

Evaluation of French Bean (*Phaseolus vulgaris* L.) Varieties for Summer Season Production in the Mid–Hills of Central Region of Nepal

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Abstract

The experiment on evaluation of open pollinated genotypes of French bean (*Phaseolus vulgaris* L.) was conducted during the summer season of 2016 and 2017 at HRD, Khumaltar, Lalitpur, Nepal to assess the variability in the genotypes and yield potentiality for commercial production. The experiment was laid out in Randomized Complete Block Design (RCBD) with five replications. The two new genotypes viz. Semi Light Long and Long Green Bean were compared with Trishuli and Four Season. Fresh pod yield and yield attributing parameters were recorded. The pooled analysis of both years' data showed significant differences among the genotypes on plant uniformity, number of pods/plants, single pod weight, fresh pod yield/plant and total yield. The number of pods per plant was observed the highest in Semi Light Long (113) followed by Long Green Bean (82) whereas the lowest in Trishuli (73). Similarly, the average pod weight was the highest (12 g) in Long Green Bean and the lowest in Trishuli (9.65 gm). The highest fresh pod yield per plant was observed in Semi Light Long (1188.5 g) followed by Long Green Bean (1015.00 g) and the lowest in Trishuli (768.50 g). The highest total pod yield was observed in Semi Light Long (30.97 t/ha) followed by Long Green Bean (27.02 t/ha) which were statistically at par. The lowest yield was observed in Four seasons (20.58 t/ha). Semi Light Long was also found to be early maturing (70-75 DAS), having long harvesting period (28 days) and thin flesh having pod length of 18-20 cm. Long Green Bean was late in maturity (75-78 DAS), second highest yielder (27.02 t/ha) with thick flesh and light green color at maturity. Based on the two years' data, Semi Light Long and Long Green Bean genotypes seemed promising during summer season in the central mid hills of Nepal. So, it is suggested that these two genotypes may be considered for registration by the Seed Quality Control Center.

Keywords: Commercial production, Evaluation, French bean, Open pollinated, Registration, Varieties.

Introduction

French bean (*Phaseolus vulgaris* L.) is a native crop of central and South America (Swaideret al., 1992). The cultivation of French bean was started 7000 years ago by the Indian tribes in Mexico and Peru. Both pole and bush types of French beans are popular in Nepal. However,

pole bean is the most important and predominantly cultivated one as green vegetable in Nepal. It is mainly cultivated from 300 m to 2,500 m in different growing seasons (Neupane et al., 2008). It is widely cultivated in the temperate, sub-tropical and tropical regions and it is one of the most important legumes grown worldwide for human consumption (Singh, 1999). In Nepal

and most of the tropical Asia, it is a major vegetable crop where indigenous pulses are also preferred (Kay, 1979 and Duke, 1981). The optimum mean temperature for French bean is 20-25° C for its growth and better productivity. Extreme high temperatures interfere pod filling, while low temperatures are unfavourable for vegetative growth (ICAR, 2003). Floral drop occurs in hot and rainy condition.

The total area, production and productivity of pole type French bean in Nepal is 5,297 ha, 55,400 mt and 10.46 mt/ha (MOAD, 2015) respectively. The average national productivity of French bean is very low due to the unavailability of high yielding improved varieties and package of cultivation practices. In Nepal, only one variety of pole type bean named Trishuli has been registered in 1994 and even today, farmers do not have choices for pole bean varieties with higher yield potentiality and preferred characters. Hence, the present study was done to select, verify and register new pole type bean varieties for farmers' choice as alternative varieties and contribute to some extent in increasing the national productivity.

Materials and Methods

Four varieties of open pollinated pole type bean viz. Semi Light Long, Long Green Bean, Trishuli and Four Season were evaluated at Horticulture Research Division (HRD), Khumaltar (1332 m amsl) during summer season of 2016 and 2017. The two varieties viz. Semi Light Long and Long Green Bean were received from Green Seeds Pvt.Ltd., and the remaining two varieties viz. Trishuli and Four Season were used as check varieties. Seeds were sown on April 11, 2016 and 2017 consecutively in an open field at a spacing of 120 cm × 30 cm. Each experimental plot was 2.88 m². The space between the plots and replications were 0.5 and 1 m respectively. A total of eight plants were accommodated in each plot (two rows with four plants/row) with five replications. In each plot, the plants were randomly selected and five plants were taken as observational plants in a net plot area of 1.88 m². The standard recommended dose of fertilizers (80:120:60 NPK kg/ha) and 15 t/h FYM were applied. Half dose of total nitrogen, full dose of potash and phosphorus fertilizers were incorporated at sowing time and the remaining half dose of nitrogen fertilizer was top dressed at 35 days of sowing. No any pesticides were applied. Scoring of agro-morphological characters was

done according to the procedures given in the IBPGR (International Board for Plant Genetic Resources) descriptors (IBPGR, 1982). The recorded data were analysed by using Gen Stat software (version 12.1, VSN International, Hemel Hempstead, UK).

Observations were recorded on various parameters like plant uniformity, plant vigor, plant height, flower color, seed color, pod appearance and its color, and flesh type by visual observation. Plant uniformity was taken on the basis of homogeneity of crop whereas vigor was on the basis of size of the plant and its growth habit and was observed at full emergence and after flowering period. The observations were taken after the time of 50 % flowering based on a hedonic scale of 1 – 5 (1 for very poor whereas 5 for excellent). Plant uniformity and vigor were recorded twice by visual observation as a combination of active growth, plants appearing to be healthy and strong at full emergence and flowering stage by a team of scientists using hedonic grades of very poor, poor, acceptable/medium, good and very good. The scale rating of very poor was defined as inactive growth with weak and unhealthy plants, whereas very good was defined as active growth with healthy and strong plants.

Plant height was measured at green pod maturity stage from the cotyledon scar to the highest tip of the plant. Maturity characters, yield and yield attributing parameters viz. Days to 50% flowering, Days to first harvesting, Harvest duration, Number of flowers per node, Number of pods per plant, Fresh pod yield per plant, Average pod weight and Total pod yield were recorded on the basis of randomly selected five sample plants from the net plot area. Days to flowering was recorded when 50 % of plants had set flowers in each plot and duration from seed sowing to that date was expressed in days after sowing (DAS). Days to first harvesting was counted from the date of seed sowing to the date of first pod harvest in each treatment. Harvest duration was recorded from the date of first pod harvest to last harvest. The number of flower buds per inflorescence was recorded from the lateral inflorescence (3rd from the apex) and number of pods were recorded by counting the number of total pods from the selected five plants and then average number were calculated. Fresh pod yield per plant and total pod yield were obtained by adding the total pods of observational plants in each plot and then average yield was calculated. Pod length was measured on the largest, fully expanded, immature, green pod. Pod color

was recorded on the fully expanded immature pods as normal green, shiny green, dull green, dark pink, pale red stripe on green or other. Pod appearance was recorded from randomly selected pods as attractive, medium and smooth. Seed color was recorded from matured dry seeds as black, brown, pure white or white. Lastly, incidence of bean rust, virus and leaf minor were scored using 1-5 scale where 1 is less affected and 5 is highly susceptible. They were observed at 85 and 90 DAS after the first harvest in both the years.

Results and Discussion

Plant uniformity and vigor

P Plant uniformity and plant vigor have direct effect on

productivity of crop. The difference in Plant uniformity among the varieties was non-significant in first year but it was significant in the second year and mean of both the years (Table 1). The highest mean plant uniformity (4.95) was recorded in Long Green Bean and statistically it was at par with Semi Light Long (4.85) and Four season (4.75), while the lowest uniformity was observed in Trishuli (4.20). On the other hand, the difference in Plant vigor was non-significant among the varieties in both the years although Four Season was the highest scorer. Similar result was also reported by Pandey et al. (2011) in which they tested 18 exotic and indigenous French bean varieties and Four Season showed the highest score.

Varieties	Uniformity (1-5 scale) *			Plant vigor (1-5 scale) *		
	2016	2017	Mean	2016	2017	Mean
Long Green Bean	5.0	4.9	4.95	4.7	4.5	4.60
Semi Light Long	4.7	5.0	4.85	4.7	4.8	4.75
Four Season (check)	4.7	4.8	4.75	5.0	5	5.00
Trishuli (check)	4.0	4.4	4.20	4.7	4.8	4.75
Mean	4.8	4.6	4.6	4.7	4.7	4.7
F-test	Ns	***	**	Ns	Ns	Ns
LSD(0.05)		0.59	0.59	-	-	-
CV %	20.25	9.3	14.77	12.15	8.1	10.1

Plant height

The plant height (vine length) differed significantly among the genotypes (Table 2). Though the difference in plant height was non-significant, the tallest and shortest plant height was found in Semi light long and long Green Bean with 205.3 cm and 197.3 cm respectively. Neupane et al. (2008) reported that the plant height in beans was influenced by the genotypes. They recorded the plant height from 28 to 144 cm among different bean genotypes that were planted at the same date. Similar results were also reported by other researchers. Alghamdi (2007) reported that Faba bean genotypes significantly differed in flowering date and plant height. Similarly, Al-soqeer (2010) reported that plant height in Jojoba clones was affected by the genotype.

Days to flowering

Days to 50% flowering of a particular variety indicates its maturity. Though days to 50% flowering was non-significant among the varieties, the flowering time ranged from 58 to 60 days after seed sowing (Table

2). The flowering and fruiting days were influenced by genotypes, day length and temperature. In most of the vegetable crops, early flowering and maturing genotypes are preferred. White and Laing (1989) reported that adaptation of the common bean is strongly affected by photoperiod and there is considerable genetic variation for photoperiodic response in the bean species. Neupane et al. (2008) reported that the flowering days in beans were influenced by the genotype. They reported that flowering time varied from 40 to 84 days depending on the bean genotypes. Variety and environment interaction in common bean for days to flowering and the length of flowering period was also reported by Wallance et al. (1991).

Days to first harvesting

The pooled analysis of two years' data revealed that early harvesting was done in Semi Light Long (70 DAS) followed by Four Season (73 DAS) and Trishuli (72 DAS) which were statistically at par (Table 2). The Long Green Bean was the latest for days to first harvest (76 DAS) among the four tested varieties.

Harvest duration

The pooled analysis on harvest duration showed significant difference among the cultivars (Table 2). It varied from 23 days to 28 days with the mean value of 24 days. Significantly the longest duration was exhibited by Semi Light Long (28 days) followed by Long Green Bean (24 days) while the shortest harvest duration was observed in Trishuli (23 days) and Four-season (23 days) which were statistically at par. Similar result was also reported by Shrestha et al. (2011) that Four Season bean possessed the shortest harvest duration (22 days) among seven genotypes tested in Dailekh condition.

Pod length

The difference in pod length among the genotypes was highly significant (Table 2). The combined analysis

of two years' data revealed that the longest pods were produced by Long Green Bean (21.3 cm) and the shortest pods by Trishuli (16.5 cm). Neupane et al. (2008) also reported that the pod length in beans was influenced by the genotype. They found that all the genotypes planted on the same date produced varying pod lengths ranging from 6.7 to 17.4 cm. Similar results were also reported by other researchers. Islam et al. (2010) reported that the genotypes of hyacinth bean showed considerable variation in pod length varying from 3.96 cm to 18.20 cm. Pengelly and Mass (2001) also reported that the pod length in lablab bean ranged from 2.5 to 14 cm among 249 genotypes. Pandey et al. (2012) reported that pod length of different pole bean varieties varied from 7.6 cm to 20.7 cm. varieties varied from 7.6 cm to 20.7 cm.

Table 2: The floral and yield attributing characteristics of different varieties of French bean tested at HRD, Khumaltar in the years 2016 and 2017

Varieties	Plant height (cm)	Days to 50% flowering (DAS)	Days to first harvesting (DAS)	Harvest duration (Days)	Pod length (cm)
Long Green Bean	191.3	60	76	24	21.3
Semi light Long	205.3	58	70	28	19.4
Four Season (Check)	187.5	58	73	23	18.5
Trishuli (Check)	191.4	58	72	23	16.5
Mean	195.4	59	73	24	18.92
F-test	Ns	Ns	**	**	***
LSD (0.05)			2.31	0.74	1.04
CV%			2.3	2.2	4

Number of flowers/node and Number of pods/plants

The difference in Numbers of flowers/node was non-significant among the varieties in both the years (Table 3). The highest Number of pods/plant was recorded

in Semi Light Long (113.12) followed by Long Green Bean (81.91) whereas it was the lowest in Trisuli (73.45) (Table 3). The differences in Number of pods/plant among the varieties might be due to difference in their genetic make-up.

Table 3: Number of flowers per node and pod numbers per plant of French bean tested at HRD, Khumaltar in the years 2016 and 2017

Varieties	Number of flowers/nodes			Number of pods/plant		
	2016	2017	Mean	2016	2017	Mean
Long Green Bean	6.7	6.5	6.6	83.4	80.58	81.91
Semi Light Long	5.3	5.5	5.4	113.6	113.67	113.12
Four Season (check)	5.2	5.2	5.2	87.1	64.83	75.99
Trishuli (check)	5.3	4.8	5.05	62.6	82.72	73.45
Mean	5.5	5.5	5.56	86.7	85.45	86.09
F-test	Ns	Ns	Ns	**	**	**
LSD(0.05)				29.51	5.19	17.35
CV%	11.94	10.97	11.45	14.6	4.4	9.5

Fresh pod yield/plant

The difference in fresh pod yield/plant among the varieties was significant (Table 4). The combined analysis over the years showed that the fresh pod yield/plant was the maximum in Semi Light Long (1188.5 g/plant) followed by Long Green Bean (1015 g/plant) and the minimum was in Four Season (703.14 g/plant) followed by Trishuli (841.4 g).

Average pod weight (gm)

The two-years pooled analysis data showed that the Average pod weight was the highest in Long Green Bean (12.30 g) followed by Four season (10.70 g) and Semi light long (10.40 g) which were statistically at par and the lowest Average pod weight (9.65 g) was observed in Trishuli (Table 4).

Table 4: Fresh pod yield/plant and Average pod weight of French bean tested at HRD Khumaltar in the years 2016 and 2017

Varieties	Fresh pod yield(g/plant)			Average pod weight (g)		
	2016	2017	Mean	2016	2017	Mean
Long Green Bean	1025	1005	1015	12.1	12.5	12.30
Semi Light Long	1209	1168	1188.5	10.4	10.3	10.40
Four Season (check)	898	681	789.5	10.9	10.5	10.70
Trishuli (check)	725	812	768.5	9.8	9.5	9.65
Mean	964.25	916.5	940.25	10.8	10.7	10.76
F-test	**	***	**	**	***	**
LSD (0.05)	282	117.2	199.6	1.52	0.54	1.03
CV%	14.6	9.3	11.95	7.0	3.7	5.35

Total pod yield

The pooled analysis of two years' data showed that the total yield was the highest in Semi Light Long (30.97 t/ha) followed by Long Green Bean (27.02 t/ha) and the least was in Four Season (20.58 t/ha) followed by Trishuli (21.27 t/ha) (Table 6). The result revealed that the fresh pod yield was influenced by the genotypes. Similar results were also reported by other researchers. Neupane et al. (2008) reported that the pod and dry seed yield in beans was influenced by the genotype. They found that all the genotypes planted on the same date produced varying number of pods/plant and seed yield ranging from 5 to 32 and 5.9 to 306.5 g/sq.m., respectively. Likewise, Smittle (1986) had also this type of genetic variation and the variation found in this study ranged from 20.58 t/ha (Four Season) to 30.97 t/ha (Semi Light Long). Ndegwa et al. (2001) reported that the fresh pod yield of snap bean was influenced by the genotype ranging from 5443 to 10636 kg/ha.

Some visual observations on the morphological traits of flower, pod and seed

Four Season and Semi Light Long both showed black colored seeds with purplish pink flower while Long Green Bean showed white colored seeds with yellowish white flower and Trishuli showed brown colored seed with creamy white flower. The check varieties Four Season and Trishuli showed normal green pod color while the tested varieties Semi light long and Long Green Bean both showed pods having light green color. Bean pods were categorized on the basis of appearance as attractive, smooth and medium. Semi Light Long and Long Green Bean both showed smooth appearance on texture of pod while Four Season was attractive in appearance while Trishuli was medium type. Islam et al. (2010) reported that the genotypes of hyacinth bean showed considerable variation for most of the morphological traits. The different varieties produced different type of pod color (Table 5). Both Semi Light Long and Long Green Bean were light green in pod color while check varieties Four Season and Trishuli were normal green in pod color. Semi Light Long, Trishuli and Four-Season produced thin flesh while Long Green Bean produced thick flesh (Table 5).

Table 5: Some Visual observation on the morphology of different varieties of French Bean

Varieties	Flower Color	Seed Color	Pod appearance	Pod Color	Flesh type
Long Green Bean	Yellowish white	White	Smooth	Light green	Thick
Semi Light Long	Purplish Pink	Black	Smooth	Light green	Thin
Four Season (Check)	Purplish pink	Black	Attractive	Normal green	Thin
Trishuli (Check)	Creamy white	Brown	Medium	Normal green	Thin

Intensity of insect pest (Leaf minor)

The pooled analysis of two years' data showed that the varieties did not differ significantly with respect to leaf minor attack. But, comparatively there was more attack

in Semi Light Long (3.8) followed by Long Green Bean (3.00) whereas it was least in check varieties Four-Season and Trishuli (Table 6).

Table 6: Total pod yield and leaf minor attack of French bean tested at HRD, Khumaltar in the years 2016 and 2017

Varieties	Yield (t/ha.)			Leaf minor attack (Scale 1-5)		
	2016	2017	Average	2016	2017	Mean
Long Green Bean	26.47	27.18	27.025	2.0	4.0	3.0
Semi Light Long	29.52	32.40	30.975	3.0	4.6	3.8
Four Season (check)	19.36	21.7	20.58	2.3	3.6	2.95
Trishuli (check)	23.63	18.92	21.275	2.0	2.8	2.4
Mean	24.75	25.06	24.99	2.3	3.75	3.03
F-test	**	***	**	Ns	Ns	Ns
LSD(0.05)	6.19	2.61	4.4	-	-	-
CV%	12.5	7.6	10.5	-	-	-

Intensity of disease

i. Rust

The pooled analysis of the two years experiment showed significant difference among the varieties in case of rust disease intensity. Rust was observed more in Long Green Bean (4.65) followed by Semi Light Long (4.15) whereas the least intensity was observed in Four Season (3.10) followed by Trishuli (3.40) (Table 7).

ii. Virus susceptibility

The pooled analysis of two years data showed that the tested varieties did not differ significantly with respect to virus susceptibility, although, comparatively, Trishuli was more susceptible (3.25) followed by Four-Season (2.75). Least susceptibility (1.4) was observed in Semi Light Long followed by Long Green Bean (2.25) (Table 7).

Table 7. Rust and virus susceptibility of French bean tested at HRD, Khumaltar in the years 2016 and 2017

Varieties	Rust (Scale 1-5) (85 DAS)			Virus susceptibility (1-5 scale) 90(DAS)		
	2016	2017	Mean	2016	2017	Mean
Long Green Bean	4.7	4.6	4.65	2.3	2.2	2.25
Semi Light Long	4.3	4.0	4.15	1.3	1.5	1.40
Four Season (check)	3.0	3.2	3.10	2.7	2.8	2.75
Trishuli (check)	4.0	2.8	3.40	3.3	3.2	3.25
Mean	4.0	3.6	3.8	2.417	2.42	2.41
F-test	Ns	***	**	Ns	Ns	Ns
LSD (0.05)		0.74	0.74			
CV%	50.86	14.8	32.83			

Conclusion

Semi Light Long had the highest pod yield, early maturity time and the longest harvest duration followed by Long Green Bean and the lowest yield and the shortest harvest duration was observed in Four Season and Trishuli though the intensity of bean rust and leaf minor attack were less. Thus, these varieties could be profitably used for scaling up the target area and could be easily substitute popular varieties (Four Season and Trishuli). Based on two years data, Semi Light Long and Long Green Bean genotypes were found promising and successfully be grown during summer season in the central mid hills of Nepal. And these two genotypes were presented for registration in Seed Quality Control Center. Future research work should focus on evaluation of varieties across a range of environments to identify and select location specific and widely adaptive varieties.

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