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Assessment of quantitative differences among diverse genotypes of French bean (*Phaseolus vulgaris* L.) for yield and yield attributing traits

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Abstract
The present investigation was carried out at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.) during the *Rabi* season of 2012-13 on 21 diverse genotypes of french bean in order to evaluate the quantitative variation with respect to yield and yield contributing plant traits. The pod yield per hectare ranged from 87.93 (RLFB-58) to 138.88 (HOR-137). The highest pod yield per hectare was recorded by 138.88 (HOR-137), followed by PDR-14 (138.56) and EC-592938 (138.35 g). On the basis of results of this experiment it can be concluded that earliness behavior of the genotypes was not good for high yield while most of the high yielding genotypes were showed late maturity. In the present experiment, LVFB-2, RLFB-58 and RCFB-64 were found early maturing genotypes which may be used for the development of short duration cultivars.

Keywords: French bean, component traits, genetic variability, inheritance

Introduction
French bean (*Phaseolus vulgaris* L.) is an important leguminous crop belonging to the family Leguminosae with the chromosome number of 2n=2x=22 and originated in Central and South America. It is a nutritious vegetable which is consumed as tender green pods, shelled beans, and dry beans. It is also called rajma in Hindi and snap bean, kidney bean, and haricot bean in English. French bean having good nutritional value contains protein 1.7g, carbohydrate 5.0g, fat 0.1g, fibre 1.8g and is also rich in minerals and vitamins. It also possesses some medicinal properties which is useful in controlling diabetics and certain cardiac problems and it is a good natural cure for bladder burn. The average yield of pulses in general and french bean in particular is very low as compared to that of cereals because of the lack of suitable high yielding varieties having synchronous maturity, instability under varying environmental conditions and susceptibility to different diseases and pests. Therefore, there is an urgent need to develop high yielding varieties coupled with resistance to prevent diseases with early maturity so that maximum grain yield could be harnessed which will ultimately enhance the total pulse production at the national level.

Phenotypic expression of the plant is mainly governed by the genetic makeup of the plant and environment effect. Hence, the study of genetic variability for yield and yield contributing characters of available genotypes are essential. Growth and yield is the end product interaction of many correlated character of livening matters which refers to the change that occurs in protoplasm, cell wall, cell and organs or in the whole plant. Seed yield is a complex trait and resulting due to interaction of different yield components. The classical breeding systems that make use of additive genetic variance will be an effective breeding procedure for improving this crop. To exploit the existing genetic variability in french bean, the breeder would need the basic information regarding the inheritance of grain yield and its closely related components for devising an efficient selection programme.

Materials and Methods
The present experiment was conducted in *Rabi* season of 2012-13 at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, U.P. (India). Geographically, Varanasi is situated in eastern part of Uttar Pradesh and subtropical track of north India between latitude 25^0 15' North and longitude 83^0 03' East and is located on an elevation of about 128.93 metres above Mean Sea Level (MSL) in north Gangetic plain.

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The experiment was laid out in Randomized Complete Block Design (RCBD) with 21 genotypes of french bean and replicated thrice. The plot size is 3 x 2 m= 6.0 m² leaving the border of 30 cm from each side of the plot. The plants are planted with the spacing of 40 × 20 cm² containing 75 plants in each plot. All the genotypes were collected from the ICAR-Indian Institute of Vegetable Research, Varanasi. The genotypes are
Arka Anoop, Arka Komal, EC-592938, EC-5995960, HAFB-3, HUR-15, LVFB-2, PDR-14, RLFB-58, VHP-9, Arka Suvidha, Contender, EC-593020, EC-599750, HOR-137, Kentucky Wonder, Pant Bean-3, RCFB-64, Swarna Priya, VL-Bean3, and VRF-BB1. The observations for yield and yield contributing plant characters viz., days to first flowering; days to first picking, number of pods per plant, plant height, primary branches per plant, pod yield per plant, and pod yield per hectare were recorded on selected plants excluding the border plants at both the extreme end in each row. The mean values of the genotypes were used for Analysis of Variance (ANOVA). Replication wise mean values were subjected to RCBD analysis (Panse and Sukhtame, 1985) [4] among all the genotypes and tested using 'F' test. In order to identify and ascertain the genetic variability among genotypes and to assess the extent of environmental effect on various characteristics different genetic parameters were also estimated.

Table 1: Analysis of variance (ANOVA) of 21 genotypes of french bean for plant characters

Source of variation	Degree of freedom	Days to first flowering	Days to first picking	Number of pods per plant	Plant height	Primary branches per Plant	Pod yield/ plant	Pod yield/ hectare
Replication	2	10.99	24.58	1.10	24.59	0.17	14.92	73.72
Treatment	20.00	5623*	12253*	1478*	5753*	91*	8148*	40240*
Error	40	6.75	14.88	1.36	8.72	0.10	9.96	49.20

*Significant at 5%

Table 2: Mean performance of plant characters of 21 diverse genotypes of french bean

Genotypes	DFF	DFP	NP/P	PH	PB/P	PY/P	PY/H
Arka Anoop	48.29	70.73	19.05	37.4	6.5	60.4	134.23
Arka Suvidha	46.93	68.01	24.15	36.4	6.5	58.44	129.87
Arka Komal	46.25	71.41	8.85	37.56	5.2	60.12	133.61
Contender	46.25	68.01	30.61	36.6	6.5	58.95	130.99
EC-592938	47.95	69.03	46.59	30.56	6.2	62.25	138.35
EC-593020	51.01	74.13	29.25	34.55	5.4	58.42	129.83
EC-5995960	49.65	73.79	23.13	34.6	5.85	40.15	89.24
EC-599750	46.40	69.71	11.23	80.5	6.2	55.6	123.70
HAFB-3	49.99	73.11	34.01	32.35	4.65	61.4	136.44
HOR-137	47.27	68.01	23.81	42.25	6.2	62.5	138.88
HUR-15	51.01	75.15	24.49	35.2	5.85	60.1	133.56
Kentucky Wonder	47.04	68.73	17.35	95.4	5.6	53.4	118.67
LVFB-2	44.89	67.67	23.13	37.8	7	61.45	136.57
Pant Bean-3	49.99	72.77	23.47	40.25	5.8	60.12	133.61
PDR-14	48.97	73.11	23.81	55.7	6.4	62.35	138.56
RCFB-64	45.57	70.05	9.19	86.45	5.4	54.55	121.23
RLFB-58	45.23	67.67	9.53	55.4	6.15	39.57	87.93
Swarna Priya	46.93	69.71	7.83	35.65	5.4	52.45	116.56
VHP-9	47.09	74.81	14.63	36.26	7.75	52.88	117.51
VL-Bean 3	47.95	69.03	17.35	42.15	6.25	60.14	133.64
VRF-BB 1	48.29	71.75	14.63	65.56	6.45	55.78	123.96
Average	47.76	70.78	20.77	47.08	6.06	56.72	126.04
SEm±	1.50	2.23	0.67	1.70	0.19	1.82	4.05
CD at 5%	4.29	6.37	1.93	4.87	0.53	5.21	11.57
CD at 1%	5.74	8.52	2.58	6.52	0.71	6.97	15.49

DFF: Days to first flowering; DFP: Days to first picking; NP/P: Number of pods per plant; PH: Plant height, PB/P: Primary branches/plant, PY/P: Pod yield per plant and PY/H: Pod yield/hectare.

Results and discussion
The present investigation was carried out on 21 diverse genotypes of french bean in order to assess the quantitative difference among the genotypes of french bean for yield and yield attributing characters under agro-climatic conditions of Varanasi (Uttar Pradesh), India. The population was found to be significant for traits namely, days to first flowering, days to first picking, number of pods per plant, plant height, primary branches per plant, pod yield per plant and pod yield per hectare as illustrated in Table 1. The critical analysis of the findings of the present investigation indicates that the genotype differed among themselves in their growth, flowering, fruit characters and yield related traits. Lower mean value of days to first flowering is more useful for earliness. The data regarding the days to first flowering revealed that it ranges from LVFB-2 (44.89 days) to EC-593020 and HUR-15 (51.01 days) among the genotypes (Table 2). On the basis of earliness LVFB-2 was found good but overall performance of the genotype was very poor. Days to first flowering in general were after the sowing of 45 days. Similar findings were also reported by Lavatre *et al*. (2003) [3]. Days to first picking is also desired for earliness of the crop. In the present investigation it was observed significantly differ in all the genotypes. The data regarding the days to first picking revealed that it ranges from LVFB-2 (67.67 days) to HUR-15 (75.15 days) as shown in the Table 2. HUR-15 (75.15 days) ranks first followed VHP-9 and EC-593020. Generally early cultivars showed poor yielder. Many workers

reported same type of the results in different genotypes such as Garcia *et al.* (2012) [1]. On the basis of contribution to the yield of a genotype number of pods per plant having an important role so more number of pods per plant responsible for high yield and vice-versa. The data regarding the number of pod per plant revealed that the highest rank reported by genotype EC-592938 (46.59) and the minimum number of pods per plant was recorded in genotype Swarna Priya (7.83) and it is the significant variation in the genotypes. Jasmine *et al.* (1998) [2] and Lavatre *et al.* (2003) [3] also reported similar findings for the variation in number of pods per plant. The trait of plant height was significantly more divers for all the 21 genotypes of french bean. This trait for french bean production directly affected, if plant height is more than number of pods per plant also increase which improve yield per plant and yield per hectare. On the basis of mean value which was observed highest plant height by Kentucky Wonder (95.4 cm) followed by RCFB-64 (86045 cm) and EC-599750 (80.5 cm) (Table 2). The genotype EC-592938 (30.56 cm) was exhibited minimum plant height. Similar findings for plant height were also reported by Shah *et al.* (1999) [7] and Singh *et al.* (2011) [9]. Primary branches per plant is a highly valuable trait which increase or decrease the yield of the crop. Large number of primary branches results in the production of more number of pods and vice-versa. Recorded observation for primary branches per plant revealed that the all 21 genotypes were highly diverse. Genotype VHP-9 (7.75) ranked first for maximum number of branches per plant, followed by LVFB-2 (7.0). Arka Anoop, Arka Suvidha and Contender (6.5), these three genotypes showed same number of primary branches per plant whereas; minimum number of primary branches per plant was recorded by genotype HAFB-3 (4.65). Raffi and Nath (2004) [5], Rai *et al.* (2010) [6] have reported similar type of findings in french bean for primary branches per plant.

On the basis of observations, HOR-137 (62.5 g) was found rank first for high pod yield per plant. The mean value of pod yield per plant also ranged from 39.15 g (RLFB-58) to 62.5 g (HOR-137). PDR-14 (62.35 g) and EC-592938 (62.25 g) also showed good pod yield per plant than other genotypes but genotype RLFB-58 (39.15 g) was found poor yielder for pod yield per plant. The mean value of the pod yield per plant was found to be 56.72 g. these findings are in accordance with Lavatre, *et al.* (2003) [3]. Pod yield per hectare is the ultimate outcome of the crop hence this traits is having more important for crop improvement. The pod yield per hectare ranged from 87.93 (RLFB-58) to 138.88 (HOR-137). The highest pod yielder was HOR-137 (138.88 q/ha), followed by PDR-14 (138.56 q/ha), and EC-592938 (138.35 q/ha), and whereas minimum pod yield per hectare was recorded with genotype RLFB-58 (87.93). These results are in accordance with Singh *et al.* (2007) [9] and Rai *et al.* (2010) [6]. During selection of a genotype for the recommendation of commercial cultivation, it is very necessary to take into consideration the environmental conditions of the particular region as environment has got a vital role in expression of characters.

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