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EFFECT OF BED-TOP WIDTH, FERTIGATION AND CROP GEOMETRY ON GREEN POD YIELD AND ECONOMICS OF POLE TYPE FRENCH BEAN GROWN IN POLY-NETHOUSE

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ABSTRACT

A field experiment was conducted under protected poly-net house conditions at the Vegetable Research Farm, Punjab Agricultural University, Ludhiana during September 2021 and January 2022 to study the effect of bed-top width, fertigation levels and crop geometry on growth, yield and economics of pole type French bean (*Phaseolus vulgaris* L.). The experiment was laid out in a split plot design with three bed-top widths (105, 75 and 37.5 cm, each with 30 cm furrow), five fertigation levels (0, 60, 80, 100 and 120% recommended NPK) and two intra-row spacings (30 and 45 cm), replicated thrice. Results revealed that fertigation levels significantly influenced phenological traits, growth and yield attributes. Higher fertigation levels (100-120% NPK) increased dry haulm weight, pod length, pod weight, pod width, number of pods plant^{-1} and green pod yield, whereas 0% NPK induced early flowering and harvesting. Wider intra-row spacing (45 cm) improved yield attributes and green pod yield per plant, whereas closer spacing (30 cm) resulted in higher green pod yield per acre due to increased plant population. Among bed-top widths, 105 cm produced the highest yield per plant, whereas 75 cm bed-top recorded the maximum green pod yield per acre. Economic analysis showed that the combination of 75 cm bed-top width, 120% NPK fertigation and 30 cm intra-row spacing resulted in the highest net returns, whereas the highest benefit-cost ratio was obtained with 75 cm bed-top width, 100% NPK and 30 cm intra-row spacing. Thus, a bed-top width of 75 cm with 30 cm intra-row spacing and 100-120% recommended NPK through drip fertigation is recommended for profitable French bean cultivation under protected conditions.

Keywords: Crop geometry, Drip fertigation, French bean, NPK, Protected conditions

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French bean (*Phaseolus vulgaris* L., 2n= 2x= 22) belonging to family Fabaceae, is an important legume crop cultivated globally for dry seeds and the green tender pods. It is popular by different names such as kidney bean, navy bean, haricot bean, green bean and rajmash etc. It has high nutritional value as hundred grams of green pods contain 1.7 g protein, 4.5 g carbohydrates, 11 mg vitamin-C, 16.3 mg Vitamin-A and 50 mg calcium (Gopalkrishnan, 2007). In 2021, India's total green bean production was 0.66 million tonnes from an area of 0.23 million ha (FAOSTAT, 2021). For proper growth and pod setting, French bean require moderate climatic conditions with optimum temperature range of 16-22°C (Kalita *et al.*, 2016).

The arrangement by which plants are spatially distributed inside a particular land area is a key consideration, because an optimum density of plants is a prerequisite to effective crop production systems. It is conceivable that choosing narrow rows for intra-row spacing may improve resource efficiency and postpone the commencement of interplant competition. Poor nodulation in the roots of French bean makes it unable to fix the atmospheric nitrogen, thus, it can easily absorb the applied nitrogen fertilizers (Singh and Biswas, 2020). Nitrogen is a component of chlorophyll and is required for both the synthesis of chlorophyll and for growth (Ghosal *et al.*, 2000). On the other hand, phosphorus is essential for photosynthesis, energy transmission and storage, respiration, early root formation, cell division and growth (Karim *et al.*, 2020). Similarly, potassium influences the seed formation and helps in increasing the fruit quality (Beg and Sohrab, 2012). Potassium is required for protein synthesis, fruit development, ionic balance regulation and disease resistance. As a result, the optimum nutrient dosage is critical in the plant's life cycle. There has not been much research conducted on the French bean crop with regard to crop geometry and nutrient requirement in Punjab state under protected conditions. Therefore, keeping all the above points in view, the present study has been formulated to study the effect of bed-top width, fertigation and crop geometry on green pod yield and economics of pole type French bean grown in poly-net house.

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MATERIALS AND METHODS

The study was conducted at Vegetable Research Farm, Department of Vegetable Science, Punjab Agricultural University, Ludhiana under protected conditions in the month of September, 2021 and January, 2022. Ludhiana is situated at 30°54′N latitude, 75°48′E longitudes at 247 m above mean sea level and falls under central plain zone III of Punjab. The soil in the experimental site is sandy loam having EC (0.21, 0.22 ds m^{-1}), pH (7.25, 7.38), organic carbon (0.48, 0.35 %), available nitrogen (270, 276 kg ha^{-1}), available phosphorus (19.50, 18.16 kg ha^{-1}) and available potassium (220, 226 kg ha^{-1}). The field experiment was laid out in a split plot design with 30 treatment combinations including bed-top width of 105, 75 and 37.5 cm with a furrow of 30 cm (B_1 = 105+30 cm, B_2 = 75+30 cm, B_3 =37.5+30 cm), fertigation level of NPK (F_1 = 0, F_2 = 60, F_3 = 80, F_4 = 100 and F_5 = 120%) and two intra-row spacings (S_1 = 30 and S_2 = 45 cm). The treament was replicated thrice. FBP VAR 2 variety of French bean was used for the study. Three bed types were kept in main plots, five fertigation levels were kept in sub plots and two intra-row spacings were kept in sub sub plots. Two rows on the edges of both 105 and 75 cm bed-top and one row on the edge of 37.5 cm bed-top were sown . Fertilizers were applied through drip irrigation in the ratio of 75:100:75 (N:P:K kg/ha) to the crop in 10 splits with a gap of 7 days, respectively, as per the recommendations of ICAR-Indian Institute of Horticultural Research, Bangalore. First fertigation was applied after 15 DAS. Data on the various parameters were recorded and analyzed as per Gomez and Gomez (1984) and adapted by Cheema and Singh (1991) in statistical package CPCS-1. Different comparisons were done at the 5% level of significance.

RESULTS AND DISCUSSION

Days to 50% flowering

Days to 50% flowering is an important agronomical feature. Fertigation levels had significant influence on days to 50% flowering in French bean (Fig. 1). But, it was not effected significantly by bed-top widths and intra-row spacings. Fertigation treatment with 0% NPK recorded minimum number of days for 50% flowering (41.1) which was statistically at par with 60% NPK and maximum days were recorded with 120% NPK (43.9) which was statistically at par with 100% NPK (pooled

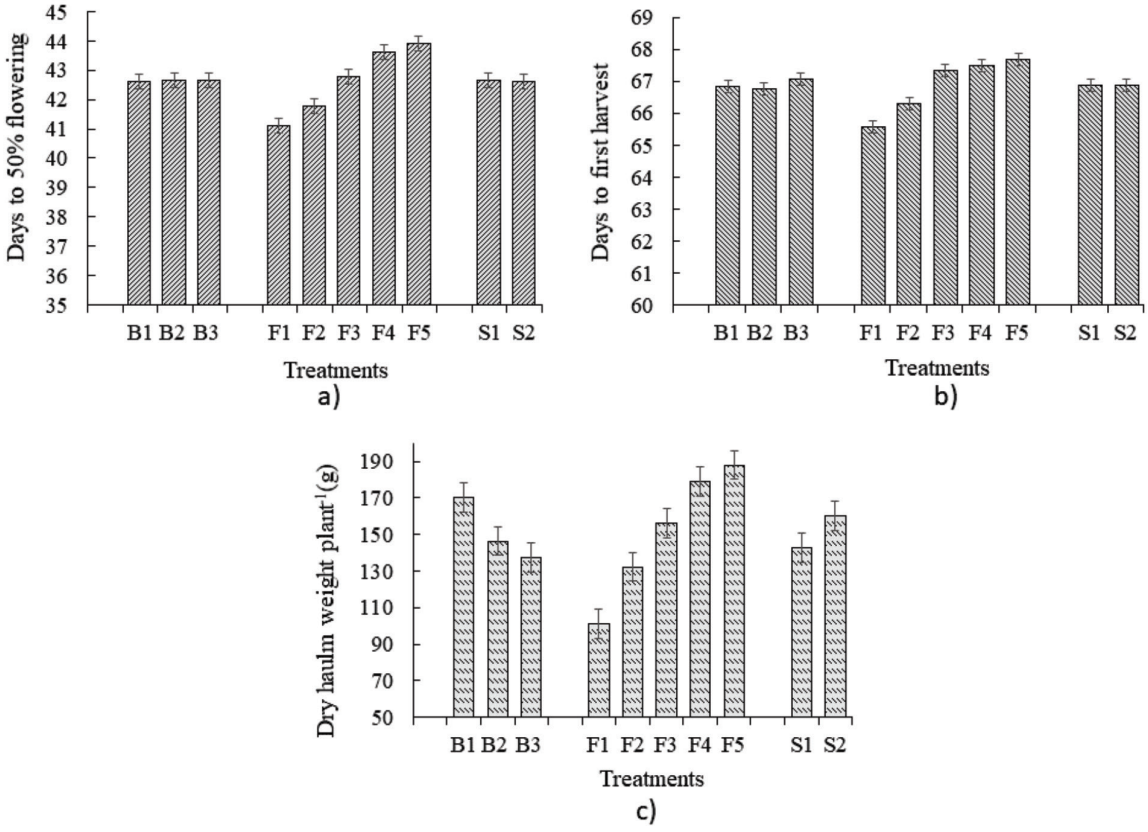


Fig. 1. Effect of bed-top width, fertigation levels and crop geometry on (a) days to 50% flowering, (b) days to first harvest and (c) dry haulm weight plant^{-1} {B_1= 105+30 cm; B_2= 75+30 cm; B_3= 37.5+30 cm; F_1= 0% NPK, F_2= 60% NPK, F_3= 80% NPK, F_4= 100% NPK, F_5= 120% NPK; S_1= 30 cm; S_2= 45 cm}

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analysis). Early flowering may represent a stress induced response in plants. Under stressful conditions, such as low nutrient availability, plants tend to initiate flowering earlier in order to ensure seed production for the next generation. Similar findings were also reported by Kumar (2019).

Days to first harvest

Fertigation levels had significant effect on days to first harvest in French bean (Fig 1). But, different bed-top widths and intra-row spacings had non-significant effects. Fertigation treatment with 0% NPK took minimum number of days to first harvest (65.6) which was statistically at par with 60% NPK and maximum days were recorded with 120% NPK (67.7) which was statistically at par with 100% NPK (pooled analysis). As the plants flower early under stressed condition, eventually this leads to early harvesting under low nutrient availability as compared to high fertilizer dose. Sheshrao (2018) also reported minimum number of days to first harvest under low NPK dose.

Dry haulm weight plant^{-1} (g)

Bed-top widths, fertigation levels and intra-row spacings had significant influence on dry haulm weight plant^{-1} (Fig 1). The bed-top width of 105 cm recorded maximum dry haulm weight plant^{-1} (170g) followed by 75 cm and 37.5 cm bed-top (pooled analysis). The fertigation level of 120% NPK had the highest dry haulm weight plant^{-1} (188 g) which was statistically at par with 100% NPK (179 g) and significantly different from other treatments. The intra-row spacing of 45 cm gave the more number of pods plant^{-1} (160 g) than 30 cm intra-row spacing. Plants with wider spacing had better access to growth resources and less competition within the plant community, which may have resulted in higher dry haulm weight plant^{-1}. Less plant density and more horizontal space among the plant facilitates the lateral spread of the plant. As plant density reduces, more sunlight will be intercepted for photosynthesis, which leads to an accumulation of photosynthates for partitioning toward the growth of new branches which finally leads to an increase in dry haulm weight plant^{-1} (Manjesh *et al.*, 2019 and Melak, 2018). Similar findings were observed in Indian bean by Joshi and Rahevar (2015) and in rice bean by Sabar (2021). Optimal nutrient availability to plants under higher fertigation doses would have resulted in higher absorption and effective utilization of nutrients into different parts of the plant resulting in an increased dry haulm weight plant^{-1}. These findings are in agreement with those reported by Jaisankar and Manivannan (2018) and Desai *et al.* (2020) in field bean.

Table 1. Effect of bed-top width, fertigation levels and crop geometry on pod length, pod weight and pod width

	Pod length (cm)			Pod weight (g)			Pod width (mm)		
	Sep 2021	Jan 2022	Pooled	Sep 2021	Jan 2022	Pooled	Sep 2021	Jan 2022	Pooled
Bed-top width									
B_1 (105+30 cm)	14.6	15.2	14.9	7.86	8.37	8.10	8.13	8.73	8.43
B_2 (75+30 cm)	14.3	15.0	14.6	7.60	8.32	7.96	8.15	8.79	8.47
B_3 (37.5+30 cm)	14.5	15.0	14.8	7.71	8.49	8.10	8.08	8.73	8.40
CD (p≤0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	13.5	11.0	12.3	14.5	17.4	15.6	8.8	9.6	9.2
Fertigation levels									
F_1: 0% NPK	12.3	12.6	12.5	6.32	7.06	6.69	7.33	8.00	7.67
F_2: 60% NPK	13.7	14.5	14.1	6.99	7.74	7.36	7.54	8.21	7.87
F_3: 80% NPK	14.0	15.0	14.3	7.77	8.48	8.13	7.79	8.50	8.15
F_4: 100% NPK	16.0	16.7	16.4	8.73	9.23	8.98	8.84	9.42	9.13
F_5: 120% NPK	16.1	16.9	16.5	8.77	9.45	9.11	9.02	9.56	9.29
CD (p≤0.05)	0.52	0.66	0.41	0.78	0.80	0.77	0.21	0.19	0.20
CV (%)	15.2	16.4	15.9	14.8	13.9	13.9	9.7	10.1	9.9
Intra-row spacing									
S_1: 30 cm	14.0	14.5	14.3	7.16	7.91	7.53	8.15	8.77	8.46
S_2: 45 cm	14.8	15.6	15.2	8.28	8.88	8.58	8.09	8.73	8.41
CD (p≤0.05)	0.38	0.54	0.32	0.41	0.54	0.46	NS	NS	NS
CV (%)	16.1	10.3	13.4	12.5	14.9	13.3	7.1	9.5	8.3

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Table 2.1. Number of pods plant^{-1} as affected by interaction between fertigation levels and crop geometry in French bean

Treatment	Sept 2021		Jan 2022		Pooled	
	S_1 (30 cm)	S_2 (45 cm)	S_1 (30 cm)	S_2 (45 cm)	S_1 (30 cm)	S_2 (45 cm)
F_1: 0% NPK	53.6	58.7	68.4	73.3	61.0	66.0
F_2: 60% NPK	94.3	101.0	116.0	123.0	105.0	112.0
F_3: 80% NPK	117.0	129.0	139.0	150.0	128.0	140.0
F_4: 100% NPK	145.0	168.0	168.0	190.0	157.0	179.0
F_5: 120% NPK	153.0	173.0	175.0	195.0	164.0	184.0
CD (*p≤0.05*)	8.95		9.30		8.90	

Pod length (cm), weight (g) and width (mm)

Significant effect of fertigation and intra-row spacing was recorded on pod length (Table 1). The highest pod length (16.5cm) was recorded with120% NPK treatment which was statistically at par with 100% NPK (pooled analysis). Significantly higher pod length was recorded in intra-row spacing of 45 cm (15.24) than 30 cm (14.3 cm). The current results are in agreement with those of Janapriya *et al.* (2010) who reported that increasing fertigation levels resulted in significantly greater pod yield and quality. Significant effect of fertigation and intra-row spacing was recorded on pod weight (Table1). The highest pod weight (9.11g) was recorded with 120% NPK treatment which was at par with 100% NPK (8.98 g). The intra-row spacing of 45 cm recorded the highest podweight (8.58 g) than 30 cm intra-row spacing. The above findings are in agreement with Dalai *et al.* (2021) in field bean and Chaudary (2020) in French bean. Significant effect of fertigation levels was recorded on pod width (Table 1). However, different bed and intra-row spacings did not show any significant effect on pod width. The highest pod weight (9.29 g) was recorded with 120% NPK treatment which was at par with 100% NPK. The similar results were reported by Kumar (2019) where maximum pod length (13.38 cm) and width (8.51 mm) were recorded under 100% RDF. Neethu *et al.* (2020) also reported the highest pod length (20.66 cm) and pod girth (2.95 cm) with wider spacing of 60 × 75 cm including the highest dose of N:P:K (44:70:53 kg ha^{-1}).

The maximum pod length, weight and width, could be linked to improved nutrient supply through higher fertigation level in the plant's root vicinity and optimum nutrient concentration in the root zone during the crop growth period. The rhizosphere's ideal nutrient content may have boosted moisture and nutrient uptake improving the French bean's quality features. Additionally, the enhanced rate of photosynthetic activity and the absorption of photosynthetically active radiation (APAR) caused a greater transfer of photosynthates towards the reproductive organ (sink), which may have ultimately improved the quality features of the French bean. The increase in pod length and weight with wider spacing could be attributed to increased vegetative growth of the plant in terms of the number of branches and leaf area which would have improved the source potential. This could have resulted in appropriate photosynthate partitioning to growing pods. The aforesaid findings are in line with those of Malagi (2005) in cowpea and Sabar (2021) in rice bean.

Number of pods plant^{-1}

Bed-top widths, fertigation levels and intra-row spacings significantly influenced number of pods plant^{-1} (Table 2). The bed-top width of 105 cm recorded maximum number of pods plant^{-1} (138) followed by 75 cm and 37.5 cm bed-top (pooled analysis). The fertigation level of 120% NPK had the highest number of pods plant^{-1} (174) which was statistically at par with 100% NPK and significantly different from other

Table 2.2. Green pod yield plant^{-1} (g) as affected by interaction between fertigation levels and crop geometry in French bean

Treatment	Sept 2021		Jan 2022		Pooled	
	S_1 (30 cm)	S_2 (45 cm)	S_1 (30 cm)	S_2 (45 cm)	S_1 (30 cm)	S_2 (45 cm)
F_1: 0% NPK	477	498	695	731	586	615
F_2: 60% NPK	712	736	918	969	815	852
F_3: 80% NPK	822	887	1,046	1,137	934	1,012
F_4: 100% NPK	929	1,010	1,173	1,284	1,051	1,147
F_5: 120% NPK	951	1,032	1,191	1,309	1,071	1,170
CD (*p≤0.05*)	28.0		29.9		25.1	

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Table 2.3. Green pod yield (q acre^{-1}) as affected by interaction between fertigation levels and crop geometry in French bean

Treatment	Sept 2021		Jan 2022		Pooled	
	S_1 (30 cm)	S_2 (45 cm)	S_1 (30 cm)	S_2 (45 cm)	S_1 (30 cm)	S_2 (45 cm)
F_1: 0% NPK	93.9	65.7	137.0	96.3	115.0	81.0
F_2: 60% NPK	140.0	97.2	181.0	127.0	161.0	112.0
F_3: 80% NPK	162.0	117.0	206.0	150.0	184.0	133.0
F_4: 100% NPK	183.0	133.0	231.0	169.0	207.0	151.0
F_5: 120% NPK	187.0	136.0	235.0	172.0	211.0	154.0
CD (*p≤0.05*)	5.17		4.93		4.35	

treatments. The intra-row spacing of 45 cm gave the more number of pods plant^{-1} (136) than 30 cm intra-row spacing. Similar results were reported by Joshi and Rahevar (2015) for field bean in which maximum number of pods plant^{-1} (27.1) were recorded under wider row spacing (60 cm). Hussein *et al.* (2018) also reported that maximum number of pods plant^{-1} (32.48) were recorded under higher nutrient dose of 0.92 g urea and 0.84 g SOP. The reason for enhanced number of pods plant^{-1} might be due to availability of favourable conditions i.e. moisture, light, nutrients and less inter-plant competition in wider spacing resulting in increased uptake of nutrients and build-up of sufficient photosynthates which enabled the increase in number and size of pods. Similar findings were also recorded by Manjesh *et al.* (2019). The nutrient supplied through fertigation throughout the growth period with split doses might have increased nutrient uptake, ultimately leading to greater photosynthetic rate and metabolic activities.

Interaction effect between fertigation levels and intra-row spacings also influenced number of pods plant^{-1} (Table 2.1) that resulted in maximum number of pods plant^{-1} (184) under treatment combination of 120% NPK and 45 cm intra-row spacing which was at par with 100% NPK and 45 cm intra-row spacing. This could be due to the presence of combination of higher dose of water soluble fertilizers and wide spacing, which gave a proper opportunity to plant for better utilization of all the available resources by increasing its source potential, which eventually increased number of pods plant^{-1}. The similar results were reported by Neethu *et al.* (2022) for French bean in which the highest number of pods plant^{-1} (220) were recorded in the treatment 60 × 75 cm spacing with 44:70:53 kg of N:P:K ha^{-1}. These findings concur with those for cowpea by Malagi (2005) and soybean by Vyas and Jamliya (2017).

Green pod yield plant^{-1} (g)

Bed-top widths, fertigation levels and intra-row spacings significantly influenced green pod yield plant^{-1} (Table 2). The bed-top width of 105 cm gave maximum green pod yield plant^{-1} (991 g) followed by 75 cm and 37.5 cm bed-top (pooled analysis). The fertigation level of 120% NPK had the highest green pod yield plant^{-1} (1121 g) which was statistically at par with 100% NPK and significantly differed from other treatments. The intra-row spacing of 45 cm gave the more green pod yield plant^{-1} (959 g) than 30 cm intra-row spacing. This could be due to congenial environment with wider spacing and optimum fertilizer dosage applied in the split dose throughout the crop duration required for the plant, which facilitates less competition for nutrients and moisture, high fertilizer use efficiency and optimum light interception in the plant canopy. This ultimately results in increase in pod length, weight, width and number of pods plant^{-1} and eventually increased the green pod yield plant^{-1}. These results are in conformity with Hussein *et al.* (2018). The similar results were also reported by Addow *et al.* (2020) in which the highest marketable pod yield (1.27 kg) was recorded from 150 kg N ha^{-1} with 120 kg K_2O ha^{-1}.

Table 2.4. Green pod yield (q acre^{-1}) as affected by interaction between bed-top width and crop geometry in French bean

Treatment	Sept 2021		Jan 2022		Pooled	
	S_1 (30 cm)	S_2 (45 cm)	S_1 (30 cm)	S_2 (45 cm)	S_1 (30 cm)	S_2 (45 cm)
B_1 (105+30 cm)	152	107	210	150	172	123
B_2 (75+30 cm)	180	129	255	183	207	149
B_3 (37.5+30 cm)	127	92.3	183	131	148	107
CD (*p≤0.05*)	4.01		3.82		3.37	

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Interaction effect between fertigation levels and intra-row spacings also influenced green pod yield plant^{-1} (Table 2.2) that resulted in maximum yield plant^{-1} (1,170 g) under treatment combination of 120% NPK and 45 cm intra-row spacing which was at par with 100% NPK and 45 cm intra-row spacing. This could be due to the presence of combination of higher dose of water soluble fertilizers and wide spacing, which gave plant a proper opportunity for better utilization of all the available resources resulting in increase in all the yield attributing charaters like pod length, weight, number of pods plant^{-1} etc. which contributed in the yield plant^{-1}. Similar results were also reported by Neethu *et al.* (2022) for French bean in which maximum pod yield plant^{-1} (4.65 kg) was recorded in the treatment 60 × 75 cm spacing with 44:70:53 (N:P:K) kg ha^{-1} whereas, the least (3.04 kg) was recorded in 60 × 45 cm spacing with 33:52.5:39.75 (N:P:K) kg ha^{-1}.

Green pod yield acre^{-1} (q)

Bed-top widths, fertigation levels and intra-row spacings significantly influenced green pod yield acre^{-1} (Table 2). The bed-top width of 75 cm gave maximum green pod yield acre^{-1} (178 q) followed by 105 cm and 37.5 cm bed-top (pooled analysis). Significantly highest

Table 3. Comparative economic analysis of French bean effected by bed-top width, fertigation levels and crop geometry during both seasons for one acre

Treatment	Yield (q acre^{-1})	Cost of cultivation (Rs)	Gross income (Rs)	Net income (Rs)	Cost benefit ratio
$B_1F_1S_1$	224	289,319	514,236	224,917	1:1.78
$B_1F_1S_2$	158	286,555	362,429	75,874	1:1.26
$B_1F_2S_1$	319	316,726	733,162	416,436	1:2.31
$B_1F_2S_2$	220	313,962	505,597	191,635	1:1.61
$B_1F_3S_1$	362	325,862	831,998	506,136	1:2.55
$B_1F_3S_2$	261	323,098	600,480	277,382	1:1.86
$B_1F_4S_1$	403	334,998	927,336	592,338	1:2.77
$B_1F_4S_2$	290	332,234	667,367	335,134	1:2.01
$B_1F_5S_1$	412	344,134	948,551	604,417	1:2.76
$B_1F_5S_2$	302	341,370	695,332	353,963	1:2.04
$B_2F_1S_1$	273	291,723	628,712	336,989	1:2.16
$B_2F_1S_2$	193	288,117	444,084	155,967	1:1.54
$B_2F_2S_1$	376	319,130	864,503	545,373	1:2.71
$B_2F_2S_2$	268	315,525	616,834	301,309	1:1.95
$B_2F_3S_1$	434	328,266	997,466	669,200	1:3.04
$B_2F_3S_2$	311	324,660	714,959	390,299	1:2.20
$B_2F_4S_1$	483	337,402	1,111,729	774,327	1:3.30
$B_2F_4S_2$	353	333,796	811,057	477,261	1:2.43
$B_2F_5S_1$	496	346,538	1,139,964	793,426	1:3.29
$B_2F_5S_2$	359	342,932	824,851	481,919	1:2.41
$B_3F_1S_1$	196	289,319	450,010	160,691	1:1.56
$B_3F_1S_2$	146	286,555	335,483	48,928	1:1.17
$B_3F_2S_1$	268	316,726	617,041	300,314	1:1.95
$B_3F_2S_2$	186	313,962	427,183	113,220	1:1.36
$B_3F_3S_1$	309	325,862	709,460	383,598	1:2.18
$B_3F_3S_2$	227	323,098	521,096	197,998	1:1.61
$B_3F_4S_1$	355	334,998	815,443	480,445	1:2.43
$B_3F_4S_2$	262	332,234	602,553	270,319	1:1.81
$B_3F_5S_1$	351	344,134	806,940	462,806	1:2.34
$B_3F_5S_2$	259	341,370	595,123	253,753	1:1.74

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green pod yield acre^{-1} (183 q) was recorded with fertigation level of 120% NPK which was statistically at par with 100% NPK. The intra-row spacing of 30 cm gave the more green pod yield acre^{-1} (176 q) than 45 cm intra-row spacing. As the plant population is high at 75 cm bed-top width with 30 cm intra-row spacing and the area is supplied with higher dose of water soluble fertilizers in split dose throughout the crop duration, the water and fertilizer use efficiency was high, which may be the reasons for high yield acre^{-1} under these treatments. Rahman *et al.* (2007) also reported the highest pod yield of French bean 15.05 t ha^{-1} from treatment with higher dose of nitrogen 150 kg ha^{-1} and phosphorus 60 kg ha^{-1}.

Significant interaction was observed between fertigation levels and intra-row spacings (Table 2.3) that resulted in maximum green pod yield acre^{-1} (211 q) under treatment combination of 120% NPK and 30 cm intra-row spacing which was at par with 100% NPK and 30 cm intra-row spacing. Significant interaction was also observed between bed-top width and intra-row spacings (Table 2.4) that resulted in maximum green pod yield acre^{-1} (207 q) under treatment combination of 75 cm bed-top and 30 cm intra-row spacing among other treatments. This could be due to presence of the optimum land configuration and crop geometry under which plants might have suitable space for the extension of roots, uptake of nutrients and the proper utilization of solar energy. The similar results were reported by Neethu *et al.* (2022) for French bean in which maximum pod yield (130.6 t ha^{-1}) was recorded in spacing of 60 × 45 cm with 44:70:53 (N:P:K) kg ha^{-1}. Hussein *et al.* (2018) also reported in pot experiment (pot of 33 × 30 cm in dimensions containing 8.5 kg soil) that maximum pods yield (26.4 t ha^{-1}) was recorded under higher fertilizers doses (0.92 g/pot urea and 0.84 g/pot SOP) and plant densities (214290 plants ha^{-1}). This may be due to planting at optimum intra-row spacing with higher dose of fertilizers which leads to fully exploit the potential productivity of the crop.

Net-returns

Economic evaluation of a technology before adoption is of utmost importance. Economic analysis of French bean effected by bed-top widths, fertigation levels and intra-row spacings during both seasons (Table 3) showed that net returns were found to be the highest in $B_2F_5S_1$ (Rs 793426 acre^{-1}) i.e. 75 cm bed-top width, 120% NPK and 30 cm intra-row spacing followed by $B_2F_4S_1$ (Rs 774327 acre^{-1}) i.e. 75 cm bed-top width, 100% NPK and 30 cm intra-row spacing. The treatment combinations $B_3F_1S_2$ resulted in the lowest returns (Rs 48928 acre^{-1}) i.e. 37.5 cm bed-top width, 0% NPK and 45 cm intra-row spacing. As the cost of cultivation is less than the gross income, net returns were found to be the highest under $B_2F_5S_1$.

Cost benefit ratio

The cost benefit ratio with treatment combination of $B_2F_4S_1$ (1:3.30) i.e. bed-top width of 75+30 cm, drip fertigation at 100% NPK and intra-row spacing at 30 cm was observed to be the highest followed by $B_2F_5S_1$ (1:3.29) i.e. bed-top width of 75+30 cm, drip fertigation at 120% NPK and intra-row spacing at 30 cm among all treatments (Table 3). The cost benefit ratio with treatment combination of $B_3F_1S_2$ (1:1.17) i.e. bed-top width of 37.5+30 cm, drip fertigation at 0% NPK and intra-row spacing at 45 cm was observed to be the lowest among all treatments. The higher C:B value might be due to higher total green pod yield and the gross return of French bean recorded in treatment combination with closer spacing and higher fertigation dose. This is in close conformity with the findings of Deka *et al.* (2015) and Manjesh *et al.* (2019). Dalai *et al.* (2021) reported that higher fertilizer dose of 25-75-50 kg N-P_2O_5-K_2O ha^{-1} recorded the highest benefit: cost ratio (5.27) but it was at par with 25-75-25 kg N-P_2O_5-K_2O ha^{-1}.

CONCLUSION

The present investigation demonstrated that bed-top width, fertigation level and intra-row spacing significantly influenced growth, yield attributes, green pod yield and economic returns of pole type French bean grown under protected poly-net house conditions. Higher fertigation levels (100-120% of recommended NPK) enhanced vegetative growth, yield-contributing characters and green pod yield which indicates the importance of adequate and timely nutrient supply through drip fertigation. Wider intra-row spacing (45 cm) favoured better plant growth and higher yield per plant due to reduced inter-plant competition, whereas closer spacing (30 cm) resulted in higher green pod yield per unit area owing to increased plant population. Among bed-top widths, 105 cm proved superior for yield per plant, whereas 75 cm bed-top width was optimal for maximizing green pod yield per acre. Economic analysis revealed that the treatment combination of 75 cm bed-top width with 30 cm intra-row spacing and 100-120% NPK fertigation was most profitable, recording the highest net returns and benefit-cost ratio. Therefore, for sustainable and economically viable production of pole type French bean under protected conditions in Punjab, cultivation on 75 cm bed-top width with 30 cm intra-row spacing and drip fertigation at 100-120% recommended NPK is recommended.

Authors' contribution

Conceptualization and designing of the research work (VS, TS, SS, RD, RS); Execution of field/lab experiments and data collection (VS, TS, SS, RS);

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Analysis of data and interpretation (VS, TS, SS, RD); Preparation of manuscript (VS, TS, SS, RD).

Conflict of interests

Authors declare that there is no conflict of interests.

LITERATURE CITED

Addow M A, Hassan A A, Adde M S N, Noor A A and Kabir M A 2020. Effect of nitrogen and potassium on the growth, yield and yield contributing traits of French Bean. *J Agric Vet Sci* **13**: 01-12.

Beg M Z and Sohrab A 2012. Effect of potassium on Moong bean. *Indian J Life Sci* **1**: 109-14.

Chaudary A 2020. *Studies on the effect of cultivars, sowing dates and spacing on growth and yield in french bean*. M. Sc. Thesis, Dr. Y. S. Parmar University, Solan, Himachal Pradesh.

Cheema H S and Singh B 1991. CPCS-1. Department of Statistics, Punjab Agricultural University, Ludhiana, India.

Dalai S, Evoor S, Mulge R and Hanchinamani C N 2021. Effect of nutrient levels on growth, yield and economics of dolichos bean (*Dolichos lablab* L.) in Northern Dry Zone of Karnataka, India. *Legume Res* **1**: 7.

Deka K K, Milu R D, Bora P and Mazumder N 2015. Effect of sowing dates and spacing on growth and yield of cluster bean (*Cyamopsis tetragonoloba*) in subtropical climate of Assam, India. *Indian J Agric Res* **49**: 250-54.

Desai N B, Leva R L, Khadadiya M B and Patel U J 2020. Integrated nutrient management in *Rabi* Indian bean (*Dolichos lablab* L.). *J Pharmacogn Phytochem* **9**: 457-59.

FAOSTAT 2021. *Food and Agricultural Organization of the United Nations*, Rome, Italy. Available at: *http://foastat.fao.org/*

Ghosal S, Singh O N and Singh R P 2000. Effect of rate and time of application of nitrogen on growih and productivity of French bean (*Phaseolus vulgaris* L.). *Legume Res* **23**: 110-13.

Gomez K A and Gomez A A 1984. Statistical Procedures for Agriculture Research, 2nd Edn., John Willey and Sons, New York.

Gopalkrishnan P 2007. *Vegetable crops*. New India Publisher. New Delhi, 176p.

Hussein A, Benmoussa M, Andabbad M 2018. Effect of population density and dose of nitrogen and potassium fertilizers on performance of green bean (*Phaseolus vulgaris* L.). *J Fundam Appl Sci* **10**: 46-58.

Jaisankar P and Manivannan K 2018. Effect of different levels of nitrogen and phosphorus on growth and yield characters of bush bean (*Dolichos lablab* var. *typicus*). *Plant Arch* **18**: 294-98.

Janapriya S, Palanisamy D and Ranghaswami M V 2010. Soilless media and fertigation for naturally ventilated polyhouse production of cucumber (*Cucumis sativus* L.). *Int J Agric Environ Biotechnol* **3**: 199-205.

Joshi S K and Rahevar H 2015. Effect of dates of sowing, row spacings and varieties on growth and yield attributes of *Rabi* Indian bean (*Dolichos lablab* L.). *Indian J Agric Res* **49**: 59-64.

Kalita H, Deka N, Guha B, Deka U K and Sadhukhan 2016. Effect of dates of sowing and spacing on rajmah (*Phaseolus vulgaris* L.) varieties under the climatic conditions of Central Brahmaputra Valley Zone of Assam**.** *J Crop Weed* **12**: 64-68.

Karim S, Uddin F J, Rashid H O and Hadiuzzaman M 2020. Effect of phosphorus and potassium on the growth and yield of French bean. *J Sci Agric* **4**: 108-12.

Kumar U 2019. *Effect of fertigation and foliar application of nutrients on growth and yield of French bean (Phaseolus vulgaris* L.*)*. M.Sc. thesis, University of Agricultural Sciences, Raichur, India.

Malagi S C 2005. *Response of cowpea genotypes to plant density and fertilizer levels under rainfed vertisols*. M.Sc. Thesis, University of Agricultural Sciences, Bangalore, Karnataka, India.

Manjesh M, Adivappar N, Srinivasa V and Girijesh G K 2019. Effect of plant densities and different environments on productivity and profitability of yardlong bean (*Vigna unguiculata* sub sp. *sesquipedalis*). *Leg Res* **42**: 348-53.

Melak A 2018. Effect of spacing on yield components and yield of chickpea (*Cicer arietinum* L.) at Assosa, Western Ethiopia. *Agric Forest Fish* **7**: 39-51.

Neethu T M, Adivappar N, Srinivasa V and Girijesh G K 2022. Effect of spacing and fertigation on growth and yield parameters of french bean (*Phaseolus vulgaris* L.) under protected cultivation. *Legume Res* **45**: 742-48.

Rahman M A, Hoque A K M S, Rahman M N, Talukdar M B and Islam M S 2007. Effect of nitrogen and phosphorus on the growth and yield of French bean. *J Soil Nat* **1**: 30-34.

Sabar J 2021. *Response of rice bean (Vigna umbellata) to different spacing and fertilizer levels*. M.Sc. Thesis, University of Agricultural Sciences, Bangalore, Karnataka, India.

Sheshrao 2018. *Effect of different levels of nutrient on growth, yield and quality of table purpose French bean (Phaseolus vulgaris* L.*)*. M.Sc. thesis, College of Agriculture, Pune, India.

Singh J and Biswas B 2020. Effect of nitrogen management on yield and water productivity of rajmash (*Phaseolus vulgaris* L.) in sub-humid climate of Indian Punjab. *J Agric Physiol* **20**: 40-47.

Vyas M D and Jamliya G S 2017. Effect of fertilizers with and without FYM on growth, yield attributes and yield of soybean [*Glycine max* (L) *Merrill*] varieties in medium black (vertisol) of Vindhyan Plateau of Madhya Pradesh, India. *Plant Arch* **17**: 1421-24.

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