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Effect of different spacing on growth and yield of bell pepper (*Capsicum annuum* L.) hybrid Bomby grown under protected conditions

Priya Thakur and Shalini Singh

Abstract
One of the very profitable vegetable crops grown in polyhouses is the bell pepper (*Capsicum annuum* L.). In recent years, it has gained the position of a valuable crop in India and it now ranks among the most delectable and pleasant-tasting vegetables in Indian food. It has a strong nutritional profile, with a high vitamin and mineral content. Since plant spacing is an important feature of successful crop production in both open and protected environments. The best plant spacing promotes healthy plant development and growth, which maximises agricultural yield and makes efficient use of the area. A study was conducted to evaluate the effect of different spacing on growth and yield of bell pepper hybrid 'Bomby' under protected conditions at Experimental Research Farm Chhapang of Dr. Khem Singh Gill, Akal College of Agriculture, Eternal University, Baru Sahib. The research trial consisted of three different spacings (60 × 30 cm, 60 × 45 cm and 60 × 60 cm). The results revealed that among different spacings, S_3 (60 × 60 cm) was superior in most of observed parameters under the study viz., number of primary branches per plant, stem diameter (cm), stem girth (cm), intermodal distance (cm), fruit length (cm), fruit breadth (cm), fruit weight (g) followed by S_1 (60 × 30 cm) which was the second desirable spacing being superior for plant height, flower initiation and S_2 being superior for fruit yield per m^2 (kg). Therefore, spacing of 60 × 60 cm for bell pepper production under protected condition is optimal and can be used by growers to increase yield.

Keywords: Bell pepper, growth, spacing, yield

Introduction
Bell pepper (*Capsicum annuum* L.) is one of the most popular vegetable crops grown in polyhouse also known as capsicum, Shimla mirch or sweet pepper. It belongs to the family Solanaceae with chromosome number (2n=2x=24). Its primary centre of origin is Tropical South America and Guatemala being its secondary centre of origin (Jakhar *et al*., 2017; Heiser and Smith, 1953) [7, 5]. In the 19th century, the British introduced it to India in the Shimla Hills. It is one of the highly profitable vegetables cultivated in various areas of the world which are mostly in European countries, Central and South America and tropical and subtropical regions of Asia (Shivakumar *et al*., 2012) [15]. The mature fruits (red, yellow and green) of bell pepper are eaten raw as salads or used frequently in stuffings, baking, burger and pizza preparations due to its mild pungency and taste. Bell pepper is used as vegetable as well as condiment (Jakhar *et al*., 2017) [7].

One-fourth of the world's bell pepper crop comes from India with an average annual production of 515 thousand million tonnes from an area of 34 thousand hectares with an average productivity of 15.147 tonnes/hectare (NHB 2019-2020) [13]. It is largely cultivated in Karnataka, Himachal Pradesh, Uttarakhand, Jammu & Kashmir, Haryana, Jharkhand, Maharashtra and Madhya Pradesh. In Himachal Pradesh bell pepper growing area is about 2.5 thousand hectares with total production of 58.29 thousand million tonnes (NHB 2019-20) [13]. It is largely cultivated in Shimla, Solan, Sirmour and Mandi districts. In some areas of India bell pepper is cultivated year-round in greenhouses, including Himachal Pradesh, Maharashtra and Karnataka.

Due to its delicate flavour, pleasant aroma and high ascorbic acid, vitamin and mineral content, bell pepper has recently become a high value crop in India and has taken pride of place among vegetables in Indian cuisine. It has high nutritional profile, being rich source of vitamin A (8493 IU), Vitamin C (283 mg) and minerals like magnesium (14.9 mg), calcium (13.4 mg), potassium (263.7 mg) and phosphorus (28.3 mg) per 100 g fresh fruit weight (Thakur *et al*., 2018) [18].

Additionally, it is a good source of carotene and capsanthin, which make up around 36% of the carotenoid content overall. Due to the high levels of antioxidant, capsaicin and capsanthin as the primary active ingredients, it is one of the most important medicinal plants in the pharmaceutical industry (Aminifard *et al*., 2012) [1].

It is a warm-season crop but it can be grown all year round under protected conditions. The basic temperature required for the growth and development of crop is about 25 to 35 °C which can be met up in protected structures where excessive deviation of the temperature can be avoided providing congenial microclimate for the precocity of the crop (Omer 2016) [14]. The major goals of growing capsicum in a polyhouse are to protect the crop from pests, diseases, temperature, humidity and light in order to assure year-round production of premium quality capsicum, particularly during the off-season. Capsicum production in polyhouses improves crop quality while also increasing productivity (Kumar *et al*., 2018) [9, 10, 11, 17, 18].

One of the crucial components of effective crop production is plant spacing. The best plant spacing promotes healthy plant development and growth, which maximises agricultural yield and makes efficient use of the area (Athira and Rani, 2020) [2]. Wider plant row spacing in polyhouse enhances plant yield per plant but reduces crop production per unit area (Islam *et al*., 2011) [6]. Higher plant density decreases fruit weight from early yield, which is linked to fruit size and is very significant because it affects sweet pepper prices (Sangma *et al*., 2018) [17].

Materials and Methods

In this investigation entitled "Effect of different spacing on growth and yield of bell pepper (*Capsicum annuum* L.) hybrid Bomby grown under protected conditions" was conducted under polyhouse condition during Kharif, 2021 at Experimental Research Farm Chhapang of Dr. Khem Singh Gill, Akal College of Agriculture, Eternal University, Baru Sahib-173101 (H.P.). Three different treatments, each replicated three times, were used in the experiment's Randomized Block Design (RBD). The treatment consists of three different spacings (60 × 30 cm, 60 × 45 cm and 60 × 60 cm). Plot size was 2 × 1 m. The total number of plots were 9. Bomby hybrid of Syngenta Private Limited was the planting material used in the experimental trail. Geographically, the Experimental Research Farm Chhapang, Eternal University Baru Sahib173101 (H.P.), India is located 4 km away from the university headquarters and is situated at 30.730 latitude in the North and 77.310 longitude in the East at an elevation of 898 m above the mean sea level. The farmland lies in the sub-temperate sub-humid mid-hill agro-climatic zone of Himachal Pradesh. The Experimental Farm's climate is generally sub-tropical to sub-temperate. The area receives an average of 985.80 mm of rain per year, the most of which falls during the Southeast monsoon season (June-September). The polyhouse was naturally ventilated and measured 25 meters in length, 20 meters in width and 15 meters in height.

Results and Discussion

Vegetative Parameters

The study's findings showed that plant spacing S_1 (60×30 cm) significantly increased the plant height with maximum of 127.76 cm followed by S_2 (123.84 cm), while lowest value for plant height was obtained in S_3 i.e., 119.24 cm. According to the findings, different treatments had a substantial impact on the number of primary branches per plant. Highest number of primary branches per plant (8.71) were found under the plant spacing of S_3 (60×60 cm) which was significantly superior over the other spacing levels and was followed by S_2 (60×45 cm) i.e., 8.02. However, the least number of branches per plant were recorded under S_1 (7.42). Examination of data showed that the plant spacing of S_3 (60×60 cm) recorded for minimum desirable internodal distance of 4.18 cm and was statistically similar with S_2 (60×45 cm) which recorded for 4.47 cm of internodal distance. The findings revealed that different plant spacing had significant effect on the stem diameter of bell pepper. Maximum value of 1.44 cm was recorded under the treatment of S_3 (60×60 cm) followed by 1.36 cm in S_2 (60×45 cm), while the minimum of 1.28 cm was observed under S_1 (60×30 cm). After examining the data revealed it was observed that the treatment of S_3 (60×60 cm) significantly improved the stem girth over the rest of the treatments with maximum of 5.20 cm followed by S_2 (4.69 cm), whereas, the lowest stem girth of 4.39 cm was recorded under the treatment of S_1 (60×30 cm).

Table 1: The effect of different spacing on vegetative parameters of bell pepper (*Capsicum annuum* L.)

Treatment (Spacing)	Plant Height (cm)	Number of primary branches per plant	Internodal Distance (cm)	Stem Diameter (cm)	Stem Girth (cm)
S_1(60×30 cm)	127.76	7.42	4.78	1.28	4.39
S_2(60×45 cm)	123.84	8.02	4.47	1.36	4.69
S_3(60×60 cm)	119.24	8.71	4.18	1.44	5.20
SEm (S)	0.800	0.079	0.102	0.010	0.047
$CD_{0.05}$ (S)	2.419	0.240	0.310	0.031	0.142

In the current investigation, S_3 (60 × 60 cm) was shown to be significantly superior for all vegetative characters, with the exception of plant height, which was reported to have the highest significant value in the case of S_1 (60 × 30 cm). This could be due to the availability of more spreadable space, more moisture and nutrients, and more sunlight compared to other plant spatial arrangements, resulting in higher plant vegetative development. This response of plant height, on the other hand, could be owing to strong competition for light and space, driving plants to grow taller and produce shorter and stout plants at wider spacings due to the availability of more growth. Nandeshwar and Bharad 2019 [12], Kumar and Rana 2018 [9], Sangma *et al*. 2018 [17], Thakur *et al*. 2018 [18], Sharma *et al*. 2016 [16] all concurred with the current findings. However, the current findings of plant height and stem diameter contradict the findings of Ganjare *et al*. 2013 [4] and Nandeshwar and Bharad 2019 [12], respectively.

Quantitative Parameters

According to the findings, earliest flower initiation (54.56 days) was observed when the plants were planted at a spacing of S_1 (60×30 cm) followed by S_2 (60×45 cm) which took

56.67 days for flower initiation. Whereas, flower initiation was delayed in S_3 (60×60 cm) i.e., 57.11 days. After closely examining the data, it revealed that plant spacing of S_3 (60×60 cm) recorded for maximum fruit length (7.46 cm) but was found statistically at par with S_2 (60×45 cm) which recorded for 7.28 cm of fruit length. While the lowest fruit length of 6.75 cm was observed in S_1 (60×30 cm) treatment. The study's findings demonstrated that the plant spacing of S_3 (60×60 cm) significantly increased the fruit breadth with the maximum of 7.78 cm followed by S_2 (7.47 cm). However, the lowest value of fruit breadth (7.09 cm) was associated with the treatment of S_1. The results of the study revealed that plant spacing of S_3 (60×60 cm) was significantly superior over the other two spacing levels as it reported for maximum fruit weight of 184.90 g followed by S_2 (162.79 g) and minimum fruit weight was recorded under S_1 (156.95 g). The results revealed that plant spacing of S_2 (60×45 cm) recorded for maximum fruit yield per m^2 (9.92 kg) and was found significantly superior over the rest of the treatments. However, it was followed by S_1 (60×30 cm) i.e., 9.21 kg and lowest value for the same was observed in S_3 (60×60 cm) i.e., 8.80 kg.

Table 2: The effect of different spacing on quantitative parameters of bell pepper (*Capsicum annuum* L.)

Treatment (Spacing)	Flower Initiation (days)	Fruit Length (cm)	Fruit Breadth (cm)	Fruit Weight (g)	Fruit yield per m^2 (kg)
S_1(60×30 cm)	54.56	6.75	7.09	156.95	9.21
S_2(60×45 cm)	56.67	7.28	7.47	162.79	9.92
S_3(60×60 cm)	57.11	7.46	7.78	184.90	8.80
SEm (S)	0.317	0.064	0.074	1.225	0.064
$CD_{0.05}$ (S)	0.958	0.194	0.225	3.703	0.193

For traits contributing towards yield, desired significant value among all the three spacings for flower initiation was recorded in S_1 (60 × 30 cm). However, plants at low plant spacing on the other hand, experienced less vegetative growth, resulting in an earlier entry into the reproductive stage, a faster maturity and a longer fruit-producing period. Kumar and Rana 2018 [9], Sangma *et al*. 2018 [17], Kaur *et al*. 2017 [8] and Ganjare *et al*. 2013 [4] also reported the similar results as in the present study. For other yield influencing characters like fruit length, fruit breadth and fruit weight, spacing responded significantly where S_3 (60 × 60 cm) was superior. This could be owing to the fact that there were more shoots, which contributed to the production of a greater number of fruits. Another reason could be that at wider spacing, there is less competition for the limited supply of water and soil-derived mineral nutrients, as well as light, resulting in the accumulation of sufficient photosynthates, allowing the fruits to grow in size (length and breadth), resulting in increased fruit weight. Athira and Rani 2020 [2], Kumar and Rana 2018 [9], Kumar *et al*. 2018, Sangma *et al*. 2018 [17], Islam *et al*. 2011 [6] and Shivkumar *et al*. 2012 all found similar results. S_2 (60 × 45 cm) was found to be superior for fruit yield per m^2. The reason for this might result from a greater plant population in spacing S_2 than S_3, as well as more fruits per plant and higher fruit weight in S_2 than in S_1, despite the fact that the number of plants in S_1 was higher. The findings of Athira and Rani 2020 [2], Nandeshwar and Bharad 2019 [12], Kumar and Rana 2018 [9], Kumar *et al*. 2018 [9, 10, 11, 17, 18], Sangma *et al*. 2018 [17], Ganjare *et al*. 2013 [4] and Aminifard *et al*. 2012 [1] all support the present results.

Conclusion

After a thorough investigation and data observation taken on the concerned parameters it was found that in the present study among all the three spacings, S_3 (60 × 60 cm) was found to be significantly superior for vegetative characters like number of primary branches per plant (8.71), stem diameter (1.44 cm), stem girth, (5.20 cm) and intermodal distance (4.18 cm). However, for plant height (127.76 cm) spacing S_1 (60 × 30 cm) was found significantly superior. For traits contributing towards yield, desired significant value among all the three spacing for flower initiation (54.56 days) was recorded in S_1 (60 × 30 cm) and the second-best value for these characters was observed with S_2 (60 × 45 cm). For other yield influencing characters like fruit length (7.46 cm), fruit breadth (7.78 cm), fruit weight (184.90 g), maximum significant value among all spacing levels was observed in S_3 (60 × 60 cm). S_2 (60 × 45 cm) for fruit yield per m^2 (9.92 kg) respectively. As a result, for bell pepper production in polyhouse, a spacing of 60 × 60 cm is excellent and can be utilized by bell pepper growers to improve yield under protected conditions with efficient use of land.

References

1. Aminifard MH, Aroiee H, Ameri A, Fatemi H. Effect of plant density and nitrogen fertilizer on growth, yield and fruit quality of sweet pepper (*Capsicum annum* L.). African J Agric. Res. 2012;7(6):859-866.
2. Athira RC, Rani TS. Effect of fertigation levels and different spacings on yield and yield attributes of bell pepper (*Capsicum annuum* L. var. *grossum*) IJEAB. 2020;5(4):898-900.
3. Biwalkar N, Singh KG, Jain AK, Sharda R, Jindal SK, KS, Chawal N. Response of coloured sweet pepper (*Capsicum annuum* var. *grossum*) to fertigation and irrigation levels under naturally ventilated greenhouse. Agric. Res. J. 2015;52(1):19-25.
4. Ganjare H, Futana NW, Dagwar S, Kurhade K. Growth and yield characters of capsicum in response to planting distance and sources of nutrients. Scholarly J of Agric. Sci. 2013;3(9):386-390.
5. Heiser CB, Smith PG. The cultivated capsicum peppers. Econ. Bot. 1953;7:214-227.
6. Islam M, Saha S, Akand MH, Rahim MA. Effect of spacing on the growth and yield of sweet pepper (*Capsicum annuum* L.). J Cent. Eur. Agric. 2011;12(2):328-335.
7. Jakhar RS, Singh AK, Kumawat N. Performance of capsicum cultivars (*Capsicum annuum* L.) grown under shade net and open field in Arid Ecosystem of Rajasthan. Environ. Eco. 2017;35(IA):290-294.
8. Kaur R, Singh SK, Raturi HC. Effect of different levels of fertigation and foliar application of nutrients on capsicum (*Capsicum annuum* var. *grossum*) grown in

soilless media under polyhouse conditions. J Pharmacogn. Phytochem. 2017;6(6):1770-1773.
9. Kumar A, Rana SS. Effect of spacing and nitrogen level on growth and yield of bell pepper (*Capsicum annuum* L.) under dry temperate climate of Western Himalayas. J Crop. Weed. 2018;14(1):78-81.
10. Kumar S, Patel NB, Saravaiya SN. Analysis of bell pepper (*Capsicum annuum*) cultivation in response to fertigation and training system under protected environment. Indian J Agric. Sci. 2018;88(7):1077-1082.
11. Kumar S, Singh N, Chaudhari DJ. Profitability of capsicum cultivation under protected condition. Chem Sci Rev Lett. 2018;7(28):900-904.
12. Nandeshwar VN, Bharad SG. Effect of planting geometry and fertigation levels on growth, yield and quality of chilli. J Krishi Vigyan. 2019;8(1):63-69.
13. NHB. Indian Horticulture Database. National Horticulture Board (NHB); c2020. http://www.nhb.govt.in
14. Omer AM. Greenhouses for food production and the environment. Global J Tech. Opt. 2016;7(1):190.
15. Shivakumar, Hussain SA, Kurubar AR, Patil MG. Yield and yield parameters of bell pepper under different spacing and fertilizers levels in shade net. Asian J. Hort. 2012;7(2):246-249.
16. Sharma V. Effect of NPK fertilizers on capsicum production inside low-cost polyhouse. Int. J Sci. Environ. Tech. 2016;5(4):2120-2125.
17. Sangma SS, Kumar AB, Longdo R, Kayia A, Khonglah L, Warade SD. Response of capsicum (*Capsicum annuum* L. var. *grossum*) to different levels of spacing and training systems under foot hills of Arunachal Pradesh. Int. J Agric. Environ. Biotech. 2018;11(2):327-332.
18. Thakur G, Singh AK, Kumar MP, Patel P, Kumar U. Effect of plant spacing on growth, flowering, fruiting and yield of capsicum (*Capsicum annuum* L.) hybrid Buffalo under natural ventilated polyhouse. J Pharmacogn. Phytochem. 2018;SPI:78-81.