod weight	10.97	6.75	15.89	99.17	21.69	21.78	4.88	44.49
100 seed weight (g)	42.31	30.45	61.22	99.31	19.98	20.05	17.35	41.01
Total soluble solids (%)	5.04	3.53	6.75	99.30	19.00	19.07	1.96	39.01
Ascorbic acid (mg/100g)	58.14	49.99	65.21	95.57	7.63	7.81	8.93	15.37
Protein(%)	9.07	7.34	10.86	98.16	11.93	12.04	2.21	24.34
Pod yield /plant(g)	100.93	34.31	156.00	99.12	34.93	34.98	72.54	70.88

Table 2. Estimates of genotypic correlation among 13 characters in French bean genotypes

Characters	Days taken to 1st flowering	Days taken to 50% flowering	Days taken to marketable maturity	No. of pods/plant	Pod Length (cm)	Pod width(cm)	No. of seeds/pod	Average pod weight (g)	100 seed weight (g)	TSS (%)	Ascorbic acid (mg/100g)	Protein (%)
Days taken to 1st flowering												
Days taken to 50% flowering	0.9782 **											
Days taken to marketable maturity	0.9557 **	0.9758**										
No. of pods/plant	0.0492 NS	0.0181NS	0.0323 NS									
Pod length (cm)	0.1864 NS	0.1652NS	0.1611 NS	-0.1049 NS								
Pod width(cm)	-0.0069 NS	0.0551NS	-0.0152 NS	-0.3857 *	0.1263NS							
No. of seeds/pod	0.1868 NS	0.1764NS	0.2307 NS	-0.13 NS	0.8725**	0.0615 NS						
average pod weight(g)	0.0011 NS	0.0165NS	0.0143 NS	-0.1835 NS	0.9141**	0.2216 NS	0.7877 **					
100 seed weight(g)	0.182 NS	0.1717NS	0.2261 NS	-0.1199 NS	0.8735**	0.058 NS	0.9995 **	0.7859 **				
TSS (%)	0.4312 *	0.3786*	0.3624 *	0.2057 NS	-0.103	-0.185 NS	-0.2023 NS	-0.1638 NS	-0.2048 NS			
Ascorbic acid (mg/100g)	-0.42 *	-0.37766	-0.3662 *	-0.2166 NS	0.1075NS	0.2063 NS	0.2276 NS	0.1556 NS	0.2314 NS	-0.9798 **		
Protein (%)	-0.2622 NS	-0.222	-0.2215 NS	0.1059 NS	0.0074NS	-0.0458 NS	-0.0107 NS	-0.0949 NS	0.0016 NS	-0.2346 NS	0.236 NS	
Pod yield/plant (g)	0.0383 NS	0.0132NS	0.0285 NS	0.7792 **	0.4711**	-0.2389 NS	0.3985 *	0.4323 *	0.4087 *	0.0522 NS	-0.0625 NS	0.0209 NS

Note: * and **: indicated significant at 5% and 1%level of probability, respectively. NS indicates non-significant.

Table 3. Estimates of Phenotypic correlation among 13 characters in French bean genotypes

	Days taken to 1st flowering	Days taken to 50% flowering	Days taken to marketable maturity	No. of pods/plant	Pod Length (cm)	Pod width(cm)	No. of seeds/pod	Average pod weight (g)	100 seed weight (g)	TSS (%)	Ascorbic acid (mg/100g)	Protein (%)
Days taken to 1st flowering	1 **											
Days taken to 50% flowering	0.9789 **	1 **										
Days taken to marketable maturity	0.9567 **	0.9756 **	1 **									
No. of pods/plant	0.0596 NS	0.0287 NS	0.0453 NS	1 **								
Pod Length (cm)	0.1988 NS	0.1776 NS	0.1762 NS	-0.0988 NS	1 **							
Pod width(cm)	0.0154 NS	0.0751 NS	0.0122 NS	-0.3744 **	0.1356NS							
No. of seeds/pod	0.1979 NS	0.1873 NS	0.2422*	-0.1243 NS	0.8734**	0.0705 NS	1 **					
Average pod weight (g)	-0.0052 NS	0.0101 NS	0.0062 NS	-0.1843 NS	0.9032**	0.2147 *	0.7787 **	1 **				
100 seed weight (g)	0.1931 NS	0.1828 NS	0.2377*	-0.1142 NS	0.8744**	0.0671 NS	0.9995 **	0.7769 **	1 **			
TSS (%)	0.4375 **	0.3858 **	0.3703**	0.2095 *	-0.0958NS	-0.1731 NS	-0.1944 NS	-0.1656 NS	-0.1968NS	1 **		
Ascorbic acid (mg/100g)	-0.3654 **	-0.3265 **	-0.3022*	-0.1983 NS	0.1232NS	0.2252 *	0.2387 *	0.1446 NS	0.2425*	-0.9378 **	1 **	
Protein (%)	-0.2309 *	-0.1931 NS	-0.184NS	0.1128 NS	0.0192NS	-0.029 NS	0.4004 NS	-0.0987 NS	0.0126NS	-0.2208 *	0.2568 *	1 **
Pod yield/plant (g)	0.0461 NS	0.0213 NS	0.0382NS	0.7794 **	0.4729**	-0.2312 *	0.4005 **	0.4364 **	0.4107**	0.0558 NS	-0.0513 NS	0.027 NS

Note: * and **: indicated significant at 5% and 1%level of probability, respectively. NS indicates non-significant.

Table 4. Direct (diagonal) and indirect effect of various characters on pod yield in french bean genotypes.

Characters	Days taken to 1st flowering	Days taken to 50% flowering	Days taken to marketable maturity	No. of pods/plant	Pod Length (cm)	Pod width(cm)	No. of seeds/pod	Average pod weight (g)	100 seed weight (g)	TSS (%)	Ascorbic acid (mg/100g)	Protein (%)	Pod yield/plant (g)
Days taken to 1st flowering	-0.89992	-1.07945	0.49871	-0.0572	-0.00767	-0.00082	0.24989	-0.0005	-0.33108	0.52571	-0.54946	-0.04261	0.08359
Days taken to 50% flowering	0.8803	-0.11035	0.50921	-0.02107	-0.00679	0.00655	0.23595	-0.00724	-0.31245	0.46151	-0.49389	-0.03611	0.02894
Days taken to marketable maturity	0.86003	-1.07679	0.22185	-0.0376	-0.00663	-0.0018	0.30856	-0.00627	-0.4113	0.44185	-0.47899	-0.036	0.06216
No. of pods/plant	0.04423	-0.01997	0.01686	0.11638	0.00431	-0.04586	-0.17388	0.08045	0.21814	0.25078	-0.28339	0.01721	1.70178
Pod length (cm)	0.16777	-0.1823	0.08408	0.12208	0.04113	0.01502	1.16689	-0.40085	-1.5892	-0.12655	0.14064	0.0012	1.02896
Pod width(Cm)	-0.00621	-0.06077	-0.00791	0.44885	-0.00519	0.11891	0.08219	-0.09718	-0.1055	-0.2255	0.26979	-0.00745	-0.5217
no of seeds/pod	0.16815	-0.19469	0.1204	0.15132	-0.03589	0.00731	0.33737	-0.34542	-1.81833	-0.24667	0.29773	-0.00173	0.87029
average pod weight(g)	0.00102	-0.01821	0.00746	0.21351	-0.0376	0.02635	1.05342	0.43853	-1.42983	-0.19972	0.2036	-0.01543	0.95307
100 seed weight(g)	0.16377	-0.18952	0.11797	0.13954	-0.03593	0.0069	1.33663	-0.34464	0.18193	-0.24964	0.30271	0.00027	0.89272
TSS(%)	0.38806	-0.41774	0.18913	-0.2394	0.00427	-0.02199	-0.27059	0.07184	0.37253	-0.12195	-1.28173	-0.03812	0.11397
Ascorbic acid(mg/100g)	-0.378	0.41664	-0.19108	0.25213	-0.00442	0.02452	0.30439	-0.06825	-0.42101	-1.19457	-0.13081	0.03835	-0.1366
Protein(%)	-0.23595	0.24521	-0.11559	-0.12325	-0.0003	-0.00545	-0.01427	0.04163	-0.003	-0.28597	0.3087	-0.16251	0.04574
Pod yield/plant(g)	0.03444	-0.01462	0.01485	-0.9068	-0.01938	-0.0284	0.53289	-0.19136	-0.74361	0.06362	-0.08181	0.0034	0.71413

Residual value= 0.1087 Note: * and **: indicated significant at 5% and 1%level of probability, respectively. NS indicates non-significant.

effect on yield plant^{-1} was exhibited by days taken to 1st flowering (-0.89992), days taken to 50% flowering (-0.11035), ascorbic acid (-0.13081), TSS (-0.12195) and protein% (-0.16251). Lyngdoh et al. (2017) also reported similar findings for negative direct effect of days taken to 1st flowering on pod yield. Whereas, positive direct effect on pod yield were seen in 100 seed weight (0.18193), days taken to marketable maturity (0.22185), number of seeds per pod (0.33737), number of pods per plant (0.11638), average pod weight (0.43853), pod width (0.11891) and pod length (0.04113) as shown in the table 4. Similar reporting of positive direct effect on pod yield by number of seeds per pod and pod width were given by Aklade et al. (2018). Hence, purposeful and balanced selection based on these particular characters would be rewarding for improvement in French bean genotypes and thereby confirmed the past findings (Kanaujia et al., 2017).

CONCLUSION

The present study has recorded significant agro-morphological variation in the genotypes which shows that there is sufficient variation for selection of suitable genotypes for various production systems. The variability observed in floral characters and pod yield could be utilized in variety improvement programs. Traits like number of pods per plant, pod length, number of seeds per pod, average pod weight and 100 seed weight which exhibited desirable association *w.r.t* pod yield per plant should be given more importance for genetic improvement to bring about an increase in overall production of french through enhanced pod yield per plant. It would therefore, be rewarding to lay stress on these characters in hybridization program for further improvement of yield and related characters in French bean. Future research work should focus on the agronomic management and evaluation of genotypes across a range of environments to identify and select location- specific and widely adaptive genotypes.

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