Screening of pole type French bean (*Phaseolus vulgaris* L) genotypes for high yield potential under mid-hill conditions of Himachal Pradesh

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 Received: 24.09.2023/Accepted: 28.10.2023

ABSTRACT

French bean is a profitable crop that is grown as a fresh vegetable throughout summer and rainy seasons and fetches off-season prices during the spring and autumn in Himachal Pradesh. Twenty nine pole type genotypes of French bean were screened to select a suitable one which could provide optimum yield of fresh pod and dry seed yield. The study showed that LCPB-1 resulted in highest number of pods per plant (42.33), seed yield per plant (100.76 g) and 100-seed weight (49.15 g) as compared to all other genotypes tested. This genotype also resulted in minimum days to 50 per cent flowering and days to 1st picking, highest plant height and pod yield per plant along with some other genotypes. Based on phenotypic and agronomic performance, the genotype LCPB-1 could be taken under multi-location testing programme for assessing its suitability and adaptability.

Keywords: French bean; mean performance; pole type; quantitative traits; screening

INTRODUCTION

French bean (*Phaseolus vulgaris* L) is a diploid, herbaceous annual, belonging to the family Leguminosae with a chromosome number 2n = 22. It is a self-pollinated and bisexual crop. It is also known as kidney bean, snap bean, string bean, wax bean, haricot bean, navy bean and garden bean and large dry seed type varieties are called as Rajmash in India. According to van Schoonhoven and Oswaldo (1991), it was domesticated around 8,000 years ago in Mexico, Peru and Colombia. It has a primary origin in south Mexico and central America and a secondary origin in Peruvian Ecuador, according to Vavilov.

French bean is a nutritious vegetable and can be consumed as tender pods, shelled beans and dry beans. In addition to being a good source of carbohydrates, it is a rich source of proteins and minerals like phosphorus, calcium, iron and crude fiber. It contains depurative and carminative qualities that prevent diarrhoea and indigestion. Green beans are found in two major groups, bush beans and pole beans. French bean is grown in Himachal Pradesh as a intercrop or mixed crop with maize in temperate orchards.

In order to develop new cultivars with desired yield and quality traits in the present situation, a breeder must have a thorough understanding of the variability found in the existing germplasm. The more variation in the available germplasm, higher is the probability of identifying superior genotypes. The economic component of vegetable French beans is the green pod yield. Yield is a complex trait that depends upon many attributes of the plant.

As a result, when determining for yield, one should consider improving traits that contribute to yield, provided information illustrating their relationship to yield are available. Therefore, the aim and objectives of this study were to select superior genotype of French bean, which required short duration, possessed quick plant growth habit, was stringless, had 90 per cent flowering,

pod setting and maturation and gave highest yield of pods and seeds.

MATERIAL and METHODS

Twenty nine pole type genotypes of French bean including check were grown in a randomized complete block design with three replications at the experimental farm of the Department of Vegetable Science, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during kharif season of 2020.

The experimental farm was situated at an elevation of 1,275 m amsl with 30°86' N latitude and 77°172' E longitude. The seeds were sown at a spacing of 90 cm × 15 cm in a plot size of 4.5 m × 1.2 m accommodating 40 plants per plot. Recommended package of practices was followed for healthy growth of the crop.

The observations were recorded on randomly taken five plants of each genotype in each replication for fourteen quantitative traits, viz days to 50 per cent flowering, days to first picking, harvest duration, number of pods per plant, pod length, pod width, pod weight, pod yield per plant, plant height, number of seeds per pod, seed length, seed width, 100-seed weight and seed yield per plant.

The data recorded were analyzed by using MS-Excel, OPSTAT, Windostat 9.3 and XLSTAT. Analysis of variance was carried out as per the procedure given by Gomez and Gomez (1983). The mean values of each genotype of each replication for all the traits under study were subjected to statistical analysis as per randomized complete block design.

RESULTS and DISCUSSION

The analysis of variance for the experimental design revealed significant differences among the genotypes for all the traits studied (Table 1) which indicated the existence of adequate genetic variability in the germplasm.

The data on yield and yield attributes showing mean performance of twenty nine genotypes of pole type French bean are given in Table 2.

Precocious flowering is one of the most important breeding techniques; plants with early flowering are preferred as they offer early yields. The data show that days taken to 50 per cent flowering in French bean ranged from 42.67 to 64.67 with a grand mean of 50.62 days. The mean performance of different genotypes for this trait revealed that the genotypes LCPB-23 (42.67 days), LCPB-12 (43.33 days), LCPB-5 (43.67 days), Pusa Himlata (43.67 days), LCPB-3 (44.00 days), LCPB-9 (44.33 days), LCPB-1 (44.67 days), LCPB-24 (44.67 days), LCPB-7 (45.00 days) and LCPB-2 (45.33 days) took minimum days to 50 per cent flowering, which were at par, whereas, maximum days to 50 per cent flowering were observed

Table 1. Analysis of variance for various quantitative agro-morphological traits in French bean

Component	Mean sum of squares		F_{cal}	
	Replications (df = 2)	Genotypes (df = 28)	Error (df = 56)	
Days to 50% flowering	24.24	135.76*	2.66	51.07
Days to 1st picking	6.43	218.49*	1.37	159.97
Harvest duration	1.74	139.90*	0.69	203.34
Number of pods/plant	1.25	134.90*	3.61	37.33
Pod length (cm)	1.81	12.61*	0.73	17.34
Pod width (mm)	0.47	10.74*	0.13	82.07
Pod weight (g)	0.19	1.08*	0.06	18.33
Pod yield/plant (g)	14.26	4789.37*	18.72	255.89
Plant height (cm)	12.03	2519.93*	66.18	38.08
Number of seeds/pod	0.93	3.16*	0.15	21.61
Seed length (mm)	0.63	12.99*	0.19	67.32
Seed width (mm)	1.28	0.75*	0.14	5.29
100-seed weight	5.50	274.45*	2.16	126.95
Seed yield/plant (g)	2.36	1257.71*	4.12	305.52

*Significant at 5% LoS; df = Degrees of freedom

Table 2. Yield and yield attributes showing mean performance of twenty nine genotypes of pole type French bean

Genotype	Days to 50% flowering	Days to 1st picking	Pod length (cm)	Pod width (mm)	Pod weight (g)	Number of pods/plant	Plant height (cm)
LCPB-1	44.67	57.33	12.94	9.84	5.67	42.33	204.00
LCPB-2	45.33	58.33	14.01	10.16	5.17	30.84	156.67
LCPB-3	44.00	59.67	12.98	11.19	6.53	30.78	167.33
LCPB-4	45.67	62.67	15.73	7.26	6.93	33.22	163.33
LCPB-5	43.67	63.33	15.88	7.27	6.20	33.56	102.33
LCPB-6	51.33	67.67	12.04	11.82	7.53	17.22	105.00
LCPB-7	45.00	61.67	12.25	11.19	5.80	15.56	127.00
LCPB-8	55.67	78.33	14.58	8.26	5.17	34.78	154.33
LCPB-9	44.33	67.33	14.00	10.08	6.67	27.00	133.67
LCPB-10	47.33	76.33	9.47	8.41	6.73	31.00	151.00
LCPB-11	48.33	75.67	10.99	6.32	5.53	34.89	141.67
LCPB-12	43.33	56.67	17.56	5.26	5.63	38.11	165.33
LCPB-13	53.00	78.67	12.84	10.80	6.37	24.89	147.00
LCPB-14	63.00	82.67	13.63	10.04	6.07	16.89	136.33
LCPB-15	64.33	83.00	14.69	9.06	5.43	32.00	154.00
LCPB-16	55.00	74.67	12.27	10.31	6.03	32.22	127.67
LCPB-17	51.00	67.67	14.00	9.26	6.33	31.67	142.00
LCPB-18	64.67	82.67	10.61	8.43	6.73	31.33	172.33
LCPB-19	47.67	73.67	12.67	6.44	6.87	27.67	183.00
LCPB-20	52.33	78.33	13.91	11.11	6.13	28.55	199.33
LCPB-21	57.00	77.67	10.51	7.38	5.33	18.67	98.67
LCPB-22	56.00	70.33	11.50	9.29	6.43	17.00	104.33
LCPB-23	42.67	57.67	10.28	8.31	5.30	23.00	133.33
LCPB-24	44.67	58.33	10.41	8.33	6.83	30.45	174.67
LCPB-25	47.00	62.33	15.88	9.31	6.23	31.78	199.00
SVM-1	53.33	67.00	14.35	10.56	6.47	28.22	162.00
Kentucky Wonder	53.33	72.00	12.04	10.50	6.17	35.11	182.00
Pusa Himlata	43.67	63.33	10.67	12.20	5.63	25.56	172.33
Lakshmi (Check)	60.67	73.67	15.87	13.39	6.43	32.78	170.33
Range	42.67-64.67	56.67-83.00	9.47-17.56	5.26-13.39	5.17-7.53	15.56-42.33	98.67-204.00
Mean	50.62	69.26	13.05	9.37	6.15	28.86	152.76
SEm(±)	0.94	0.68	0.49	0.21	0.14	1.10	4.70
$CD_{0.05}$	2.67	1.92	1.40	0.59	0.40	3.12	13.34

in LCPB-18 (64.67 days), LCPB-15 (64.33) and LCPB-14 (63.00), the three being at par.

Days taken to first picking also provides the information about earliness of the genotypes. The data revealed that days taken to first picking ranged from 56.67 to 83.00. The general mean for the character was recorded as 69.26 days. Minimum days taken to first picking were recorded in LCPB-12 (56.67), LCPB-1 (57.33), LCPB-23 (57.67), LCPB-2 (58.33) and LCPB-24 (58.33), all being at par and maximum were observed in LCPB-14 (82.67), LCPB-18 (82.67) and LCPB-15 (83.00), the three being at par.

Differences among the genotypes regarding pod length were significant and ranged from 9.47 to 17.56 cm with the mean value of 13.05 cm. The maximum pod length was recorded in LCPB-12 (17.56 cm) and minimum in LCPB-10 (9.47 cm), LCPB-23 (10.28 cm), LCPB-24 (10.41 cm), LCPB-21 (10.51 cm), LCPB-18 (10.61 cm) and Pusa Himlata (10.67 cm), the six being at par.

The pod width ranged from 5.26 to 13.39 cm with mean value of 9.37. The check variety Lakshmi recorded maximum pod width (13.39 mm), whereas, minimum (5.26 mm) was recorded in LCPB-12.

Individual pod weight for 29 genotypes, under study, varied from 5.17 to 7.53 g with an overall mean of 6.15 g. LCPB-2 (5.17 g), LCPB-8 (5.17 g), LCPB-23 (5.30 g), LCPB-21 (5.33 g), LCPB-15 (5.43 g) and

Table 2. Contd…..

Genotype	Harvest duration (days)	Pod yield /plant (g)	Seed yield /plant (g)	Number of seeds/pod	Seed length (mm)	Seed width (mm)	100-seed weight (g)
LCPB-1	44.67	217.65	100.76	7.45	12.77	6.21	49.15
LCPB-2	42.33	166.61	95.82	8.22	13.26	6.56	45.74
LCPB-3	46.67	205.76	91.23	7.56	13.08	6.55	44.23
LCPB-4	39.00	207.50	73.82	7.11	14.44	6.52	34.79
LCPB-5	40.33	207.98	32.57	6.89	12.42	7.14	30.16
LCPB-6	33.33	126.86	45.36	6.00	13.28	5.61	30.18
LCPB-7	39.67	92.89	51.63	4.89	12.74	5.41	33.67
LCPB-8	43.33	164.67	78.78	5.56	11.53	6.27	23.56
LCPB-9	39.33	187.85	55.08	6.89	13.21	6.37	30.20
LCPB-10	38.33	202.79	48.51	7.22	11.82	6.75	21.76
LCPB-11	42.33	193.93	35.93	7.45	12.17	6.85	20.54
LCPB-12	38.33	207.94	29.46	7.45	16.94	6.13	13.79
LCPB-13	37.00	154.37	34.77	4.78	14.19	7.02	40.32
LCPB-14	33.00	102.33	67.75	6.44	10.72	6.85	24.18
LCPB-15	30.33	170.42	40.50	6.56	8.28	6.86	15.93
LCPB-16	26.00	187.16	39.95	6.44	15.24	6.88	39.45
LCPB-17	24.00	201.51	76.05	5.78	15.06	6.32	43.65
LCPB-18	28.67	206.73	60.89	4.67	8.87	6.89	21.59
LCPB-19	33.00	204.00	50.39	5.33	14.68	7.43	37.41
LCPB-20	25.33	176.55	43.93	5.56	15.31	7.08	43.44
LCPB-21	28.00	99.38	38.03	6.11	15.97	7.13	40.38
LCPB-22	26.33	105.14	26.75	6.89	11.03	6.15	14.83
LCPB-23	24.67	124.11	25.58	4.44	14.22	7.17	30.79
LCPB-24	39.33	209.43	35.38	6.22	17.01	7.17	25.80
LCPB-25	42.00	201.26	55.28	7.67	12.31	5.93	30.27
SVM-1	44.00	180.71	60.23	6.33	14.17	6.05	30.75
Kentucky Wonder	43.00	220.50	63.27	6.89	11.27	6.10	28.18
Pusa Himlata	36.33	145.88	55.91	6.44	12.17	6.40	29.32
Lakshmi (Check)	38.00	216.70	60.74	8.11	12.83	6.28	33.91
Range	24.00-46.67	92.89-220.50	25.58-100.76	4.44-8.22	8.28-17.01	5.41-7.43	13.79-49.15
Mean	36.09	175.47	54.29	6.46	13.14	6.55	31.31
SEm(±)	0.48	2.50	1.17	0.22	0.25	0.22	0.85
$CD_{0.05}$	1.36	7.10	3.33	0.63	0.72	0.62	2.41

LCPB-11 (5.53 g) resulted in minimum pod weight and were at par with one another. On the other hand, LCPB-6 (7.53 g) resulted in maximum pod weight.

Number of pods per plant in French bean has been a significant yield contributing trait as it extremely influences the final yield. A wide range of variation of 15.56-42.33 with an overall mean of 28.86 was observed among 29 genotypes for number of green pods per plant.

The genotype LCPB-1 (42.33) had the maximum number of pods per plant. Minimum number of pods per plant was observed in LCPB-7 (15.56), LCPB-14 (16.89), LCPB-22 (17.00) and LCPB-6 (17.22), all being at par.

Plant height is one of the significant growth traits that help in prolonged harvesting of fruits and also helps in avoiding the plant from soil borne diseases. The mean value of genotypes relating to plant height depicted the existence of a wide range of variability ranging from 98.67 to 204.00 cm with a population mean of 152.76 cm. The genotypes LCPB-1, LCPB-20 and LCPB-25 showed maximum plant height of 204.00, 199.33 and 199.00 cm respectively and were at par. LCPB-21 (98.67 cm), LCPB-5 (102.33 cm), LCPB-22 (104.33 cm) and LCPB-6 (105.00 cm) exhibited minimum plant height and were at par.

Longer harvest duration is usually preferred in the current marketing system under Indian conditions, where not only glut is evaded

but off-season importance of crop in market is also retained due to prolonged availability of green pods, which finally profits the farmers. Harvest duration varied from 24.00 to 46.67 days with mean value of 36.09 days. Longest harvest duration was observed in LCPB-3 (46.67 days), whereas, shortest of 24.00, 24.67 and 25.33 days in LCPB-17, LCPB-23 and LCPB-20 respectively, the three being at par.

Among the genotypes, the number of seeds per pod varied from 4.44 to 8.22 with an overall mean of 6.46. The genotype LCPB-2 (8.22), Lakshmi (Check) (8.11) and LCPB-25 (7.67) had the maximum number of seeds per pod and were at par, whereas, the genotype LCPB-23 (4.44), LCPB-18 (4.67), LCPB-13 (4.78) and LCPB-7 (4.89) recorded minimum number of seeds per pod and were at par.

Categorizing genotypes on the basis of seed size is important for planning future breeding approach for satisfying the selective market requirements of concerned community. The seed length varied from 8.28 to 17.01 mm with mean of 13.14 mm. The maximum seed length was recorded in LCPB-24 (17.01 mm) and LCPB-12 (16.94 mm), which were at par, whereas, minimum in LCPB-15 (8.28 mm) and LCPB-18 (8.87 mm), the two being at par.

Seed width range was 5.41-7.43 mm with mean of 6.55 mm. Genotypes LCPB-19 (7.43 mm), LCPB-23 (7.17 mm), LCPB-24 (7.17 mm), LCPB-5 (7.14 mm), LCPB-21 (7.13 mm), LCPB-20 (7.08 mm), LCPB-13 (7.02 mm), LCPB-18 (6.89 mm), LCPB-16 (6.88 mm), LCPB-15 (6.86 mm), LCPB-11 (6.85 mm), and LCPB-14 (6.85 mm) were at par with maximum seed width. Minimum seed width was recorded in LCPB-7 (5.41 mm), LCPB-6 (5.61 mm) and LCPB-25 (5.93 mm), which were at par.

The 100-seed weight has important role in determination of seed yield. The data pertaining to 100-seed weight revealed significant variations among the genotypes ranging from 13.79 to 49.15 g with an overall mean of 31.31 g. LCPB-1 (49.15 g) exhibited maximum 100-seed weight. Minimum 100-seed weight was recorded in LCPB-12 (13.79 g), LCPB-22 (14.83 g) and LCPB-15 (15.93 g), which were at par.

Pod yield is one of the most important characters which deserve highest consideration in any breeding programme. The pod yield per plant varied from 92.89-220.50 g with mean of 175.47 g. Highest pod yield of 220.50, 217.65 and 216.70 was observed in Kentucky Wonder, LCPB-1 and Lakshmi (Check) respectively, which were at par and lowest in LCPB-7 (92.89 g) and LCPB-21 (99.38), two being at par.

Seed yield per plant ranged from 25.58-100.76 g with mean of 54.29 g. It was highest in case of LCPB-1 (100.76 g) and lowest in LCPB-23 (25.58 g) and LCPB-22 (26.75 g), which were at par.

The study showed that LCPB-1 resulted in highest number of pods per plant (42.33), seed yield per plant (100.76 g) and 100-seed weight (49.15 g) as compared to all other genotypes tested. This genotype also resulted in minimum days to 50 per cent flowering and days to 1st picking, highest plant height and pod yield per plant along with some other genotypes.

Gupta et al (2019) determined the available variability among 135 genotypes of common bean in Jammu and Kashmir and reported remarkable variability among the genotypes for all the characters studied. The observations showed that the genotype namely K12 (Bandipora) was early maturing, N3 (Nishat) had the longest pod, R3 (Rajouri) exhibited the largest pod width, MT6 (Marmat) had the maximum seed weight and the genotypes P3 (Poonch), KS6 (Shopian) and VLR125 (Almora, Uttarakhand) showed the highest yield. Comparatively higher values for seeds per plant and pods per plant parameters were noticed in the genotypes belonging to Almora (VLR-125), Poonch (P11), Shopian (KS1 and KS6), Marmat (MT5) and Uganda (UG5, UG6, UG9 and UG11) region.

Kumar (2022) evaluated various genotypes of French bean for yield and its contributing traits at Amritsar and Tarn Taran districts of Punjab and reported that genotypes Arka Anoop, Arka Sharat and Falguni showed highest yield and its contributing traits like germination days, days to 50 per cent flowering, days to first picking and number of pods per plant.

Noor et al (2015) screened eleven genotypes of french bean and found the maximum seed yield in case of genotypes BB-9 (2.96 tonnes/ha) and BARI Bush Bean-1 (2.95 tonnes/ha) and maximum fresh pod yield (14.25 tonnes/ha) in BARI Bush Bean-1. BARI Bush Bean-1 required the minimum time of 88.33 days to attain 90 per cent pods maturity.

Singh et al (2019) assessed twenty one diverse genotypes for quantitative differences for yield and yield attributing traits. For pod yield per plant, HOR-137 (62.5 g) ranked first. PDR-14 (62.35 g) and EC-592938 (62.25 g) showed good pod yield per plant. The pod yield per hectare ranged from 87.93 (RLFB-58) to 138.88 (HOR-137). The maximum pod yielder was HOR-137 (138.88 q/ha). HOR-137, PDR-14 and EC-592938 were found to be the high yielders.

Chauhan et al (2023) worked on 16 genotypes of French bean for twelve quantitative traits in Pune, Maharashtra. Genotype Raj-20-8 had least number of days to 50 per cent flowering (36.33 days); Phule Rajmah recorded the maximum number of pods per plant (14.84), longest pod length (9.31 cm) and maximum mean seed yield per plant (24.80). Phule Rajmah (5.27) and Varun (5.02) recorded maximum mean number of seeds per pod. GRB- 912 (38.32 g) had highest 100-seed weight.

Hema and Rana (2020) evaluated fifteen French bean genotypes at Garhwal, Uttarakhand. The genotype Rudraprayag Local responded superior for number of pods per plant (21.10), yield of green pods per plant (249.92 g), yield of green pods per ha (499.75 q/ha) and number of pickings (5.00). The genotype Anupam was best for plant height (63.61 cm), number of nodules per plant (14.5), fresh weight of nodules per plant (150.27 mg) and number of primary branches per plant (8.29). The average weight of the pod (13.52 g) was estimated in genotype Pant Anupama. Genotype Rudraprayag Local was recorded the best performer over check cultivar Contender with respect to yield parameters.

At Dailekh, Nepal, Kalauni et al (2019) studied the performance of six genotypes of French bean for pod and seed yield. The genotype Chaumase (35.0 tonnes/ha) recorded the maximum green pod yield. Chaumase (2.1 tonnes/ha), Trishuli (2.1 tonnes/ha), Dhankute Chirrke (1.44 tonnes/ha) and White OP (1.09 tonnes /ha) were found promising for seed production purpose.

At Lalitpur, Nepal, Subedi et al (2022) reported that among 7 genotypes of French bean, Pahelo Gheusimi was found to be early maturing (81 days after sowing). Pod length (20.52 cm) and pod weight (16.60 g) were recorded highest in Long Green Bean, while the highest pod diameter in Pahelo Gheusimi (12.59 mm). The highest number of pods (92/plant) was observed in Four Season and fresh pod yield (1,030.3 g/plant) in Long Green Bean and Four Season (997.1 g/plant).

CONCLUSION

Crop improvement depends upon various factors that includes the examination of various parameters for understanding yield and yield attributing traits responsible for crop development. It can be concluded that LCPB-1 resulted in highest number of pods per plant, seed yield per plant and 100-seed weight as compared to all other genotypes tested. This genotype also resulted in minimum days to 50 per cent flowering and days to 1st picking, highest plant height and pod yield per plant along with some other genotypes.

The agro-morphological variation observed in growth and pod characters could be utilized in varietal improvement programmes. Future research work is needed to be focused on the further evaluation of these genotypes under different production systems for yield and seed production and to identify traits useful for crop improvement. Based on phenotyping and agronomic performance, the genotype LCPB-1 could be taken under multi-location testing programme for assessing its suitability and adaptability in the study area.

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