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Growth and productivity of French bean (*Phaseolus vulgaris* l.) as influenced by plant spacing and sowing date

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ABSTRACT

The present study was conducted at the Horticulture Farm of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh to study the effect of plant spacing and sowing date on the growth and yield of French bean during the period from October 2021 to January 2022. The experiment consisted of two factors namely plant spacing (30 cm x 25 cm, 30 cm x 20 cm and 30 cm x 15 cm) and sowing date (24 October 2021, 03 November 2021 and 13 November 2021). The experiment was laid out in randomized complete block design with three replications. Results showed that both plant spacing and sowing date significantly influenced the growth and yield of French bean. The maximum yield (13.19 t/ha) was obtained from 30 cm x 15 cm plant spacing and the lowest (8.12 t/ha) was obtained with the spacing of 30 cm x 25 cm. The yield increased due to early sowing. The highest fresh pod yield (11.05 t/ha) was obtained from 24 October sowing. The lowest (9.81 t/ha) was obtained from 13 November sowing. The combined and interaction effects of plant spacing and time of sowing were statistically significant on these above characters. The combination of 30 cm x 15 cm plant spacing with 24 October sowing gave the highest yield (13.80 t/ha) and lowest yield (7.69 t/ha) was obtained from the treatment combination of 30 cm x 25 cm plant spacing with 13 November sowing treatment combination. Considering the above finding 30 cm x 15 cm plant spacing with early sowing was recommendable for French bean cultivation.

INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is a vegetable crop belonging to the family Leguminosae. It is popularly known as Rajma, haricot bean, kindey bean, snap bean, navy bean, field bean, dry bean, pole bean etc. and also known as 'Jhar sheem' in Bangladesh. (Kakon et al., 2019). It is used for its fresh pods or dry seeds. The crop has gained popularity for its short durability and high nutritive value. French bean is a good source of protein, carbohydrate, calcium, iron, phosphorus and vitamins, particularly vitamin B (Messina, 2014; Wiesinger et al., 2016). French bean can play an important role to overcome the national protein deficit.

Production of French bean depends on many factors such as quality of seed, variety, plant spacing, and proper management practices. Plant spacing is an important factor that affects the yield contributing characters and yield which can be manipulated to maximize yield (Babu and Mitra, 1989). Among the various factors that contribute towards the attainment to potential yield of French bean, optimum plant spacing or plant population is one of the important factor (Pawar et al., 2007). Optimal density is the density through which environmental factors (water, weather, light, and soil) are used perfectly and at the same time inter-plant and intra- plant competition is minimized. Population density modifies the canopy structure and influence light interception, dry matter production and yield of the crop (Fuci et al., 1990). Plant spacing affects plant growth and yield due to increased competition with increased plant population (Elhag and Hussein, 2014). References (Al Ghamdi. 2007; Osman et al., 2010; Stutzel et al., 1994; Singh et al., 1992) pointed that seed, pods and straw yields per plant were increased by increasing row spacing.

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In Bangladesh, it is usually cultivated after T. Aman harvest. If delay of T. Aman harvest than the crop faces unfavorable weather conditions at its reproductive phase and gave low yield (Kakon et al., 2014). The optimum sowing date depends on the existing cropping pattern and prevailing environmental conditions. 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 date is one of the important factors which affect productivity through growing the timing and duration of the vegetative and reproductive stages, since environmental factors such as temperature and light duration differ with varying sowing date (El-Seifi et al., 2014).

Some of its cultural practices such as sowing date and plant spacing should be tested to have high yield and quality and at the proper time for markets. This study was conducted to asses which sowing date and plant population would be optimum for maximizing bean production.

Materials and Methods

The experiment was carried out at the Horticulture Farm of the Department of Horticulture, BAU. The experimental area belongs to subtropical climatic zone that is characterized by heavy rainfall, high humidity, high temperature and relatively long dry period during Kharif season (April-September) and scarce rainfall, low humidity, low temperature and short dry period during Rabi season (October-March). The variety of French bean used in the experiment was BARI Zharshim-1. The seeds were collected from Bangladesh Agricultural Research Institute (BARI), Jaydebpur, Gazipur.

The experimental treatments consisted of three different spacing viz., S_1: 30 cm x 25 cm, S_2: 30 cm x 20 cm and S_3: 30 cm x 15 cm and three different dates of sowing viz., D_1: Sowing on 24 October, 2021, D_2: Sowing on 3 November, 2021; D_3: Sowing on 13 November, 2021. The two factor experiment was laid out in the randomized complete block design with three replications. The size of each unit plot was 2.1 m x 1.5 m. Spacing of 1.0 m and 0.5 m were provided between the blocks and plots, respectively. After land preparation, the experimental plots were laid out in accordance with the experimental design. The seeds were sown on the respective sowing dates according to the spacing of 30 cm x 25 cm, 30 cm x 20 cm and 30 cm x 15 cm.

Different intercultural operations such as gap filling, thinning, weeding, manuring and fertilizing were performed as and when necessary. To collect data, ten plants were randomly selected from inner side of each plot to avoid border effect. Plant height and number of leaves per plant were recorded at 15, 25, 35 and 45 days after sowing (DAS). Yield attributes such as number of pods per plant, length and diameter of pod, Fresh pod yield per hectare was recorded and expressed in ton.

Collected data on yield and yield controlling characters under study were statistically analyzed using MSTST C program. The means for all the treatments were calculated and analysis of variances (ANOVA) for all the characters under consideration was performed by F-test. The significance of the 1 % and 5% levels of probability (Gomez and Gomez, 1984).

RESULT AND DISCUSSION

Plant height

Plant height was recorded at different growing stages i.e. 15, 25, 35 and 45 days after sowing (DAS). The result of spacing and sowing date showed highly significant effect on the height of French bean plants at 15, 25, 35 and 45 days after sowing (Figure 1). The highest plant height (51.03 cm and 56.29 cm) was recorded at 45 DAS from the spacing and sowing date of 30 cm x 15 cm and 24 October sowing. The lowest (48.45 cm and 47.03 cm) was recorded from the treatments of 30 cm x 25 cm spacing and in case of 03 November sowing at 45 DAS. The combined effect of different spacing and sowing dates on plant height was found to be statistically significant at 15, 25, 35 and 45 days after sowing (Table 1). From the combined impacts of spacing and sowing date, the tallest plant (57.07 cm) was found from the treatment combination of S_3D_1 (30 cm x 15 cm spacing with 24 October sowing) and the lowest

plant height (42.06 cm) from the treatment combination of S_1D_2 (30 cm x 25 cm spacing with 03 November sowing).The finding is consistent with the report of Kakon et al. (2018).

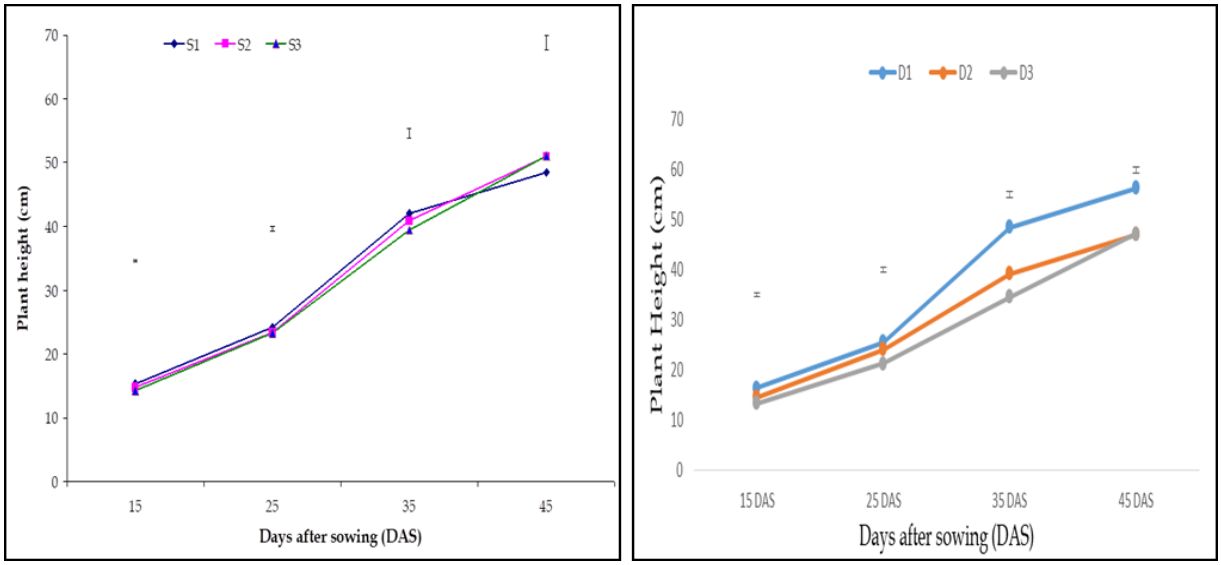

Figure 1: Effect of spacing (left) and sowing date (right) on the plant height of French bean at different DAS. Vertical bars represent LSD at 1% level of probability. S_1 = 30 cm x 25 cm, S_2 = 30 cm x 20 cm and S_3 = 30 cm x 15 cm; D_1 = 24 October 2021, D_2= 03 November 2021 and D_3 = 13 November 2021

Table 1: Combined effect of spacing and sowing date on plant height of French bean at different days after sowing (DAS)

Spacing x date of sowing	Plant height (cm) at			
	15 DAS	25 DAS	35 DAS	45 DAS
S_1D_1	16.92	25.78	49.02	55.09
S_1D_2	15.03	24.83	42.08	42.06
S_1D_3	13.95	22.06	35.08	48.19
S_2D_1	16.63	25.09	49.80	56.72
S_2D_2	14.68	23.97	38.12	48.07
S_2D_3	13.09	21.09	34.78	48.08
S_3D_1	15.85	25.69	46.78	57.07
S_3D_2	14.08	23.58	37.52	50.96
S_3D_3	12.98	20.69	33.98	45.07
$LSD_{0.05}$	0.324	0.622	1.511	2.35
$LSD_{0.01}$	0.446	0.857	2.082	3.24
Level of significance	**	**	**	**

** = Significant at 1% level of probability, * = Significant at 5% level of probability, S_1 =30 cm x 25 cm, S_2 = 30 cm x 20 cm, S_3 = 30 cm x15 cm; D_1 = 24 October 2021, D_2 = 3 November 2021 and D_3 = 13 November 2021

Number of leaves per plant

The number of leaves per plant was influenced significantly due to different plant spacing and sowing dates (Table 2). The highest number of leaves per plant (14.96) was obtained in the spacing of 30 cm x 25 cm while the lowest (14.07) was obtained in closest spacing of 30 cm x 15 cm (Table 2). The early sowing D_1 (24 October) gave the highest number of leaves (15.67) at 45 DAS and the lowest number of leaves was found from the late sowing D_3 (13 November) (Table 3). Impact of plant spacing and sowing date was statistically significant. The result indicated that the treatment combination of (S_1D_1) (spacing of 30 cm x 25 cm with the sowing date 24 October) at 45 DAS had the largest number of leaves (16.33) followed by S_1D_2 (16.10) and the S_3D_3 combination responded with the lowest number of leaves (12.00) preceded by S_2D_3 (12.22). The findings of the present study agree with the observations of El-Seifi et al. (2014).

Leaf size

Leaf size exhibited an impressive variation among the tested treatments. It increased gradually up to

45 DAS. In the S_2 treatment (30 cm x 20 cm spacing), the larger leaf (8.49 cm x 7.49 cm) was determined at 45 DAS followed by S_1 (8.43 cm x 7.32 cm) (Table 2). The shortest leaf (7.82 cm x 6.71 cm) was measured in the S_3 treatment. At 45 DAS, the larger leaves (8.54cm x 7.43 cm in length and breadth respectively) were produced from early sowing D_1 (24 October 2021) and the smaller leaves (8.06cm x 7.02 cm in length and breadth respectively) were found from late sowing D_3 (13 November 2021) (Table 3). The combination of S_1 with D_1 treatment was measured to have the largest leaf (8.97cm x 7.70 cm) at 45 DAS whereas the S_3D_3 treatment combination was observed with the shortest leaf (7.59 cm x 6.28 cm) preceded by S_3D_3 (Table 4).

Table 2: Main effect of spacing on number of leaves/plant and leaf size of French bean at different days after sowing

Spacing	Number of leaves/plant at				Leaf size (cm)	
	15 DAS	25 DAS	35 DAS	45 DAS	Length	Breath
S_1	3.03	5.49	8.52	14.96	8.43	7.32
S_2	2.92	5.47	8.41	14.41	8.49	7.49
S_3	2.74	5.41	8.32	14.07	7.82	6.71
$LSD_{0.05}$	0.109	0.170	0.118	0.182	0.251	0.179
$LSD_{0.01}$	0.151	0.234	0.163	0.250	0.346	0.246
Level of significance	**	NS	**	**	**	**

* = Significant, ** = Significant at 1% level of probability, NS = Not significant, S_1 = 30 cm x 25 cm, S_2 = 30 cm x 20 cm, and S_3 = 30 cm x 15 cm

Table 3: Main effect of date of sowing on number of leaves/plant and leaf size of French bean at different days after sowing

Date of sowing	Number of leaves/plant at				Leaf size (cm)	
	15 DAS	25 DAS	35 DAS	45 DAS	Length	Breadth
D_1	3.18	6.07	8.48	15.67	8.54	7.43
D_2	2.88	5.63	9.07	15.55	8.13	7.07
D_3	2.63	4.68	7.70	12.22	8.06	7.02
$LSD_{0.05}$	0.109	0.170	0.118	0.182	0.251	0.179
$LSD_{0.01}$	0.151	0.234	0.163	0.250	0.346	0.246
Level of significance	**	**	**	**	**	**

** = Significant at 1% level of probability, D_1 = 24 October 2021, D_2 = 3 November 2021 and D_3 = 13 November 2021

Table 4: Combined effect of spacing and sowing date on number of leaves/plant and leaf size of French bean at different days after sowing

Spacing x sowing date	Number of leaves/plant at				Leaf size (cm)	
	15 DAS	Length	Breadth	45 DAS	Length	Breadth
S_1D_1	3.33	8.97	7.70	16.33	8.97	7.70
S_1D_2	2.88	8.26	7.16	16.10	8.26	7.16
S_1D_3	2.88	8.05	7.09	12.45	8.05	7.09
S_2D_1	3.22	8.68	7.56	15.56	8.68	7.56
S_2D_2	3.00	8.24	7.22	15.45	8.24	7.22
S_2D_3	2.55	4.66	7.56	12.22	8.55	7.69
S_3D_1	3.00	6.22	8.33	15.11	7.97	7.03

S_3D_2	2.77	5.46	8.87	15.11	7.90	6.82
S_3D_3	2.45	4.56	7.77	12.00	7.59	6.28
$LSD_{0.05}$	0.190	0.295	0.205	0.314	0.434	0.310
$LSD_{0.01}$	0.261	0.406	0.282	0.433	0.599	0.427
Level of significance	*	**	**	NS	*	NS

* = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant, S_1 = 30 cm x 25 cm, S_2 = 30 cm x 20 cm, S_3 = 30 cm x 15 cm; D_1 = 24 October 2021, D_2 = 3 November 2021, D_3 = 13 November 2021

Number of branches per plant

In this experiment, the number of branches per plant showed statistically significant difference. Number of branches gradually increased by increasing spacing. The maximum number of branches (10.29) was measured on the S_1 (30 cm x 25 cm) treatment whereas on the S_3 (30 cm x 15 cm) treatment, the minimum number of branches (8.96) was counted (Table 5). The number of branches per plant was influenced significantly by sowing date. The highest number of branches per plant (10.55) was obtained in early sowing D_1 (24 October) while the lowest (8.59) was obtained in late sowing D_3 (13 November) (Table 6). The number of branches per plant was determined highest (11.45) in the S_1D_1 treatment and lowest in the S_3D_3 (8.12) treatment (Table 7). Similar results were also recorded by Wallace et al. (1991) who reported a decrease of plant height, stem width and number of branches with delayed sowing, which was attributed to short growth period.

Days to first flowering

The treatments exerted significant effects on days to first flowering. Longer time (34.26 days) was required for flowering in case of wider spacing of (30 cm x 25 cm). On the other hand, shorter time (33.76 days) was recorded in case of spacing of (30 cm x 20 cm) (Table 5). The results on main effect of sowing date on days to first flowering have been presented in (Table 6). Longer time (35.55 days) was required for flowering in case of late sowing D_3 (13 November) plants. On the other hand, shorter time (33.18 days) was recorded in case of early sowing time D_1 (24 October) (Table 6). The combined effect of spacing and sowing date influenced non-significantly the days required to first flowering (Table 7). A study on snap bean conducted by Elhag and Hussein, (2014) supports the present findings.

Number of flowers per plant

Significant variation was observed among different plant spacing in terms of number of flowers per plant. The highest number of flowers (38.40) was measured on the S_1 (30 cm x 25 cm) treatment whereas on the S_3 (30 cm x 15 cm) treatment, the lowest number of flowers (34.44) was measured (Table 5). Number of flowers per plant also differed significantly due to sowing dates. The maximum number of flowers (45.06) was acquired in plants that were treated with D_1 (24 October) treatments followed by D_2 (36.25) (Table 6). The number of flowers per plant was determined maximum (48.03) in the S_1D_1 treatment and minimum in the S_3D_3 (27.05) treatment (Table 7). The present findings are similar to the results as replied Kakon et al. (2017).

Table 5: Main effect of spacing on number of branches/plant, days to first flowering and number of flowers/plant of French bean

Spacing	No. of branches/ plant	Days to first flowering	No. of flowers/ plant
S_1	10.29	34.26	38.40
S_2	9.93	33.76	37.70
S_3	8.96	34.45	34.44
$LSD_{0.05}$	0.241	0.479	0.990
$LSD_{0.01}$	0.332	0.660	1.36
Level of significance	**	*	**

* = Significant at 5% level of probability, ** = Significant at 1% level of probability S_1 = 30 cm x 25 cm, S_2 = 30 cm x 20 cm, S_3 = 30 cm x 15 cm

Table 6: Main effect of sowing date on number of branches/plant, days to first flowering and number of flowers/plant of French bean

Sowing date	No. of branches/ plant	Days to first flowering	No. of flowers/ plant
D_1	10.55	33.18	45.06
D_2	10.03	33.74	36.25
D_3	8.59	35.55	29.24
$LSD_{0.05}$	0.241	0.479	0.990
$LSD_{0.01}$	0.332	0.660	1.36
Level of significance	**	**	**

** = Significant at 1% level of probability, D_1 = 24 October 2021, D_2 = 3 November 2021, and D_3 = 13 November 2021

Table 7: Combined effect of spacing and date of sowing on number of branches/plant, days to first flowering and number of flowers/plant of French bean

Spacing x sowing date	No. of branch/ plant	Days to first flowering	No. of flowers/ plant
S_1D_1	11.45	33.87	48.03
S_1D_2	10.55	34.05	38.08
S_1D_3	8.88	34.86	29.08
S_2D_1	10.67	33.59	44.54
S_2D_2	10.33	32.11	36.98
S_2D_3	8.78	35.58	31.58
S_3D_1	9.55	32.08	42.60
S_3D_2	9.22	35.05	33.68
S_3D_3	8.12	36.22	27.05
$LSD_{0.05}$	0.417	0.830	1.72
$LSD_{0.01}$	0.574	1.14	2.36
Level of significance	**	NS	**

** = Significant at 1% level of probability
S_1 = 30 cm x 25 cm, S_2 = 30 cm x 20 cm, S_3 = 30 cm x 15 cm; D_1 = 24 October 2021, D_2 = 3 November 2021, D_3 = 13 November 2021 NS = Not significant

Number of pods per plant

It was noted that variation in plant spacing was significant on number of pods per plant. S_1 (30 cm x 25 cm) treatment showed superior performance in case of number of pods per plant which gave the highest values in this trait (23.45) (Table 8). The minimum number of pods per plant (20.27) was achieved in the S_3 (30 cm x 15 cm) treatment. Time of sowing had significant effect on the number of pods per plant. The highest number of pods per plant (25.14) was obtained from D_1 (24 October 2021) and lowest number of pods (18.52) per plant was obtained from late sown crop D_3 (13 November 2021) (Table 9). In the S_1D_1 treatment combination, the highest number of pods per plant (26.98) was recorded followed by S_3D_3 (18.09) (Table 10). The parallel finding is recorded by Kakon et al. (2018)

Number of pods per plot

A significant result in the number of pods per plot was noticed with different plant spacing. Number of pods per plot (1453.66) markedly increased in the closest spacing of S_3 (30 cm x 15 cm) but declined (937.86) in the widest spacing of S_1 (30 cm x 25 cm) (Table 8). The D_1 (24 October 2021) treatment attained maximum number of pods per plot (1324.04) which was in contrast to the minimum number of pods per plot (982.33) producing the D_3 (13 November 2021) treatment (Table 9). The combined effect of spacing and sowing date was significant in this respect. The highest number of pods per plot (1647.80) was recorded in the treatment combination of 30 cm x 15 cm plant spacing with 24 October sowing (S_3D_1) and the lowest number of pods per plot (773.20) was found from the treatment combination of 30 cm x 25 cm plant spacing with 13 November sowing (S_1D_3) (Table 10). The finding is consistent with the report of Kakon et al. (2018).

Length of green pod

The length of green pod was influenced markedly due to different plant spacing. It was recorded as the longest (14.98 cm) in the S_1 (30 cm x 25 cm) treatment followed by S_2 (14.32 cm) and S_3 (13.62 cm) treatment (Table 8). The longest pod (15.02 cm) was obtained from D_1 (24 Oct. 2021) whereas the shortest pod (13.13 cm) was obtained from late sown crop D_3 (13 November 2021) (Table 9). The combination of S_1 with D_1 generated the highest length of green pod (15.77 cm) while the combination of S_3D_3 produced the least length of

green pod (12.68 cm) (Table 10). The significant positive effects of sowing date on pod yield and quality and their components were also confirmed by (Mishra et al. 1998 and Amer et al. 2002) who reported improvement of both quantitative and qualitative traits of bean depended on sowing on the proper date.

Diameter of green pod

The result on main effect of plant spacing revealed that there was no significant variation among different plant spacing for diameter of green pod (Table 8). There was a considerable difference in the diameter of green pod due to different sowing time. The highest diameter of green pod (1.45 cm) was observed in the sowing time D_1 (24 October 2021) and the lowest (1.33 cm) was found in the D_3 (13 November 2021) treatment (Table 9). The lowest diameter of green pod was measured in the S_2D_3 treatment followed by S_1D_3 whereas the highest diameter of green pod was measured in the S_1D_1 treatment combination (Table 10). The present findings are almost similar to the results as replied by Mishra et al. 1998 and Amer et al. 2002.

Table 8: Main effect of spacing on no. of pods per plant, no. of pods per plot, length of green pod and diameter of green pod of French bean

Spacing	Number of pods/plant	Number of pods/plot	Length of green pod (cm)	Diameter of green pod (cm)
S1	23.45	937.86	14.98	1.42
S2	21.71	1085.66	14.32	1.40
S3	20.77	1453.66	13.62	1.37
LSD0.05	0.398	20.73	0.100	0.045
LSD0.01	0.549	28.56	0.138	0.062
Level of significance	**	**	**	NS

** = Significant at 1% level of probability, NS = Not significant, S_1 = 30 cm x 25 cm, S_2 = 30 cm x 20 cm, S_3 = 30 cm x 15 cm

Table 9: Main effect of sowing date on number of pods per plant, number of pods per plot, length of green pod and diameter of green pod of French bean

Date of sowing	No. of pods/plant	No. of pods/ plot	Length of green pod (cm)	Diameter of green pod (cm)
D_1	25.14	1324.04	15.02	1.45
D_2	22.26	1170.82	14.77	1.42
D_3	18.52	982.33	13.13	1.33
$LSD_{0.05}$	0.398	20.73	0.100	0.045
$LSD_{0.01}$	0.549	28.56	0.138	0.062
Level of significance	**	**	**	**

** = Significant at 1% level of probability, D_1 = 24 October 2021, D_2 = 3 November 2021, D_3 = 13 November 2021

Table 10: Combined effect of spacing and sowing date on number of pods per plant, number of pods per plot, length of green pod and diameter of green pod of French bean

Spacing x sowing date	No. of pods/plant	No. of pods/ plot	Length of green pod (cm)	Diameter of green pod (cm)
S_1D_1	26.98	1079.33	15.77	1.52
S_1D_2	24.03	961.06	15.57	1.41

S_1D_3	19.33	773.20	13.59	1.33
S_2D_1	24.90	1245.00	15.06	1.42
S_2D_2	22.09	1104.50	14.79	1.46
S_2D_3	18.15	907.50	13.12	1.31
S_3D_1	23.54	1647.80	14.23	1.39
S_3D_2	20.67	1446.90	13.96	1.38
S_3D_3	18.09	1266.30	12.68	1.35
$LSD_{0.05}$	0.690	35.90	0.173	0.077
$LSD_{0.01}$	0.951	49.47	0.238	0.107
Level of significance	**	*	**	**

* = Significant at 5% level of probability, ** = Significant at 1% level of Probability, S_1 = 30 cm x 25 cm, S_2 = 30 cm x 20 cm, S_3 = 30 cm x 15 cm, D_1 = 24 October 2021, D_2 = 3 November 2021 and D_3 = 13 November 2021

Number of seeds per green pod

The effect of different plant spacing on the number of seeds per green pod was found to be statistically significant. The maximum number of seeds per green pod (6.77) was obtained in pods from crops sown at closest spacing of S_1 (30 cm x 25 cm). The minimum number of seeds per green pod (6.22) was found in pods from crops sown at the spacing of S_2 (30 cm x 20 cm) (Table 11). The treatment of sowing date also showed a highly significant influence on number of seeds per green pod. In the D_1 (24 October 2021) treatment maximum number of seeds per green pod (6.76) was attained whereas it was minimum (6.00) in the D_3 (13 November 2021) treatment (Table 12). Maximum number of seeds per green pod (7.10) was achieved from the S_1D_1 combination and the minimum (5.88) from the S_2D_2 treatment (Table 13). A study conducted by Kakon et al. (2017) found the similar findings.

Fresh weight of pod per plant

The fresh weight of pod per plant was differed significantly due to the effect of different plant spacing (Figure 2). The maximum weight of fresh green pod (64.12 g) was obtained from crops sown at widest spacing of S_1 (30 cm x 25 cm). The minimum weight of fresh green pod (59.35 g) was found in pods from crops sown at the closest spacing of S_3 (30 cm x 15 cm) (Table 11). The fresh weight of pod was found to be the highest in crops sown at D_1 (24 October 2021) and the lowest in case of crops sown on D_3 (13 November 2021) (Table 12). The combined effect between plant spacing and sowing date was found significant on fresh weight of pod per plant. The highest fresh weight of pod per plant (69.53 g) was found in the treatment combination of S_1D_1 and the lowest (56.98 g) was obtained from S_3D_3 treatment combination (Table 13). Most of the similar findings have been observed in Kakon et al. (2018).

Fresh pod yield of French bean per plot and per hectare

The effect of plant spacing on the pod yield per plot and per ha at harvest differed significantly. The highest pod yield per plot was recorded in the S_3 (30 cm x 15 cm) spacing and the lowest fresh pod yield was obtained from S_1 (30 cm x 25 cm) spacing (Table 11). The treatment of sowing date also showed a highly significant influence on the yield per plot and per hectare. The highest yield per plot (3.48 kg) (Table 12) and ha (11.05 t) (Figure 3) was obtained from D_1 (24 October 2021) treatment while the lowest yield per plot (3.09 kg) (Table 12) and (9.81 t) (Figure 3) per hectare was recorded from the D_3 (13 November 2021). The combined effect of spacing and sowing date on yield per plot was found statistically non-significant but per hectare was found to be statistically significant. The maximum yield per plot (4.35 kg) (Table 13) and (13.80 t) (Figure 4) per hectare was found in the treatment combination of S_3D_1 while the minimum yield per plot (2.44 kg) and (7.69 t) (Figure 4) per hectare was observed from the treatment combination of S_1D_3.The same results were found by Sabale et al. (2010); Mohanty et al. (2001).

Table 11: Main effect of spacing on number of seeds per green pod, wt. of fresh pod per plant and fresh pod yield per plot of French bean.

Spacing	Number of seeds/green pod	Weight of fresh pod/plant (g)	Fresh pod yield/plot (kg)
S_1	6.77	64.12	2.56
S_2	6.11	61.02	3.05
S_3	6.32	59.35	4.15
$LSD_{0.05}$	0.236	0.780	0.105
$LSD_{0.01}$	0.326	1.075	0.156
Level of significance	**	**	**

** = Significant at 1% level of probability, S_1 = 30 cm x 25 cm, S_2 = 30 cm x 20 cm, S_3 = 30 cm x 15 cm

Table 12: Main effect of sowing date on number of seeds per green pod, wt. of fresh pod per plant and fresh pod yield per plot of French bean

Sowing date	Number of seeds/green pod	Weight of fresh pod/plant (g)	Fresh pod yield/plot (kg)
D_1	6.76	65.85	3.48
D_2	6.00	60.28	3.21
D_3	6.44	58.36	3.09
$LSD_{0.05}$	0.236	0.780	0.105
$LSD_{0.01}$	0.326	1.075	0.156
Level of significance	**	**	**

** = Significant at 1% level of probability, D_1 = 24 October 2021, D_2 = 3 November 2021, D_3 = 13 November 2021

Table 13: Combined effect of plant spacing and sowing date on number of seeds per green pod, wt. of fresh pod per plant and fresh pod yield per plot of French bean

Spacing x sowing date	Number of seeds/green pod	Weight of fresh pod/plant (g)	Fresh pod yield/plot (kg)
S_1D_1	7.10	69.53	2.48
S_1D_2	6.15	61.80	2.47
S_1D_3	7.06	61.02	2.44
S_2D_1	6.29	65.91	3.30
S_2D_2	5.88	60.07	3.00
S_2D_3	6.17	57.07	2.85
S_3D_1	6.89	62.10	4.35
S_3D_2	5.97	58.98	4.13
S_3D_3	6.10	56.98	3.99
$LSD_{0.05}$	0.410	1.35	0.201
$LSD_{0.01}$	0.564	1.86	0.365
Level of significance	*	**	NS

** = Significant at 1% level of probability
D_1 = 24 October 2021, D_2 = 3 November 2021, D_3 = 13 November 2021, NS = Not significant

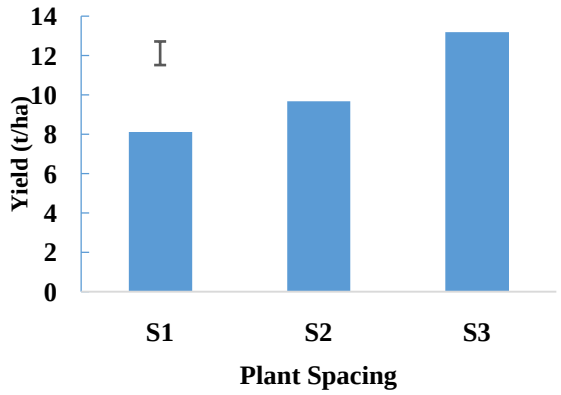

Figure 2: Effect of plant spacing on fresh pod yield per hectare of French bean. Vertical bar represents LSD at 1% level of probability. S_1 = 30 cm x 25 cm, S_2 = 30 cm x 20 cm and S_3 = 30 cm x 15 cm.

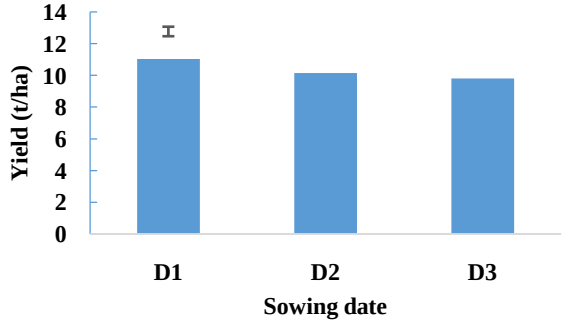

Figure 3: Effect of sowing date on fresh pod yield per hectare of French bean. Vertical bar represents LSD at 1% level of probability. D_1 = 24 October 2021, D_2 = 3 November 2021, D_3 = 13 November 2021

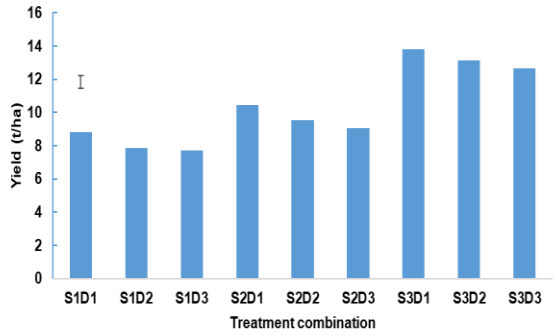

Figure 4: Combined effect of plant spacing and sowing date on fresh pod yield per hectare of French bean at different DAS. Vertical bar represents [TP1] LSD at 1% level of probability.

CONCLUSION

Response of French bean to plant spacing and sowing date was studied in this experiment. Among all the plant spacing 30 cm x 15 cm plant spacing showed the maximum yield. On the other hands the spacing of 30 cm x 25 cm showed the maximum growth and development. According to the findings of this experiment, French bean responded positively to the early sowing on 24 October 2021 in terms of growth and yield. Another conclusion that can be drawn is that the maximum fresh pod yield per plot (4.35 kg), pod yield per hectare (13.80 t/ha) were measured under treatment combination of S_3D_1 (30 cm x 15 cm spacing with 24 October sowing). The overall work concluded that an effective combination strategy of spacing and sowing date may be adjuvant of increasing the yield of French bean.

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