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Optimum sowing dates and varieties for seed productivity of pole Frenchbean (*Phaseolus vulgaris* L.) under north western Himalayas

Akhilesh Sharma[1], G. D.Sharma[2], Yudhvir Singh[1], Munish Sharma[1], Viveka Katoch[1] and K. C. Sharma[1]

[1]Department of Vegetable Science and Floriculture, College of Agriculture, C.S.K. Himachal Pradesh Agricultural University, Palampur-176062, India.
[2]Department of Agronomy, College of Agriculture, C.S.K. Himachal Pradesh Agricultural University, Palampur-176062, India.

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Optimum sowing **time and a promising variety are of prime importance to harness potential yield of any crop. Pole frenchbean is cultivated as a potential off-season crop in north-western hilly areas where information on these important agronomic aspects is lacking. Keeping this in view, a field experiment was conducted for two consecutive years during June to September 2007 and 2008 by following split plot design with three replications. The 12 treatment combinations comprised of four dates of sowing at weekly interval starting from 1st June in main plot and three varieties namely Luxmi, SVM-1 and Kentucky Wonder in sub-plots. The early sowing on 1st June significantly resulted in higher seed yield with 23, 77 and 85% more increase over 8th June, 15th June and 22nd June, respectively in pooled years. Among the varieties, 'SVM-1' significantly out performed 'Luxmi' and 'Kentucky Wonder' for seed yield with a respective increase of 63 and 44% in pooled years and also performed better for pods/plant and straw yield. Interaction effects of sowing dates and varieties on the performance revealed that the seed yield of all the varieties, in general, decreased with each delay in sowing with more drastic reduction after 15th June. The cultivar 'SVM-1' performed significantly better on all four dates of sowings over 'Luxmi' and 'Kentucky Wonder' for number of pods/plant, seed yield and straw yield over the years. Hence, it can be concluded that early sowing on 1st June and the cultivar 'SVM-1' was the most ideal combination to obtain higher seed yield of pole frenchbean under sub-humid temperate environment.**

Key words: *Phaseolus vulgaris* L., variety, pod, sowing dates, seed yield, straw yield, plant characteristics.

INTRODUCTION

Frenchbean (*Phaseolus vulgaris* L.) is one of the important legume crops worldwide for direct human consumption. The crop is principally consumed for its green pods and shell beans and constitutes an important source of protein. On the basis of growth habit, frenchbean varieties are grouped into bush and pole type. The bush type varieties find favour amongst the growers on account of their short duration and as such no training material is required for their proper growth. However, these can not be cultivated during rainy season as pods are rotten while coming in contact with soil. Therefore, pole type varieties find favour as off-season crop in mid hills of Himachal Pradesh. The pods are available in the rainy months and find ready market in the

*Corresponding author. E-mail: assharmaakhil1@gmail.com.

plains bringing lucrative returns to the growers. Simultaneously, it is also important to harvest quality seed of pole type varieties as the seed maturity coincides with rains resulting in poor quality seed.

Among the various agronomic practices, optimum sowing date and a suitable variety are of primary importance for harnessing potential yield (Amanullah et al., 2002). The sowing times has marked effects on growth and yield of most crops in different parts of the world as delay in sowing beyond the optimum time usually results in yield reduction (Vange and Obi, 2006). Sowing time of any crop depends on environmental conditions that are required for its good growth and development without involving additional costs and varies according to cultivars. It is a critical factor in determining the environmental conditions at planting, anthesis, pod filling and drying especially during rainy season and hence, important in determining the success of the crop in maximizing seed yield (Dapaah et al., 2000).

In principle, delay in sowing beyond optimum date results in a progressive reduction in the potential yield of the crop (Green et al., 1985). A number of varieties are known in pole beans which differ in their optimum sowing dates and period of maturity. Hence, the positive effect of environmental factors on growth and yield could be harnessed if the information on optimum time of sowing is made available (Moniruzzaman et al., 2007) along with a suitable variety.

Further, no systematic research has been done particularly in pole beans to evaluate the effect of sowing dates on quality seed formation and seed yield of different varieties under sub-humid temperate environment in the north-western Himalayas. Beans have traditionally been grown in the humid sub temperate regions of the north western Himalayas and have great potential for its commercial cultivation. To facilitate this process, suitable cultivars and sowing times need to be determined (Bozoglu et al., 2007). Keeping in view the importance of genotypes and sowing time as key factors in determining the yield and seed quality, the experiments reported in this investigation examined the influence of time of sowing and varieties on pole beans seed yield and its attributes along with quality seed parameters.

MATERIALS AND METHODS

A field experiment was undertaken at Experimental Farm of the Department of Vegetable Science and Floriculture, CSK HP Agricultural University, Palampur (32° 6′N and 76° 3′E at an elevation of 1290.8 m amsl). The 12 treatment combinations were laid out in split plot design for two consecutive years during 2007 and 2008 in summer season wherein growing period of pole bean extended from June-September. The main plot treatments consisted of four dates of seed sowing at weekly interval starting from 1st June while sub-plot treatments consisted of 3 recommended varieties for cultivation namely Luxmi, SVM-1 and Kentucky Wonder. The sowing of seeds of these varieties was done on raised beds of 3.6 m × 3.0 m size with spacing of 0.9 m between rows and 0.15 m between plants with in rows to provide proper drainage during rainy season.

Soil was once ploughed with tractor using a 3-disc plough and harrowed twice using a 7-disc harrow followed by once with power tiller. The seeds were sown at depth of 4 to 5 cm. The crop was well managed for optimum growth and yield. The fertilizers were applied at the time of sowing at the rate of 50 kg N, 90 kg P_2O_5 and 60 kg K_2O/ha. Weeds were controlled with pendimethalin at 1.5 kg a.i. /ha as pre emergence application followed by two manual weeding at 40 days and 60 days after sowing. The sprinkler irrigation was applied in the initial stages at weekly interval before the onset of monsoon. The data were recorded on ten randomly taken plants for days to flowering, pod length (cm), seeds/plant, branches/plant, internodal distance (cm), plant height (cm), pods/plant and days to seed maturity. The biological yield, straw yield and seed yield were recorded on plot basis and were converted to tonnes/ha. Seed quality was determined using internationally accepted methods for all treatments (ISTA, 1985). Hundred seed weight was recorded by weighing three replicates of 100 seeds at 12% seed moisture content. Germination was assessed using the between paper method with three replicates of 50 seeds/treatment. The seed vigour was calculated by multiplying germination percentage with seedling length (cm). The mean values over the replications in the respective years and pooled over years were statistically analysed using statistical software WINDOSTAT 8.0 developed by Indostat Services for split plot design. The results were discussed as per the interpretation of Gomez and Gomez (1983).

RESULTS AND DISCUSSION

Date of sowing significantly influenced number of days to flowering, seed maturity and plant height of frenchbean during both the years and pooled over environments (Table 1). Early sowing on June 1 significantly took more days to flowering and seed maturity compared to other dates of sowing. Also, it resulted in increased plant height significantly in comparison to sowing on June 15 and June 22 during 2008 and pooled data over years. Among the varieties, ‘Kentucky Wonder’ was observed to be early in flowering and seed maturity while ‘Luxmi’ was late maturing during both the years and pooled over years (Table 1). On the other hand, significantly shorter internodes were recorded in the variety ‘Luxmi’ and ‘SVM-1’ compared to ‘Kentucky Wonder’ during 2008 and pooled years. No significant differences were observed in these varieties for plant height during 2007 and pooled years though, ‘Luxmi’ recorded significantly maximum plant height during 2008 over the other two varieties.

It was further observed that yield contributing characters and yields were significantly influenced by different dates of sowing. Sabale et al. (2010) also found similar differences in the performance of bush beans under different dates of sowing. Each delay in sowing (one week interval) resulted in gradual decrease in pod length, seeds/pod and pods/plant which, in turn adversely affected both seed and straw yields compared to early sowing on June 1 (Table 2). The early sowing on 1st June produced significantly higher number of seeds/pod and pods/plant, resulting in significantly highest seed and straw yield in the respective years and also when pooled over the years. Pooling of data revealed that the early sowing on 1st June increased the seed yield by 23, 77

Table 1. Effect of sowing dates and varieties on growth stages and plant height of pole bean

Treatment	Days to flowering			Days to seed maturity			Branches/plant			Plant height (m)		
	2007	2008	Pool	2007	2008	Pool	2007	2008	Pool	2007	2008	Pool
Date of sowing												
June 1	55	53	54	104	105	104	2.53	2.64	2.59	2.49	2.60	2.55
June 8	50	49	49	100	100	100	2.40	2.48	2.44	2.37	2.41	2.39
June 15	48	47	47	98	99	98	2.58	2.68	2.63	2.34	2.27	2.30
June 22	46	48	48	94	94	94	2.33	2.31	2.32	2.13	2.08	2.11
CD (P≤0.05)	2.18	2.10	1.29	1.88	1.42	1.21	NS	NS	NS	NS	0.23	0.19
Varieties												
Luxmi	56	58	57	107	107	107	2.58	2.61	2.59	2.32	2.47	2.39
SVM-1	50	49	50	96	97	97	2.66	2.68	2.67	2.29	2.23	2.26
Kentucky Wonder	42	41	42	94	94	94	2.15	2.92	2.22	2.39	2.32	2.36
CD (P≤0.05)	1.72	1.13	1.32	2.08	1.68	1.07	0.17	0.23	0.16	NS	0.15	NS

CD, Critical difference; NS, non-significant.

Table 2. Effect of sowing dates and varieties on yield contributing characters and seed yield of pole bean.

Treatment	Pod length (cm)			Seeds/pod			Pods/plant			Seed yield (t/ha)			Straw yield (t/ha)		
	2007	2008	Pool	2007	2008	Pool	2007	2008	Pool	2007	2008	Pool	2007	2008	Pool
Date of sowing															
June 1	14.01	13.60	13.80	7.51	7.87	7.69	20.53	14.46	17.49	1.18	1.45	1.32	2.05	2.40	2.22
June 8	13.89	13.43	13.66	7.16	7.54	7.35	16.34	12.0	14.17	0.93	1.20	1.07	1.84	1.94	1.89
June 15	14.10	12.93	13.52	6.88	7.16	7.02	13.67	7.09	10.38	0.78	0.71	0.74	1.41	1.10	1.26
June 22	12.74	11.91	12.33	6.38	6.55	6.46	14.94	5.57	10.25	0.87	0.56	0.71	1.24	0.90	1.07
CD (P≤0.05)	0.60	1.12	0.61	0.41	0.35	0.24	0.97	0.82	0.71	0.12	0.08	0.08	0.10	0.09	0.07
Varieties															
Luxmi	13.08	12.42	12.75	6.75	7.27	7.01	11.92	8.51	10.21	0.68	0.85	0.76	1.19	1.38	1.29
SVM-1	13.57	12.47	13.02	6.55	7.24	6.89	22.10	12.24	17.17	1.27	1.22	1.25	2.21	2.04	2.13
Kentucky Wonder	14.41	14.02	14.21	7.65	7.33	7.49	15.08	8.59	11.83	0.88	0.86	0.87	1.50	1.33	1.42
CD (P≤0.05)	0.73	0.77	0.58	0.41	NS	0.27	0.78	0.41	0.38	0.10	0.04	0.05	0.08	0.07	0.03

CD, Critical difference; NS, non-significant.

and 85% compared with 8th June, 15th June and 22nd June, respectively. Getachew and Woldeyesus (2012) in chick pea, and Labuda and Brodaczewska (2011) in processing type frenchbean also observed the highest yield from early sown crop. This indicated that sowing date was an important parameter in determining the success of the crop and in maximizing seed yield (Dapaah et al., 2000). On the contrary, Singh and Singh (2000), Rahman et al. (2001) reported that yield was increased with a more lately sowing dates.

Table 3. Effect of sowing dates and varieties on seed quality traits of pole bean.

Treatment	100 seed weight (g)			Germination (%)			Seed vigour index		
	2007	2008	Pool	2007	2008	Pool	2007	2008	Pool
Date of sowing									
June 1	20.43	22.51	21.47	84.22	88.67	86.44	1968.25	3162.18	2565.21
June 8	20.71	21.32	21.01	83.89	87.78	85.83	1931.24	3191.78	2561.51
June 15	20.11	20.78	20.45	83.67	90.44	87.06	1918.13	3106.13	2512.13
June 22	19.67	20.35	20.01	80.56	86.87	83.72	1750.26	3171.85	2461.05
CD (P≤0.05)	NS	NS	0.69	NS	NS	NS	NS	NS	NS
Varieties									
Luxmi	16.96	18.91	17.93	82.75	90.83	86.79	1912.58	3122.79	2517.68
SVM-1	24.39	23.43	23.91	84	89.83	86.92	1910.18	3277.23	2593.7
Kentucky Wonder	19.34	21.39	20.36	82.50	84.67	83.58	1853.16	3073.94	2463.55
CD (P≤0.05)	0.76	1.33	0.80	NS	2.80	1.88	NS	NS	NS

CD, Critical difference; NS, non-significant.

Significantly higher yield and attributing characters of early sown crop were owing to relatively more favourable climatic conditions during the initial crop growth stage as compared to the later sowings where the growth was adversely influenced by high intensity monsoon rains. The proper vegetative growth in the early sown crop might have resulted in more accumulation of carbohydrates and thus increased the biological and seed yield. Gradual increase in the intensity of monsoon rains from early to late sowings proportionally reduced the vegetative growth and also affected flowering and pod setting in late sown crop.

The significant difference in the performance of pole bean varieties *viz.*, 'Luxmi', 'SVM-1' and 'Kentucky Wonder' were observed for seed yield and its related traits during both the years in 2007 and 2008 and also in pooled over years (Table 2). The basic objective of majority of research programmes is to achieve high yield. It is of immense importance to identify a variety which has the potential to surpass a commercially adopted/adapted cultivar(s). Number of pods per plant and branches/plant has a direct bearing on the total productivity of frenchbean crop. In the present study, the variety 'SVM-1' significantly out performed the other verities for pods/plant and seed yield. The increase in seed yield over 'Luxmi' and 'Kentucky Wonder' was to the tune of 88 and 45, 44 and 42, and 63 and 44% during 2007, 2008 and pooled over years (Table 2). The better performance of 'SVM-1' seemed to be the result of more number of branches and pods/plant which also significantly increased its straw yield to the tune of around 65% over Luxmi and 45% over Kentucky Wonder in pooled data over years. Further, it was found that variety 'Kentucky Wonder' had significantly maximum pod length and seeds/pod in comparison to 'Luxmi' and 'SVM-1'.

The differences among varieties were attributed to their genetic make up which revealed that 'SVM-1' found to have the tendency to perform better under high rainfall conditions in comparison to other two varieties. The poor performance of 'Kentucky Wonder' and 'Luxmi' for seed yield might also be the result of their maturity period as early flowering in the former variety coincided with more number of rainy days while the late flowering and maturity habit of 'Luxmi' coincided with low night temperatures in the later months of September.

For seed quality traits, different sowing dates had no significant differences for seed quality traits *viz.,* 100-seed weight, germination percentage and seed vigour index during both the years of 2007 and 2008 (Table 3). However, early sowing on 1st June had maximum 100-seed weight which was significant over sowing on 15th and 22nd June. On the other hand, the varieties differed significantly for 100-seed weight and germination percentage wherein 'SVM-1' had significantly more 100-seed weight while performed at par with 'Luxmi' for germination percentage.

Interaction effects of sowing dates and varieties

The effect of sowing dates on the performance of different varieties were found to be significant for yield and related traits *viz.,* days to seed maturity, branches/plant, seeds/pod and pods/plant. 'SVM-1' performed significantly better on all four dates of sowing over 'Luxmi' and 'Kentucky Wonder' for number of pods/plant, straw yield and seed yield during 2007, 2008 and pooled years (Table 4). The seed yield of all the varieties was decreased with each delay in sowing during both the years except sowing of 'Kentucky Wonder' on 22nd June during 2007. However, the performance for

Table 4. Interaction effect of sowing dates and varieties on yield and yield attributes of pole bean.

Date of sowing/ variety	Days to seed maturity			Branches/plant			Seeds/pod			Pods/plant			Seed yield (t/ha)			Straw yield (t/ha)		
	Luxmi	SVM-1	KW	Luxmi	SVM-1	KW	Luxmi	SVM-1	KW	Luxmi	SVM-1	KW	Luxmi	SVM-1	KW	Luxmi	SVM-1	KW
First year (2007)																		
June 1	111.67	102.67	97.00	2.93	2.73	1.93	5.87	7.0	8.20	26.12	50.95	35.44	0.96	1.54	1.05	1.63	2.66	1.87
June 8	107.67	96.00	96.00	2.67	2.43	2.10	5.1	6.07	6.87	17.45	44.64	25.65	0.70	1.46	0.96	1.26	2.62	1.64
June 15	104.67	94.67	95.67	2.57	2.73	2.43	4.37	5.23	5.77	21.66	31.28	22.58	0.55	1.14	0.79	0.99	1.95	1.29
June 22	102.67	92.00	87.67	2.13	2.73	2.13	3.93	4.27	4.46	13.94	38.43	30.94	0.50	0.94	0.70	0.89	1.61	1.23
CD (P≤0.05)																		
At same level			4.16			0.34			0.63			4.36			0.20			0.16
At same or different level			5.52			0.61			0.83			6.23			0.28			0.22
Second year (2008)																		
June 1	112.00	104.67	98.00	3.07	2.73	2.13	6.21	7.84	8.07	35.23	60.41	38.22	1.38	1.80	1.16	2.41	3.01	1.76
June 8	108.67	94.33	97.67	2.63	2.53	2.27	5.32	6.97	7.71	31.34	42.71	37.73	1.05	1.41	1.14	1.59	2.52	1.70
June 15	105.00	97.00	94.00	2.67	2.83	2.53	4.71	5.47	5.63	16.22	32.86	19.95	0.54	1.01	0.58	0.84	1.54	0.93
June 22	102.67	92.67	88.00	2.07	2.63	2.23	3.76	4.37	4.51	13.85	23.02	18.61	0.44	0.69	0.55	0.69	1.09	0.92
CD (P≤0.05)																		
At same level			3.35			0.45			0.41			4.04			0.08			0.14
At same or different level			4.41			0.82			0.70			5.86			0.14			0.20
Pooled over years																		
June 1	111.83	103.67	97.50	3.00	2.73	2.03	6.04	7.42	8.13	30.68	55.68	36.83	1.17	1.67	1.11	2.02	2.84	1.82
June 8	108.17	95.17	96.83	2.65	2.48	2.18	5.21	6.52	7.29	24.40	43.67	31.69	0.87	1.44	1.05	1.43	2.57	1.67
June 15	104.84	95.83	94.83	2.62	2.78	2.48	4.54	5.35	5.70	18.94	32.07	21.27	0.55	1.08	0.69	0.92	1.75	1.11
June22	102.67	92.33	87.83	2.10	2.68	2.18	3.85	4.32	4.49	13.89	30.73	24.78	0.47	0.81	0.63	0.79	1.35	1.08
CD (P≤0.05)																		
At same level			2.14			0.32			0.35			3.48			0.10			0.07
At same or different level			2.94			0.57			0.53			4.98			0.15			0.12

CD, Critical difference.

seed yield of 'SVM-1' was at par on sowing date of 1st June and 8th June during 2007 and that of 'Kentucky Wonder' on 1st June and 22nd June during 2007 and also on 1st June and 8th June during 2008. More drastic decrease in seed yield of 'SVM-1' and 'Luxmi' was noticed when sowing was carried out after 15th June. The poor yields of these varieties with late sowing might be the result of cloudy weather and heavy rainfall at reproductive stage which caused mainly abscission of flowers and young pods. This may also be ascribed to short growing season and ultimately lesser accumulation of photosynthates (Mauromicale et al., 1991).

The better performance of SVM-1 with early sowing on 1st June compared to crop sown afterwards was owing to more number of branches/plants, pods/plant and longer crop duration which resulted in significantly higher straw and seed yield. The reduction in seed yield with every weekly delay of sowing over 1st June

was 16, 71 and 83% in SVM-1, 46, 90, and 150% in Luxmi, and 15, 73 and 47% in Kentucky Wonder, respectively. All the genotypes bore maximum pods with 1st June sowing and these were reduced drastically when sowings were delayed (Table 4). Jana (2005), Kamble et al. (2007), Yoldas and Esiyok (2007) and Ngueguim et al. (2011) also observed reduction in yields in bush type frenchbeans with delayed sowings. The other characters seemed to have little influence on seed yield. The variation in seed yield and related traits of pole bean varieties due to heterogeneity in genetical constitution has also been reported by Saglam et al. (2000). The quality of seed of these varieties was not influenced by sowing dates as depicted from 100- seed weight and seed vigour index.

From this study, it can be concluded that appropriate sowing date and improved varieties can substantially increase the productivity. The maximum seed yield of pole type frenchbean can be harnessed from the cultivar 'SVM-1' by carrying out early sowing on 1st June under sub-humid temperate conditions.

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