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OPTIMIZING SOWING STRATEGIES: A COMPARATIVE STUDY OF FRENCH BEAN CULTIVAR IN PROTECTED VS. OPEN FIELD CONDITIONS

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ABSTRACT

The present study was undertaken to check the combined effect of different dates of sowing under two different environments on French bean cultivar 'Moraleda'. Four different dates of sowing *viz.,* 1st September, 15th September, 1st October and 15th October were selected for the two different environmental conditions such as open field and polyhouse. The experiment was laid out in factorial randomized block design (FRBD) with three replications. In this study various quantitative traits *viz.* days to first seed germination, plant height (cm), number of primary branches per plant, leaf area (cm^2), chlorophyll content (SPAD value), days to first flowering, days to first pod initiation, days to first harvest, days to last harvest, pod length (cm), pod weight (g), number of pods per plant, and pod yield per plant (g) of French bean cultivar were analyzed. The results showed a significant improvement for various earliness traits [like days to first seed germination, days to first flowering, days to first pod initiation, and days to first harvesting), vegetative traits [such as plant height (cm), leaf area (cm^2), number of primary branches per plant], physiological trait [like chlorophyll content (SPAD value)] and yield and related traits [such as days to last harvest, pod length (cm), pod weight (g), number of pods per plant, and pod yield per plant (g)] for the 15th September and 1st October date of sowing which provided the optimal conditions for polyhouse and open field, respectively.

Thus, it can be inferred that sowing of French bean on 15th September under polyhouse and 1st October in the open field is recommended, as these sowing schedules significantly improved over all traits and provided optimal conditions for enhanced growth and productivity. Adopting these timings will optimize French bean cultivation under respective conditions.

Keywords: Crop improvement, French bean, *Phaseolus vulgaris*, polyhouse, protected cultivation

Introduction

The French bean (*Phaseolus vulgaris L.*, 2n=2x=22*)* is an important leguminous vegetable, cultivated for its tender green pods and dry beans. It is originated from temperate region of Central America and introduced in India during the 17th century from Europe (Singh *et al.,* 2009; Prakash and Ram, 2014; Bharti *et al.,* 2024). It is an excellent source of protein, calcium, and vitamins like A, B complex and C. French beans can improve health conditions as they can decrease the level of cholesterol in body. Dry seeds are helpful in the treatment of cancer (Campos-Vega *et*

al., 2013). It also possesses fungicidal properties due to the presence of a compound called 'Phaseolin'. French bean is also called the 'meat of the poor' (Singh, 1999), 'grain of hope' (Sofi *et al.,* 2011) and 'superfood' (Jena *et al.,* 2020). Morphologically, they are herbaceous annuals that possess determinate and indeterminate growth habits, variation in flower colour, size of pods and seed colour. It is a self-pollinated crop which shows epigeal germination and requires a temperature of 15-16°C to germinate, while 15-25°C required for its optimum growth and development (Greven *et al.,* 2004; Bharti *et al.,* 2024). French bean

is sensitive to water logging, frost and chilling temperatures. Extreme high temperatures interfere with pod filling.

Time of planting is the priceless resource in agricultural sector which plays a vital role in the successful production of the crop (Mozumder *et al.,* 2003; Ali and Mishra, 2004). Sowing the crop at appropriate time allows crops to expose in favorable weather condition that contributes towards sufficient growth and development of a crop to obtain a satisfactory yield (Basnet *et al.,* 2022). Among the environmental factors, the primary elements which influence the growth and development of French bean plants are air, temperature, and rainfall (Moniruzzaman *et al.*, 2008). High temperature causes major environmental stresses affecting growth and development that causes damage to reproductive organs (Savin and Nicolus, 1996). While, low temperature negatively affects the metabolism resulting in deteriorating crop quality and quantity (Kumar *et al.,* 2014; 2018; 2020).

Weather fluctuations and temperatures outside the optimum range can affect the plant growth patterns, phenological stages and crop duration which ultimately affect the plant produce (Sharma *et al.* 2013; Kakon *et al.,* 2018). Therefore, optimum sowing time is one of the most important farming practices to increase crop productivity and allow the crops to escape from adverse weather conditions. The low and high temperatures both are the underlying challenges for successful cultivation of French bean in open field conditions in Punjab (Begum *et al.*, 2003). The benefits of protected cultivation are well known and many researchers addressed its advantages time by time in many vegetable crops for high yield, quality produce and protection from insects and pests.

The objective of this research was to identify the optimal sowing strategies for enhancing the growth, yield, and quality traits of a French Bean cultivar by comparing the effects of different sowing dates under protected (polyhouse) and open field conditions, thereby providing valuable insights for improving cultivation practices.

Materials and Methods

The experiment was conducted during the late Kharif season (2023–2024) at the Vegetable Research Farm, Lovely Professional University, Phagwara, Punjab. A commercial cultivar namely 'Moraleda' (Seminis Pvt. Ltd.) (pole-type) of French bean was considered for the experiment. Four different dates of sowing *viz.,* 1st September, 15th September, 1st October and 15th October were selected for the two different

environmental conditions such as open field and polyhouse. The experiment was laid out in factorial randomized block design (FRBD) with three replications. The mean of maximum and minimum temperature (from September to December of 2023) as 28.17°C and 14.45°C in open field, whereas in polyhouse it was recorded as 33.75°C and 23.05°C. The ploughing and harrowing tillage operations were carried out to obtain fine tilth of the experimental land. The recommended dose of fertilizers @ 40:60:50 (N:P:K) kg/ha and FYM @ 20 t/ha was applied during the preparation of field. The experimental land was irrigated before one day from sowing with drip irrigation system under polyhouse and by surface method in open field. Seeds were sown by a hand-dibbled method at a spacing of 60 × 15 cm onto the raised beds. The sowing was done on 1st September, 15th September, 1st October and 15th October in the open field as well as under polyhouse. The gap filling was done within the 1st fortnight of sowing to maintain the desired population of plants. The irrigation was given within 2 -3 days depending upon the rainfall and soil moisture. All the recommended cultural practices were followed to raise a healthy crop. The observations of various quantitative traits *viz.* days to first seed germination, plant height (cm), number of branches per plant, leaf area (cm^2), chlorophyll content (SPAD value), days to first flowering, days to first pod initiation, days to first harvest, days to last harvest, pod length (cm), pod weight (g), number of pods per plant, and pod yield per plant (g) were recorded in five randomly labelled plants from each replication. The recorded mean value for the respective parameter in each replication was further statistically analyzed through Online Statistical Analysis Tools (OPSTAT) software developed Hisar Agricultural University, Haryana.

Result and Discussion

The obtained results (presented in Table 1-3) indicate that sowing dates significantly influence the various growth, physiological, flowering, yield and other related parameters of French bean cultivar under different environmental conditions. The results shown in Table 1 stated that among date of sowing, 15th September significantly recorded maximum plant height (271.60 cm), number of primary branches per plant (40.80), leaf area (31.25 cm^2), chlorophyll content (48.25 SPAD value), and significantly minimum days to first seed germination (2.46) under the polyhouse. Similar response under open field conditions was observed for the 1st October date of sowing which recorded significant and maximum value for plant height (190.65 cm), leaf area (26.14 cm^2),

chlorophyll content (45.51 SPAD value) with the exception of number of primary branches per plant (31.33) by 15th September. This indicates that the sowing dates of 15th September and 1st October provided the optimal conditions for vegetative growth. This could be due to favorable temperature, light, and humidity levels that enhance cell elongation and expansion, contributing to greater plant height and leaf area. Higher chlorophyll content observed on these dates indicates better photosynthetic efficiency. The controlled environment of the polyhouse likely maintained optimal light and temperature conditions, enhancing chlorophyll synthesis. In the open field, the 1st October sowing might have coincided with suitable weather conditions, leading to increased chlorophyll accumulation. The greater number of primary branches on 15th September in the polyhouse suggests that early sowing in a controlled environment supports branching, possibly due to consistent environmental conditions that promote apical dominance. The slightly lower number in the open field might reflect fewer stable conditions affecting branch formation. The results were in conformation with the findings of Santosh (2021), Malshe *et al.* (2016), Pooja & Hakkim (2017), who also observed better performance of various growth parameters of different horticultural crops under polyhouse conditions as compared to open field conditions. The results related to various improved growth characteristics were in agreement with Zelaing *et al.* (2018) and Akter *et al.* (2021).

The results presented in Table 1 related to minimum days required for first seed germination was found to be significant in 15th September date of sowing (2.46) under polyhouse and 1st October (4.53) in open field conditions which was at par with sowing time of 15th September (4.66). Early emergence was found in polyhouse conditions as compared to open field. The significantly shorter germination time for seeds sown on 15th September (polyhouse) and 1st October (open field) indicates that these dates provided optimal soil and atmospheric conditions, such as temperature and moisture, which are critical for rapid seed germination and early seedling vigor. The results are confirmed with the findings of Dixit (2007) who reported that under polyhouse conditions 12-20% more germination was found as compared to open field conditions. While, Kalauni *et al.* (2019) and Subedi *et al.* (2022) observed early germination in different French bean genotypes in the mid hill conditions.

Parameters like days to first flowering, days to first pod initiation and days to first harvesting are indicative of the plant's reproductive phase and are influenced by temperature, light, and possibly stress conditions. The timing of these events can affect the overall yield and quality of the beans. The span between first and last harvesting is essential for understanding the productivity window of the cultivar. This can vary significantly between polyhouse and open field conditions due to different stress factors and growth environments. The results shown in Table 2 revealed that among sowing dates 15th September under polyhouse exhibited the minimum and significant days to first flowering (30.46), days to first pod initiation (34.60), and days to first harvesting (40.47). However, for open field conditions 1st October sowing favoured the minimum and significant days count to first flowering (30.46), days to first pod initiation (34.60), days to first harvesting (40.47). This suggests that these sowing dates coincided with optimal environmental conditions, such as temperature, light, and possibly humidity, which accelerated the physiological processes leading to reproductive development. In both environments, these conditions likely provided a favorable balance of vegetative growth and energy allocation towards reproduction. On the other hand, in comparison to open field the maximum duration of harvesting was noticed in polyhouse (Table 2). The results revealed that 15th September sowing exhibited maximum days to last harvesting (123.60) which was significantly differ with other sowing dates. Whereas the significant and maximum duration of harvesting was recorded in 1st October sowing (99.93) in open field conditions. This extended period may be attributed to the stable and controlled environment of the polyhouse, which could reduce stress factors (like temperature fluctuations, pests, or diseases) and extend the plant's productive life. The polyhouse likely maintained optimal conditions throughout the growing season, allowing the plants to sustain pod production over a longer period. These findings were corroborated with the findings of Das *et al.* (2018).

Traits like pod length (cm), pod weight (g), number of pods per plant, and pod yield per plant (g) are critical quality and yield parameters that determine the commercial value of the crop. Environmental conditions, such as temperature fluctuations and humidity levels, can significantly impact these traits. Pod yield is a varietal character and can be influenced by external factors. The results presented in Table 3 showed that combined effect of different sowing and growing conditions significantly influenced the yield and related attributes. Among date of sowing, 15th September recorded the highest pod length (15.48 cm) which was statistically *at par* with 1st September (15.08 cm) under polyhouse. However, in open field 1st

October (14.46 cm) showed the maximum pod length which was statistically *at par* with 1st (14.15 cm) and 15th September (14.05 cm). Similarly, under polyhouse condition the maximum pod weight was found for 15th September (8.13 g) which was statistically *at par* with 1st September (7.99 g), whereas 1st October showed the maximum pod weight (7.83 g) in open field followed by 15th September (7.45). The results revealed the significant difference for the trait number of pods per plant. The date 15th September was observed with the maximum number of pods per plant (80.67) under polyhouse, while 1st October (59.00) was for the open field. In comparison to other sowing dates, significant and maximum pod yield per plant was recorded for 15th September (562.07 g) under polyhouse and 1st October (400.87 g) in open field conditions. The present findings revealed that polyhouse conditions appear to offer a more controlled environment that enhances yield potential. It may be due to more suitable growing conditions provided under the polyhouse along with a greater number of primary branches were found in these conditions. The results of the present investigation were in confirmation with the studies done Panigrahi *et al.* (2007), Devi *et al.* (2015), Panchbhaiya *et al.* (2017), Zelaing *et al.* (2018), Whankate *et al.* (2021) and Kumar (2022) in French bean.

Based on the obtained results, it is recommended to schedule the sowing of the French bean cultivar on 15th September under polyhouse conditions and 1st October under open field conditions. These sowing dates have demonstrated significant improvements in various earliness traits, vegetative growth, physiological characteristics, and yield-related parameters. The 15th September sowing date in the polyhouse resulted in optimal growth conditions, leading to earlier germination, flowering, and pod initiation, as well as enhanced plant height, leaf area, and chlorophyll content. Similarly, the 1st October sowing date in the open field provided favorable environmental conditions that maximized yield-related traits, including pod length, weight, and overall yield per plant. Adopting these sowing schedules can therefore optimize the growth and productivity of the French bean cultivar in both polyhouse and open field conditions.

Table 1: Combine effect of sowing time and growing conditions on growth parameters of french bean

Date of sowing		Days to first seed germination		Plant height (cm)		Number of primary branches per plant		Leaf area (cm^2)		Chlorophyll content (SPAD value)	
		C1	C2	C1	C2	C1	C2	C1	C2	C1	C2
S1	1st Sep.	3.60	5.40	262.13	172.23	34.93	29.73	30.55	19.25	47.34	42.05
S2	15th Sep.	2.46	4.66	271.60	184.80	40.80	31.33	31.25	20.71	48.25	43.35
S3	1st Oct.	3.73	4.53	248.20	190.65	37.67	30.67	30.18	26.14	46.41	45.51
S4	15th Oct.	4.06	5.16	241.0	152.26	32.67	27.93	28.28	17.12	45.54	39.40
SEm±		0.12		1.80		0.51		0.07		0.18	
CD (P=0.05)		0.30		5.51		1.57		0.22		0.54	

Table 2: Combine effect of sowing time and growing conditions on reproductive and harvesting parameters of french bean

Date of sowing		Days to first flowering		Days to first pod initiation		Days to first pod harvesting		Days to last pod harvesting	
		C1	C2	C1	C2	C1	C2	C1	C2
S1	1st Sep.	33.47	45.20	36.40	48.47	42.07	54.13	115.06	83.87
S2	15th Sep.	30.46	41.07	34.60	44.06	40.47	50.13	123.60	91.80
S3	1st Oct.	35.27	37.07	37.20	40.07	44.46	46.47	106.13	99.93
S4	15th Oct.	37.13	42.86	40.73	52.13	47.07	52.28	98.87	73.47
SEm±		0.34		0.34		0.32		0.14	
CD (P=0.05)		1.04		1.06		0.99		0.42	

Table 3: Combine effect of sowing time and growing conditions on yield and yield contributing traits of french bean

Date of sowing		Pod length (cm)		Pod weight (g)		Number of pods per plant		Pod yield per plant (g)	
		C1	C2	C1	C2	C1	C2	C1	C2
S1	1st Sep.	15.08	14.15	7.99	6.91	73.60	42.60	489.87	287.87
S2	15th Sep.	15.48	14.05	8.13	7.45	80.67	50.67	562.07	345.60
S3	1st Oct.	14.38	14.46	7.54	7.83	64.53	59.00	436.13	400.87
S4	15th Oct.	14.15	12.52	7.23	6.96	56.60	35.67	373.67	231.67
SEm (±)		0.26		0.07		0.66		6.31	
CD (P=0.05)		0.82		0.22		2.02		19.32	

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References

Akter, M., Mostarin, T., Khatun, K., Samad, M. A., Haq, M. E., Badrunnesa, A., & Shamim, A. S. A. (2021). Growth and yield comparison of French bean as influenced by three varieties and nutrients. *Asian Journal of Research in Crop Science*, **6**, 8–19.

Ali, M., & Mishra, J. P. (2004). Rabi pulses. In R. Prasad (Ed.), *Textbook of field crops production* (pp. 317–372). ICAR.

Basnet, D. B., Basnet, K. B., & Acharya, P. (2022). Effect of date of sowing of French bean (*Phaseolus vulgaris* L.) in minimizing climate change impact and in its performance in inner terai region of Nepal. *International Journal of Environment, Agriculture and Biotechnology*, **7**, 187–197. https://doi.org/10.22161/ijeab.71.21

Begum, A., Ahad, A., Kaisar, M. O., Islam, M. M., & Anam, M. K. (2003). Effect of sowing dates and fertilizer treatments on the reproductive variability of French bean (*Phaseolus vulgaris* L.). *Pakistan Journal of Biological Sciences*, **6**, 1897–1901.

Bharti, Mal, D., Goutam, E., & Kumar, L. (2024). Performance of French bean (*Phaseolus vulgaris* L.) genotypes under trans-gangetic plains region. *Indian Journal of Agricultural Research*, **58**, 101–105. https://doi.org/10.18805/IJARe.A-6148

Campos-Vega, R., Oomah, B. D., Loarca-Piña, G., & Vergara-Castañeda, H. A. (2013). Common beans and their non-digestible fraction: Cancer inhibitory activity An overview. *Foods*, **2**, 374–392. https://doi.org/10.3390/foods2030374

Das, K., Datta, S., & Sikhdar, S. (2018). Performance of bush type French bean varieties (*Phaseolus vulgaris* L.) with or without *Rhizobium* inoculation. *Indian Journal of Agricultural Research*, **52**, 284–289. https://doi.org/10.18805/IJARe.A-4981

Devi, J., Sharma, A., Singh, Y., Katoch, V., & Sharma, K. C. (2015). Genetic variability and character association studies in French bean (*Phaseolus vulgaris* L.) under North-Western Himalayas. *Legume Research*, **38**, 149–156. https://doi.org/10.5958/0976-0571.2015.00066.1

Dixit, A. (2007). Performance of leafy vegetables under protected environment and open field condition. *Asian Journal of Horticulture*, **2**, 197–200.

Greven, M. M., McKenzie, B. A., Hampton, J. G., Hill, M. J., Sedcole, J. R., & Hill, G. D. (2004). Factors affecting seed quality in dwarf French bean (*Phaseolus vulgaris* L.) before harvest maturity. *Seed Science and Technology*, **32**, 797–811.

Jena, N. K., Pattnaik, A. K., Mahapatra, P., Nandi, A., Panda, J., & Swain, A. A. (2020). Effect of nutrients on yield attributing character of French bean (*Phaseolus vulgaris* L.). *International Journal of Chemical Studies*, **8**, 2713–2716.

Kakon, S. S., Khan, M. S. A., Choudhury, J. A., Ali, M. Z., & Aziz, M. A. (2017). Influence of sowing time-based temperature on flowering and seed yield of French bean (*Phaseolus vulgaris* L.). *SAARC Journal of Agriculture*, **15**, 77–84.

Kalauni, S., Pant, S., Luitel, B. P., & Bhandari, B. (2019). Evaluation of pole-type French bean (*Phaseolus vulgaris* L.) genotypes for agro-morphological variability and yield in the mid hills of Nepal. *International Journal of Horticulture*, **9**, 15–23.

Kumar, A. (2022). Assessment of French bean (*Phaseolus vulgaris* L.) genotypes for yield traits. *Journal of Krishi Vigyan*, **11**, 1–6. https://doi.org/10.5958/2349-4433.2022.00093.9

Kumar, P. A., Reddy, R. V. S. K., Pandravada, S. R., Rani, C. V. D., & Chaitanya, V. (2014). Genetic divergence studies in indigenous French bean (*Phaseolus vulgaris* L.) germplasm. *Plant Archives*, **14**, 189–192.

Kumar, R., Chaurasiya, P. C., Singh, R. N., & Singh, S. (2018). Low temperature stress for crop production: A review. *International Journal of Pure and Applied Biosciences*, **6**, 575–598. http://dx.doi.org/10.18782/2320-7051.3031

Kumar, R., Deka, B. C., Kumawat, N., & Thirugnanavel, A. (2020). Effect of integrated nutrition on productivity,

profitability and quality of French bean (*Phaseolus vulgaris*). *Indian Journal of Agricultural Sciences*, **90**, 431–435.

Malshe, K. V., Palshetkar, M. G., & Desai, B. G. (2016). Comparative study of different capsicum varieties under open and protected conditions. *Plant Archives*, **16**, 931–933.

Moniruzzaman, M., Islam, M. R., & Hasan, H. (2008). Effect of N, P, K, S, Zn and B on yield attributes and yield of French bean in south eastern hilly region of Bangladesh. *Journal of Agriculture and Rural Development*, **6**, 75–82.

Mozumder, S. N., Moniruzzaman, M., Islam, M. R., & Alam, S. N. (2003). Effect of planting time and spacing on the yield performance of bush bean (*Phaseolus vulgaris* L.) in the eastern hilly area of Bangladesh. *Legume Research*, **26**, 242–247.

Panchbhaiya, A., Singh, D. K., Jatav, V., Sanganamoni, M., & Verma, P. (2017). Variability, heritability and genetic advance for yield and yield contributing characters in French bean (*Phaseolus vulgaris* L.) germplasm under tarai region of Uttarakhand. *Journal of Applied and Natural Science*, **9**, 1926–1930.

Panigrahi, J., Kumar, D. R., Mishra, M., Mishra, R. P., & Jena, P. (2007). Genomic relationships in the genus *Cajanus* as revealed by seed protein polymorphisms. *Plant Biotechnology Reports*, **1**, 109–116. https://doi.org/10.1007/s11816-007-0013-8

Pooja, B. G., & Abdul Hakkim, V. M. (2017). *Comparative evaluation of naturally ventilated polyhouse and rainshelter on the performance of tomato* (Master's thesis). Kelappaji College of Agricultural Engineering and Technology.

Prakash, J., & Ram, R. B. (2014). Genetic variability, correlation and path analysis for seed yield and yield related traits in French bean (*Phaseolus vulgaris* L.). *International Journal of Innovative Science, Engineering and Technology*, **1**, 41–50.

Santosh, D. T. (2021). Response of horticultural crops under variable microclimatic conditions of different protected cultivation structures. *International Journal of Agricultural Sciences*, **17**, 515–521.

Savin, R., & Nicolas, M. E. (1996). Effect of short periods of drought and high temperature on grain growth and starch accumulation of barley. *Australian Journal of Plant Physiology*, **23**, 201–210.

Sharma, B. K., Kushwah, S. S., Verma, K. S., & Singh, O. P. (2013). Studies on French bean (*Phaseolus vulgaris* L.) varieties under different nutrient levels. *Journal of Horticultural Science*, **8**, 268–270.

Singh, A. K., Singh, A. P., Singh, S. B., & Singh, V. (2009). Relationship and path analysis for green pod yield in French bean. *Legume Research*, **32**, 270–273.

Singh, S. P. (1999). Improvement of small-seeded race Mesoamerican cultivars. In S. P. Singh (Ed.), *Common bean improvement in the twenty-first century* (pp. 225–274). Springer. https://doi.org/10.1007/978-94-015-9211-6_10

Sofi, P. A., Zargar, M. Y., Debouck, D. G., & Graner, A. (2011). Evaluation of common bean (*Phaseolus vulgaris* L.) germplasm under temperate conditions. *Journal of Phytology*, **3**, 47–52.

Subedi, S., Gautam, I. P., Pradhan, N. G., Ghimire, D., & Thapa, S. (2022). Evaluation of French bean genotypes for spring season planting in mid hills of Nepal. *Nepalese Horticulture*, **16**, 36–44.

Whankate, R. A., Garande, V. K., Shinde, U. S., Dhumal, S. S., Sonawane, P. N., Sarvade, S. A., & Ambad, S. N. (2021). Growth and yield performance of French bean (*Phaseolus vulgaris* L.) germplasm under sub-montane zone of Maharashtra. *Legume Research*, **44**, 138–144. https://doi.org/10.18805/LR-4249

Zelaing, P. K., Kumar, M., Kumar, R., Meena, K. L., & Rajkowa, D. J. (2018). Varietal evaluation of French bean for higher productivity under foot hill ecosystem of Nagaland. *Indian Journal of Hill Farming*, **31**, 206–213.