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Performance of French bean (*Phaseolus vulgaris* L.) Genotypes under Trans-Gangetic Plains Region

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ABSTRACT

Background: French bean is one of the nutritious leguminous crops which is an integral part of Indian cuisine and popular in overseas countries from a long time. At different parts of the world several researches have been implemented and still in continuation for the improved production of the crop.

Methods: This experiment study was conducted at the Vegetable Research Farm of Lovely Professional University, Punjab in the summer season during 2021 and 2022, respectively. The experiment comprised of total 21 genotypes consisting of three replications which were laid out in randomized block design for different growth and yield parameters of French bean.

Result: The pooled analysis data showed significant differences between various growth and yield traits. From the acquired results it was found that the genotype IC-043572 (T_6) was more adaptive and productive over other evaluated genotypes of French bean in various growth characters including germination percentage (95.40%), plant height at 30 DAS (17.85 cm), 45 DAS (35.02 cm) and final harvesting stage (42.51 cm), number of leaves at 35 DAS (25.69), 45 DAS (54.65) and final harvesting stage (100.48), fresh (13.58 g) and dry (5.80 g) weight of root, fresh (113.96 g) and dry (88.53 g) weight of shoot and yield characters like pod length (14.68 cm), weight of individual pod per plant (5.65 g), green pod yield per plant (205.50 g) and green pod yield per hectare (59.51 t) under Trans-Gangetic plains region.

Key words: French bean, Genotype, Legume, Production, Yield.

INTRODUCTION

French bean (*Phaseolus vulgaris* L.; 2n=22) is an important leguminous vegetable crop which is grown popularly for its green pods and dry seeds. It is native to temperate region of Central America. It can be grown throughout the world and contribute nearly 30% of the total production of food legumes (Vasishtha and Srivastava, 2012). It is known with several others names like kidney bean, haricot bean, navy bean, snap bean, etc. Its highest yield can be obtained in the soils having a pH range of 5.5-6.5 (Choudhary, 2015). The optimum temperature for its cultivation is 15-25°C. Dropping of flowers may occur if temperature falls below 10°C or goes above 35°C which resulted into reduction of yield (Kumar, 2022). The green pods of French bean contain 22% protein, 78% carbohydrate, 221 I.U. vitamin A, 11 mg vitamin C and 381 mg calcium per 100 g of edible portion. India occupied an area of 137.54 (000'ha) with annual production of 1370.21 (000'Mt) and an average productivity of 9.96 Mt/ha of French bean. The major French bean growing states are West Bengal, Andhra Pradesh, Jharkhand, Jammu and Kashmir and Himachal Pradesh in India. The cultivated area of French bean in Punjab is distributed to nearly 2.0 (000'ha) area, which provide an annual production of 1.9 (000'Mt) with a productivity of 1.6 (Mt/ha) (Kumar, 2022).

The performance of crop is the result of interaction between environment and genetic make-up of the crop. It has also been observed that different genotypes belonging to the same species when grown in the similar climatic conditions may show differential yield output. Development of novel varieties is quite a lengthy process which seek time and scientific handling. Researchers as well as plant breeders time to time evaluate the performance of various available genotypes of a particular crop to select the desired ones on the basis of adaptability, tolerance level, yield and other related traits. Therefore, the present investigation was implemented to check the performance of procured French bean genotypes in Trans-Gangetic plains region for their adoption and improved production.

MATERIALS AND METHODS

The experiment was performed at the Vegetable Research Farm of Lovely Professional University, Punjab-India, during the summer seasons of the year 2021 and 2022, respectively. This research work was consisted of total 21

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genotypes of French bean out of which 20 indigenous collections were procured from NBPGR, Shimla, Himachal Pradesh and 1 standard check (Falguni) of Seminis Pvt. Ltd and utilized. The experiment was laid out in a randomized block design with three replications. The plant population was maintained at a spacing of 45 cm × 15 cm. During the last ploughing FYM @ 20 t/ha was applied. The recommended dose of fertilizers was applied @ 50:65:50 kg/ha (N:P:K) in the form of Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP), respectively. The full dose of P and K along with half dose of N was applied before sowing of seeds as basal dose. After 30 days of sowing the remaining half dose of N was given as top dressing.

The observations were recorded on various growth and yield traits *viz*., days taken to 50% seed germination, germination percentage (%), plant height (cm) and number of leaves at 30 DAS, 45 DAS, final harvesting stage, fresh and dry weight of root (g) and shoot (g), days taken to 50% flowering, pod length (cm), pod diameter (cm), weight of individual pod per plant (g), green pod yield per plant (g) and green pod yield per hectare (t/ha).

Statistical analysis

The significance of variation among the treatments was observed by applying Analysis of Variance (ANOVA) and Critical Difference (C.D) at 5% probability level (Snedecor and Cochran, 1961).

RESULTS AND DISCUSSION

On the basis of two years pooled data analysis, various growth and yield parameters showed significant differences which are stated and discussed in the following heads:

Growth parameters

Days taken to 50% seed germination

The pooled analysis results stated in Table 1, revealed that the minimum days taken to 50% seed germination was observed in T_9 (8.17; IC-265934) that was statistically *at par* with T_{13} (8.67; IC-278508) and T_{14} (9.00; IC-328626). Whereas, the maximum days was recorded in T_{17} (14.00; IC-341856) which was statistically *at par* with T_1 (IC-037145) and T_{19} (IC-341860) with standing the similar mean value as 13.17 days. This result might be due to the presence a sufficient amount of soil moisture, soil temperature, seed viability, genetic variability within the genotype itself. Previously, the similar differences were reported by Subedi *et al.* (2022).

Germination percentage (%)

On the basis of pooled analysis (Table 1), the maximum germination percentage was observed in T_6 (95.40%; IC-043572), while the minimum germination percentage was recorded in T_{11} (69.28%; IC-274530). This result might be due to bold seeded nature of some of the genotypes. Similar finding was reported by Kalauni *et al.* (2020).

Plant height at 30 DAS, 45 DAS and at final harvesting stage (cm)

It was clearly obvious from the pooled data tabulated in Table 1, that there was a significant difference in plant height among French bean genotypes. The maximum plant height at 30 DAS was measured in T_6 (17.85 cm; IC-043572), followed by T_{16} (16.16 cm; IC-341851). Whereas, the minimum height was observed in T_9 (8.53 cm; IC-265934), that was statistically *at par* with T_{11} (9.51 cm; IC-274530). The highest mean value at 45 DAS was recorded in T_6 (35.02 cm; IC-043572) and the minimum was observed T_9 (18.01 cm; IC-265934) and at the final harvesting stage maximum height was in T_6 (42.51 cm; IC-043572), followed by T_4 (40.57 cm; IC-037172), whereas, minimum was observed in T_9 (25.87 cm; IC-265934). The disparity in plant height may be due to genetic differences among the genotypes. The results of present findings were in agreement with Zelaing *et al*. (2018) and Akter *et al.* (2021).

Number of leaves at 30 DAS, 45 DAS and at final harvesting stage

The pooled data results presented in Table 1, clearly stated that the maximum number of leaves was noticed in T_6 (25.69; IC-043572), followed by T_5 (22.93; IC-043557) at 30 DAS. Whereas, the minimum was observed in T_{11} (7.12; IC-274530), which was statistically *at par* with T_9 (8.57; IC-265934). The highest mean value at 45 DAS was in T_6 (54.65; IC-043572), that was statistically *at par* with T_{10} (51.37; IC-265941) and T_5 (49.74; IC-043557), while the least number of leaves was observed in T_{11} (24.47; IC-274530), which was *at par* with T_{20} (28.81; IC-341868) and T_{16} (26.83; IC-341851). The maximum number of leaves at final harvesting stage was recorded in T_6 (100.48; IC-043572), whereas the minimum was observed in T_{11} (62.70; IC-274530), which was statistically *at par* with T_{20} (65.15; IC-341868). This result might be due to environmental effects and photosynthetic activity of the plant. Similar results were documented by Akter *et al.* (2021).

Fresh and dry weight of root per plant (g)

Perusal of the data presented in Table 1, revealed that the maximum fresh weight of root per plant was found in T_6 (13.58 g; IC-043572) followed by T_{17} (11.74 g; IC-341856), while the minimum was recorded in T_{13} (3.43 g; IC-278508) followed by T_{18} (3.91 g; IC-341858) whereas, the maximum dry weight of root per plant was observed in T_6 (5.80 g; IC-043572) and minimum was recorded in T_{13} (1.63 g; IC-278508) which was found statistically *at par* with T_{19} (1.83 g; IC-341860), T_3 (2.05 g; IC-037169) and T_{18} (2.15 g; IC-341858).

Fresh and dry weight of shoot per plant (g)

From the analyzed pooled data (Table 1) related to fresh and dry weight of shoot per plant a significant variation was observed in French bean genotypes. The highest fresh weight/plant was noticed in T_6 (113.96 g; IC-043572), while,

Table 1: Pooled analysed data of days taken to 50% seed germination, germination percentage (%), plant height (cm) and number of leaves at 30 DAS, 45 DAS, final harvesting stage, fresh and dry weight of root and shoot per plant (cm) of French bean genotypes.

Treatments	Germplasms	Days taken to 50% seed germination	Germination percentage (%)	Plant height (cm)			Number of leaves			Fresh weight of root/ plant (g)	Dry weight of root/ plant (g)	Fresh weight of shoot/ plant (g)	Dry weight of shoot/ plant (g)
				30 DAS	45 DAS	Final harvesting stage	30 DAS	45 DAS	Final harvesting stage				
T_1	IC- 037145	13.17	84.54	14.24	21.69	32.92	22.17	40.85	80.94	9.14	4.10	68.83	33.17
T_2	IC- 037156	10.50	83.45	11.30	27.17	34.59	19.25	46.93	76.52	9.87	3.86	90.00	57.59
T_3	IC- 037169	12.67	89.50	11.86	22.47	31.59	17.51	41.13	83.73	4.44	2.05	43.87	21.44
T_4	IC- 037172	11.83	83.14	13.98	30.75	40.57	16.71	36.87	82.12	11.43	5.05	50.93	24.65
T_5	IC- 043557	12.50	85.47	12.90	28.52	39.53	22.93	49.74	91.34	10.20	4.12	92.83	50.57
T_6	IC- 043572	11.67	95.40	17.85	35.02	42.51	25.69	54.65	100.48	13.58	5.80	113.96	88.53
T_7	IC- 264259	12.67	90.03	11.80	23.30	30.51	20.23	47.28	79.16	9.43	3.78	49.02	21.51
T_8	IC- 265910	11.17	90.52	9.93	21.43	28.14	8.79	43.84	88.91	11.20	4.08	63.05	28.35
T_9	IC- 265934	8.17	84.40	8.53	18.01	25.87	8.57	30.81	69.99	11.17	4.52	42.10	20.57
T_{10}	IC- 265941	11.33	81.61	13.59	21.96	36.60	19.58	51.37	80.93	9.04	3.15	55.10	29.88
T_{11}	IC- 274530	10.17	69.28	9.51	20.69	32.55	7.12	24.47	61.75	11.18	4.25	44.95	21.42
T_{12}	IC- 278499	12.17	84.35	15.81	25.68	40.17	15.12	34.01	88.47	7.67	2.37	76.42	35.00
T_{13}	IC- 278508	8.67	88.26	13.76	23.61	38.89	11.03	33.31	83.62	3.43	1.63	97.17	51.36
T_{14}	IC- 328626	9.00	84.80	11.23	25.99	33.17	11.61	33.09	87.11	6.70	2.85	74.83	33.98
T_{15}	IC- 341850	12.17	74.59	12.25	20.99	36.60	19.02	38.34	86.00	9.71	4.20	88.17	43.08
T_{16}	IC- 341851	11.83	82.28	16.16	26.71	30.98	13.10	26.83	75.92	10.58	4.11	101.50	81.48
T_{17}	IC- 341856	14.00	86.35	14.08	30.92	37.90	19.07	43.57	88.42	11.74	4.93	94.80	50.60
T_{18}	IC- 341858	10.17	89.52	11.43	26.74	34.58	20.16	46.45	74.62	3.91	2.15	82.77	40.97
T_{19}	IC- 341860	13.17	81.09	11.79	24.52	34.96	20.69	48.10	73.08	5.57	1.83	61.25	30.88
T_{20}	IC- 341868	11.67	83.24	14.81	25.68	36.95	14.11	28.81	65.15	8.33	2.67	57.10	28.82
T_{21}	Falguni	9.50	81.18	11.84	24.22	33.63	15.19	35.94	76.71	10.12	3.91	61.25	30.62
	S. Em (±)	0.46	0.42	0.35	0.61	0.35	0.55	1.92	1.24	0.49	0.18	0.90	1.08
	CD (5%)	1.31	1.22	0.99	1.75	1.01	1.57	5.51	3.57	1.39	0.52	2.57	3.11

The level of significance was tested at 5%.

the minimum was observed in T_9 (42.10 g; IC-265934) and maximum dry weight of shoot/plant was noticed in T_6 (88.53 g; IC-043572), whereas, the minimum was found in T_9 (20.57 g; IC-265934). These results were in agreement with Barcchiya and Kushwah, (2017).

Yield parameters

Days taken to 50% flowering

On the basis of pooled data, as presented in Table 2, revealed that the minimum days taken to 50% flowering was observed in T_9 (34.17; IC-265934), which was statistically *at par* with T_4 (34.50 days; IC-037172), T_{11} (34.33 days; IC-274530) and T_{13} (35.33 days; IC-278508). In contrast, the maximum days were recorded in T_{17} (42.17; IC-341856) which was *at par* with T_2 (IC- 037156) and T_{19} (IC-341860) that were having same mean value as 40.83 days and T_{15} (41.83 days; IC-341850). The differences in flowering duration may be ascribed to genetic disparity, these findings were corroborated with the findings of Das *et al.* (2018).

Pod length (cm)

On the basis of pooled data analysis (Table 2), the maximum pod length was measured in T_6 (14.68 cm; IC-043572), whereas, the minimum was in T_{12} (7.68 cm; IC-278499). Similar findings were reported by Zelaing *et al.* (2018) and Whankate *et al.* (2021) in French bean.

Pod diameter (cm)

The highest mean value of pod diameter was noticed in T_2 (1.24 cm; IC-037156), followed by T_3 (1.04 cm; IC-037169) and T_7 (IC-264259) and T_8 (IC-265910) which were having same mean value as 1.03 cm (Table 2). While, the minimum was found in T_{16} (0.63 cm; IC-341851), that was *at par* with T_{10} (0.67 cm; IC-265941), T_{11} (IC-274530) and T_{17} (IC-341856) that were standing with same mean value of 0.68 cm, T_{14} (0.71 cm; IC-328626) and T_{20} (0.72 cm; IC-341868). This result might be due to their inherited traits and to some extent by environmental factors. The present findings were in close conformity with the results reported by Das *et al.* (2018).

Weight of individual pod per plant (g)

The results tabulated in Table 2, showed that the maximum weight of individual pod was recorded in T_6 (5.65 g; IC-043572), followed by T_{11} (4.58 g; IC-274530), whereas, the minimum was found in T_7 (2.03 g; IC-264259), which was *at par* with T_2 (2.65 g; IC-037156), T_5 (2.47 g; IC-043557), T_{18} (2.79 g; IC-341858) and T_{21} (2.68 g; Falguni). The present findings

Table 2: Pooled analysed data of days taken to 50% flowering, pod length (cm), pod diameter (cm), weight of individual pod per plant (g), green pod yield per plant (g) and green pod yield per hectare (t) of French bean genotypes.

Treatments	Germplasms	Days taken to 50% flowering	Pod length (cm)	Pod diameter (cm)	Weight of individual pod/plant (g)	Green pod yield/plant (g)	Green pod yield /ha (t)
T_1	IC- 037145	35.83	10.98	1.00	2.47	94.11	26.92
T_2	IC- 037156	40.83	10.34	1.24	2.65	97.75	28.20
T_3	IC- 037169	37.39	9.00	1.04	2.98	98.02	28.39
T_4	IC- 037172	34.50	10.97	0.91	3.63	125.01	36.68
T_5	IC- 043557	36.00	11.33	0.93	2.47	122.35	35.40
T_6	IC- 043572	35.67	14.78	1.00	5.65	205.50	59.51
T_7	IC- 264259	40.50	9.90	1.03	2.03	146.65	42.79
T_8	IC- 265910	35.83	10.80	1.03	4.06	127.67	36.78
T_9	IC- 265934	34.17	12.10	0.83	3.00	92.77	26.62
T_{10}	IC- 265941	36.83	10.85	0.67	3.10	118.67	34.51
T_{11}	IC- 274530	34.33	10.33	0.68	4.58	104.71	36.75
T_{12}	IC- 278499	37.33	8.03	0.94	3.67	161.83	47.15
T_{13}	IC- 278508	35.33	10.72	0.75	4.09	188.17	54.78
T_{14}	IC- 328626	38.50	10.97	0.71	4.10	137.19	40.77
T_{15}	IC- 341850	41.83	9.65	0.98	4.01	194.06	57.13
T_{16}	IC- 341851	39.83	8.17	0.63	3.25	183.70	53.48
T_{17}	IC- 341856	42.17	12.23	0.68	4.46	119.99	34.98
T_{18}	IC- 341858	39.33	9.90	0.82	2.79	111.32	32.35
T_{19}	IC- 341860	40.83	11.29	0.84	3.91	166.58	48.42
T_{20}	IC- 341868	38.00	10.17	0.72	3.00	122.50	36.29
T_{21}	Falguni	39.17	11.21	0.91	2.68	93.17	26.58
	S. Em (±)	0.50	0.35	0.04	0.31	4.55	2.12
	CD (5%)	1.43	1.01	0.11	0.87	13.04	6.09

The level of significance was tested at 5%.

were in close conformity with Panchbhaiya *et al.* (2017) and Whankate *et al.* (2021) in French bean.

Green pod yield per plant (g)

On the basis of pooled analysis (Table 2), it was found that T_6 (IC-037156) recorded with the highest (205.50 g) green pod yield which was statistically *at par* to T_{15} (194.06 g; IC-341850), while the minimum measured in T_{21} (93.17 g; Falguni), which was at par with T_1 (94.11 g; IC-037145), T_2 (97.75 g; IC-037156), T_3 (98.02 g; IC-037169) and T_{11} (104.71 g; IC-274530). It might be due to indirect contribution on total association of number of branches/plant and plant height. This result was in agreement with Devi *et al.* (2015) and Kumar (2022).

Green pod yield per hectare (t)

The pooled analysis of this parameter as tabulated in Table 2, revealed that the maximum yield was recorded in T_6 (59.51 t; IC-037156), that was *at par* with T_{13} (54.78 t; IC-278508), T_{15} (57.13 t; IC-341850) and T_{16} (53.48 t; IC-341851), whereas, the minimum yield was observed in T_{21} (26.58 t; Falguni), which was statistically *at par* with T_1 (26.92 t; IC-037145), T_2 (28.20 t; IC-037156), T_3 (28.39 t; IC-037169), T_9 (26.62 t; IC- 265934) and T_{18} (32.35 t; IC-341858). This result was attributed to better root proliferation, good uptake of nutrients and water, high photosynthetic activity and enhanced food accumulation. These results were close in conformity with Whankate *et al.* (2021) and Thapa *et al.* (2022).

CONCLUSION

As per the results derived from the current study, it could be determined that among all of the French bean genotypes T_6 (IC-043572) was found the best genotype corresponding to all the characters *viz*., germination percentage (%), plant height at 30 DAS, 45 DAS and final harvesting stage, number of leaves at 30 DAS, 45 DAS and final harvesting stage (cm), fresh and dry weight of root and shoot (g), pod length (cm), weight of individual pod per plant (g), green pod yield per plant (g) and green pod yield per hectare (t). As per the obtained results it could be concluded that IC-043572 has the good potential for using it as an alternative genotype for the Trans-Gangetic plains region and could be used to boost French bean production. However, prior to giving any recommendation, additional verification through multi-locational trails and farmer's field experiments would be crucial.

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