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MORPHOLOGICAL CHARACTERIZATION AND GENETIC VARIABILITY IN FRENCH BEAN *(Phaseolus vulgaris L.)* GENOTYPES UNDER SUBTROPICAL CONDITION OF SRINAGAR GARHWAL

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ABSTRACT

In this study, 26 traditional French bean (*Phaseolus vulgaris* L.) genotypes collected from diverse regions in Uttarakhand, Himachal Pradesh, Jammu and Kashmir, and Manipur were evaluated for their genetic variability and morphological traits using RCBD with three replications. The morphological characterisation analysis revealed a reasonable amount of variation. Among the different traits under study, only pod stringiness showed 100% frequency. The analysis of variance indicated the mean sum of squares due to genotypes was highly significant at the 1% level of significance for all the characters. High GCV and PCV were found for characters like plant height (45.46, 45.5), fresh weight of nodules (28.68, 29.9), dry weight of nodules (51.59, 55.4), and number of pods per plant (27.32, 27.9), pod yield per plant (35.51, 37.5), and green pod yield per hectare (36.30, 42.2). High heritability estimates coupled with high genetic gain were observed for yield and other horticultural traits. A higher production was recorded by 25 genotypes that performed better than the check cultivar in terms of yield and other yield-related parameters. These genotypes can be taken into account for future plans for French bean breeding and suggested for cultivation in the subtropical climate of the Garhwal Hills.

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is the most commonly grown nutritious vegetable, which is also known as kidney bean, snap bean, garden bean, string bean, haricot bean, parotaparsha bean, navy bean, dwarf bean and seed type varieties are called Rajma in India (Duke, 1981). French bean was originated from Central America and Peruvian Andes in South America French bean (*Phaseolus vulgaris* L.) is the most commonly grown nutritious vegetable, which is also known as kidney bean, snap bean, garden bean, string bean, haricot bean, parotaparsha bean, navy bean, dwarf bean and seed type varieties are called Rajma in India (Duke, 1981). French bean was originated from Central America and Peruvian Andes in South America (Vavilov, 1950 and Yarnell, 1956). It is consumed as vegetables when pods are immature, delicate, and tender and green shelled or as dry pulse (Borang and Sharma, 2020). Green pods have diuretic qualities, which aid with toxin clearance and diabetic management. They are high in grain proteins (21.1%), carbohydrates (69.9%), phosphorus (42.5 mg), and iron (12.4 mg) per 100gm and provide nutritional benefits (Ali and Kushwaha, 1987). Additionally, the pods contain phenolic chemicals, such as flavonoids and bioflavonoids, which are important for plant antibacterial defence. French beans, which are low in calories, and high in fibers, minerals, folates, and antioxidants, offer extra health benefits (Thapa *et al.,* 2022).

French bean cultivation in Uttarakhand faces pitfalls due to low productivity, which is mostly due to a lack of early, high-yielding, and short-duration cultivars that are resistant to biotic and abiotic challenges. Because of this shortcoming, French bean cultivation has declined, particularly in regions with limited input assistance. Selecting and assessing high-yielding breeding lines that can flourish in subtropical climates is crucial in order to address issues with quality and productivity. There is also an urgent need to define and utilise existing variability for morphology and yield attributes in order to refresh French bean production in Uttarakhand.

Morphological characterization is a fundamental and crucial step in any crop improvement which helps determine the purity of germplasm. Existing genetic variability in a gene pool is also primary importance for any successful selection in a breeding programme. Genetic variability in crop plants provides an opportunity for selecting desirable genotypes. To determine the genetic makeup of the sample population, total variability must be partitioned into GCV and PCV, as selection based on phenotypic variation alone can be misleading because it is influenced by environmental factors (Swar *et al.* 2020). Heritability analysis is vital in identifying the traits that contribute to higher yield during the selection process (Khajuria *et al.,* 2015). Efficacy in a selection process depends directly on heritability's aggregate effects combined with genetic advance as percent of the mean for the trait (Kumar *et al.* 2019). Singh *et al.* (2020) conducted investigations similar to the current study for the reasons stated above and observed significant variations across the 12 genotypes of French bean. Various traits, including leaf fresh weight, leaf dry weight, pod

weight, ascorbic acid, total chlorophyll, reducing sugar, total sugar, and protein, showed high heritability and genetic advance, suggesting that phenotypic selection is likely to be effective due to the presence of additive gene action. In a similar vein, Ummyiah *et al*. (2022) evaluated 30 different genotypes of French beans and displayed a statistically significant difference among the genotypes with regard to the parameters under investigation, indicating diversity and distinctiveness among the genotypes investigated. Given the facts, local genotypes were colle1cted from various places in India's Northern Himalayan area, including Uttarakhand, Himachal Pradesh, Jammu & Kashmir, and Manipur, to enhance the genetic makeup of French beans. These genotypes may have useful adaptation qualities that can help improve the nutritional value, resistance to disease, and other desirable properties of French beans. The current work was designed to characterise the genetic variability among these genotypes in order to aid in future breeding attempts.

MATERIALS AND METHODS

The experiment was carried out at Horticultural Research Centre, Chauras Campus, Department of Horticulture, Hemvati Nandan Bahuguna Garhwal University, Srinagar (Garhwal), Uttarakhand, India. It is located at an elevation of 540 m above MSL, in the lesser Himalayan region. The climate is humid and sub-tropical with both the extremes in the temperature, i.e., winter and summer seasons. In fairly cold winters, the temperature sometimes goes as low as 5.0 to 9° C during December to January and up to 35-40°C in the month of May to June. Nearly 80% of the total rainfall is received during the monsoon (only up to September) with few showers in the winter. Soil of the experimental site is sandy clay in texture with pH of around 6.4.

26 diverse genotypes of French bean (Table 1) collected from North and North-eastern Himalayan states of India *viz*., Uttarakhand, Himachal Pradesh, Jammu & Kashmir and Manipur were used for the present investigations. Seeds of all the genotypes were sown at well prepared experimental beds in lines at a depth of 2cm maintaining a spacing of 40 cm x 10 cm. All the intercultural operation and plant protection measures recommended for the successful crop growth were followed and irrigation were given according to crop requirement for better growth and development of the plants. During the experiment, different morphological characters, growth, yield and quality parameters were recorded. Five plants from each treatment per replication were randomly selected for the observation. The methods assigned by PVJI (2007) and PPV &FR (2001) were followed with the application of various descriptor codes for the morphological characterization of French bean genotypes. The quality parameters were analysed according to protocol given by Rangana (2014). Analysis of variance was done following the method given by Panse and Sukhatme (1967). The average mean value was calculated by statistical analysis to test the significance of variation in given data. Genotypic and phenotypic coefficients of variations were calculated by the formula given by Burton and De-vane (1953). The Heritability in broad sense, genetic advance (GA) and genetic advance over mean (GAM) was calculated as given by Falconer (1981), Robinson *et al*. (1949) and Johnson *et al*. (1955) respectively.

RESULTS AND DISCUSSION

Morphological characterization

Generally, cultivars are identified based on morphological differences of seed, seedling, and mature plant. A qualitative trait-based morphological characterization or DUS (Distinctive,

Table.1: List of French bean genotypes with their sources.

S. No.	Genotypes	Sources	Notation
1	Bageshwar	Uttarakhand	G_1
2	Baragaon	Uttarakhand	G_2
3	Barkot	Uttarakhand	G_3
4	BharkhiUrgan Valley Chamoli-1	Uttarakhand	G_4
5	BharkhiUrgan Valley Chamoli-2	Uttarakhand	G_5
6	DumakUrganValley	Uttarakhand	G_6
7	Dunda	Uttarakhand	G_7
8	Harsil	Uttarakhand	G_8
9	J&K -1	Jammu and Kashmir	G_9
10	J&K -2	Jammu and Kashmir	G_{10}
11	J&K -3	Jammu and Kashmir	G_{11}
12	J&K -4	Jammu and Kashmir	G_{12}
13	Kelang Jispa	Himanchal Pradesh	G_{13}
14	Kunsi	Uttarakhand	G_{14}
15	Local Srinagar	Uttarakhand	G_{15}
16	Manipur-1	Manipur	G_{16}
17	Manipur-2	Manipur	G_{17}
18	Manipur-3	Manipur	G_{18}
19	Malari Valley Chamoli-1	Uttarakhand	G_{19}
20	Malari Valley Chamoli-2	Uttarakhand	G_{20}
21	Mukhba	Uttarakhand	G_{21}
22	Netala	Uttarakhand	G_{22}
23	Purola	Uttarakhand	G_{23}
24	Selang Chamoli	Uttarakhand	G_{24}
25	Solan Kullu	Himanchal Pradesh	G_{25}
26	Pant Anupama (Check cultivar)	GBPUAT Pantnagar	G_{26}

Table 2: Characterization of plant growth and leaf characteristics of French bean germplasm following descriptor based qualitative traits

Plant growth characteristics	Character	Type	Descriptor Code	Number of Genotypes	Frequency (%)
	Plant growth type	Erect	3	10	38.5
		Semi erect	5	13	50
		Spreading	7	3	11.5
	Plant: twinning habit	Viny	1	17	65.4
		Non-viny	9	9	34.6
	Plant: habit	Determinate	1	16	61.5
		Indeterminate	3	10	38.5
	Stem: Anthocyanin colouration	Absent	1	21	80.76
		Present	9	5	19.24
	Plant: height	Short (<40cm)	3	4	15.39
		Medium(40-75cm)	5	4	15.39
		Tall(>75cm)	7	18	69.32
Leaf Characteristics	Leaf: Intensity of green color	Light	3	10	38.46
		Dark	7	16	61.54
	Leaflet: Shape of central leaflet	Cordate	1	4	15.39
		Ovate	2	15	57.69
		Rhombohedric	3	5	19.23
		Hastate	4	2	7.69

Table 3: Characterization of flower and pod characteristics of French bean germplasm following descriptor based qualitative traits

Flower Characteristics	Character	Type	Descriptor Code	Number of Genotypes	Frequency (%)
	Time of flowering	Early (<50)	3	5	19.23
		Medium (50-75)	5	21	80.76
		Late (76-100)	7	0	0
		Very Late (>100)	9	0	0
	Flower: Colour of Standard petal	White	1	11	42.3
		Yellow	2	0	0
		Pink	3	9	34.61
		Voilet	4	6	23.07
	Flower: Outer surface of standard petal	Striped	1	10	38.46
		Non-striped	3	16	61.54
Pod Characteristics	Pod: Curvature	Absent	1	9	34.62
		Medium	5	12	46.15
		Strong	7	5	19.23
	Pod: Shape (in relation to suture)	Concave	1	17	65.39
		S – shaped	2	0	0
		Convex	3	9	34.61
	Pod: Shape of distal part (excluding beak)	Acute	3	4	15.38
		Acute to truncate	5	17	65.39
		Truncate	7	5	19.23
	Pod: Colour	Pale green	1	5	19.23
		Green	2	16	61.54
		Purple	3	5	19.23
	Pod: Stringiness	Absent	1	0	0
		Present	9	26	100
	Pod: Pigmentation on pod shell	Absent	1	20	76.93
		Present	9	6	23.07

Uniformity, and Stability) test is conducted to ensure the genuine supply of seed material to the farmers and breeders. The morphological characterization of all the genotypes regarding growth, leaf, flower, and pod characters is presented in Tables 2 and 3.

Under the present investigation, all the genotypes under study were morphologically identified and differentiated using various morphological features, at the same time assigning them with some descriptor codes and working out their frequencies. Erect plant growth type was found moderate in genotypes while semi erect is maximum and spreading is very few of them. Similar findings were observed by Okii *et al.* (2014). Pod curvature was found moderate in absent, maximum in medium and minimum in strong. Pod shape in relation to suture concave is maximum, concave found minimum and nothing found like s-shaped. Similar results concerning these parameters were also observed by Kumar *et al.* (2014), Okii *et al.* (2014), Pramanik *et al.* (2023) and Supriya *et al.* (2023).

Genetic variability

The analysis of variance of the experiment presented in Table 4 indicated that mean sum of squares due to genotypes were highly significant for all characters studied.

The result of various components of genetic variability is presented in Table 5. In the present investigation, the difference

Table 4: Analysis of variance for 16 characters of French bean genotypes.

Characters	Replication	Treatment	Error
Degrees of freedom	2	25	50
Days taken to first germination	0.12	8.35*	1.18
Days taken to 50% germination	1.94	4.06*	1.03
Plant height	634.42	10479.97*	48.75
Number of primary branches per plant	0.25	2.51 *	0.12
Fresh weight of Nodules (mg)	0.00025	0.0098*	0.0008
Dry weight of nodules	0.0011	0.0056*	0.00076
Days taken to first flowering	25.78	58.93*	6.04
Days taken to first pod set	75.09	113.22*	18.9
Number of pod/plants	122.17	959.99*	45.25
Pod weight (g)	2.42	2.06*	0.85
Pod width (cm)	0.33	1.22*	0.62
Pod length (cm)	5.28	3.27*	0.59
Pod yield/ plant (g)	0.0081	0.136*	0.006
Pod yield/plot (kg)	0.003	0.118*	0.0018
Pod yield per ha (q)	15.924	117.699*	12.439
T.S.S.	0.97	1.06*	0.15

* Significance at 5%

Table 5: Estimates of phenotypic and genotypic coefficient of variation, heritability, genetic advance and genetic gain for 16 different traits of French bean.

Characters	Range	Mean	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
Days taken to first germination	10.33-18.33	12.19	12.68	13.6	85.8	2.9	24.2
Days taken to 50% germination	12.0-16.33	13.74	7.32	8.4	74.7	1.7	13
Plant height at harvest	34.6-186.18	129.72	45.46	45.5	99.5	121	93.4
Number of primary branches per plant		3.73-6.27	5.25	17.01	17.4	95.3	1.7 34.1
Fresh weight of Nodules (mg)	0.06-0.29	0.19	28.68	29.9	91.7	0.1	56.5
Dry weight of nodules (mg)	0.03-0.18	0.08	51.59	55.4	86.4	0.07	98.8
Days taken to first flowering	41.67-61.67	47.4	8.86	9.3	89.8	8.1	17.2
Days taken to first pod set	34.0-65.67	50.36	11.13	12.1	83.3	10.5	20.9
Number of pod/plants	28.0-93.33	63.91	27.32	27.9	95.3	35.1	54.9
Pod width (cm)	14.37-17.41	16.5	2.71	3.8	49.1	0.6	3.9
Pod length (cm)	9.35-13.38	11.31	8.36	9.2	82	1.7	15.5
Pod weight (g)	3.41- 7.3	5.6	11.42	14.9	58.7	1.002	18
Pod yield/ plant (g)	3.97-19.94	10.82	35.51	37.5	89.2	7.4	69
Pod yield/plot (kg)	0.15-1.00	0.6	37.54	40	88	0.43	72.5
Pod yield per hectare(q)	14.06-105.96	58.47	36.3	42.2	73.9	0.03	64.2
T.S.S.	5.14-7.18	6.07	9.05	9.7	85.4	1.04	17.2

between GCV and PCV was less for all characters studied. The results revealed that the difference between the PCV and GCV value for the character like plant height, number of pods per plant, pod yield per plant, pod yield per plot and green pod yield per hectare were observed. According to Singh *et al*. (2018), minimum and the presence of high variability in the genotypes for selection indicate characters under investigation were less influenced by environment. Therefore, simple selection can be performed for the further improvement of those characters. For character like dry weight of nodules, days taken to first pod set, pod length and pod width and the difference between GCV and PCV was more so these traits are not suitable for simple direct selection Ahmed and Kamaluddin (2013) and Fatema *et al*. (2019).

High genotypic coefficient of variation was found for the characters like plant height at harvest, fresh weight of nodules, dry weight of nodules, number of pods per plant, pod yield per plant, pod yield per plot and pod yield per hectare. Similar result was also reported by Asaduzzman *et al*. (2015) and Sheelamary & Shivani (2015) and Gangadhara *et al*. (2018).

High phenotypic coefficient of variation was observed for plant height at harvest, fresh weight of nodules, dry weight of nodules, number of pods per plant, pod yield per plant, pod yield per plot and green pod yield per hectare. Similar results were also reported by Ahmed and Kamaluddin (2013), Verma *et al*. (2014), Sheelamary & Shivani (2015) and Gangadhara *et al*. (2018).

Very high heritability in broad sense along with high genetic advance as per cent over mean were recorded for the characters like number of primary branches per plant, plant height at harvest, fresh weight of nodules, dry weight of nodules, TSS, days taken to first flowering, number of pods per plants, pod yield per plant, pod yield per plot and green pod yield per hectare. Similar results were also reported by Kulkarni and Musmade (2014), Asaduzzman *et al*. (2015), Noopur *et al*. (2019) and Gamit *et al*. (2020) which indicated that the inheritance of these characters is controlled mainly by additive gene effects and therefore, selection based on phenotypic performance may prove helpful in improvement of these traits.

CONCLUSION

The key component of a crop improvement programme is characterising genetic resources to ensure their useful

involvement in hybridization programmes. The genotypes Baragaon, J&K-4, Manipur-1 and Manipur-2 exhibited a less range of variations based on morphological characterization. The genotypes used in the investigation showed good amount of genetic variability with less difference between PCV and GCV but many genotypes showed high level of PCV and GCV as well. Moderate heritability along with moderate genetic advance as per cent over mean were recorded for most of the traits indicating that selection would be effective. So, the studied genotypes could be efficiently utilized of in the future breeding programmes.

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