

Effect of Plant Spacing and Training on Fruit Quality of Capsicum (*Capsicum annuum* L) under Protected conditions

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ABSTRACT: Sweet pepper belongs to the family solanaceae. That is the world's 2nd most significant vegetable, after the tomato. Plant spacing and sowing date are significant characteristics of several agricultural production systems. During September 2016 to 2017, the experiment was conducted at Hi-Tech Horticulture, Dr. RPCAU Pusa, Samastipur, Bihar, with the effect of plant spacing and training on fruit quality of capsicum (*Capsicum annuum* L) under protected conditions. The research design was used to analysis the data factorial RBD with thrice replication with three levels of spacing and training. Under S₃P₁ (45 cm × 60 cm + two shoots), the maximum length of fruit, breadth of fruit, volume of fruit, fruit shelf life, rind thickness, A⁺ and 'A' grade fruits were found among the various combinations of spacing and training level. At all crop growth stages, maximum 'B' grade fruits were recorded in S₁P₁ (45 cm × 30 cm + two shoots), whereas highest 'C' grade fruits were reported in S₁P₃ (45 cm × 30 cm + four shoots). Hence, I have suggested for future, the intermediate spacing, with four shoots of training levels should be follow for maximum yield with better quality of capsicum fruit as well as economic benefit for growers.

Keywords: Sweet pepper, training, Plant spacing, protected conditions.

INTRODUCTION

Sweet pepper belongs to the family solanaceae. The crop has immense commercial dietary and therapeutic values (Sahani *et al.*, 2020). It is a valuable vegetable and condiment crop that is cultivated all year. It is now grown extensively throughout South America, including Bolivia and Peru as well as almost every European country, Hong Kong, and Italy. The most of sweet peppers grown in tropical and temperate climates species *Capsicum annuum*, which is believed to have originated in Mexico and Central America (Andrews *et al.*, 1984). It is used to flavour, soups and stews and contains vitamins A, C, and E. 100 g edible capsicum contains 24 calories, 1.3 g protein, 0.3 g fat, and 4.3 g carbohydrates (Anon., 2001). Pepper is grown as a secondary crop on traditional smallholder farms, with row spacing determined by the types and numbers of major crops in a typical mixed cropping system (Awodoyin, 2005). The acreage and production of bell peppers have been blended with those of hot peppers

around the world (chilli pepper). As a result, complete statistics for bell pepper/chilli are provided. India being a world largest producer, consumer and exporter of chilli. Sweet pepper is the third important vegetable crop of family Solanaceae after tomato and potato (Naz *et al.*, 2006). India produces approximately of 327 thousand tonnes from a land area of 46 thousand hectares with a productivity of 7108.70 kg/ha (Anon., 2017). In recent years, capsicum has risen to the status of a more value, less-volume crop in India, and it is regarded as one of the most delicious and pleasant-tasting vegetables in Indian meal, thanks to its fragility and pleasant aroma as well as its high amount of ascorbic acid and other vitamins and minerals reported by the Indian government (Kurubetta and Patil 2009). The find out of new approaches led to the creation of high-tech precision agriculture systems. Protected structure, India's newest trend in agriculture, are one of these approaches, in which plants are cultivated in a controlled or moderately controlled environment, resulting in maximum yields than in open environment.

When plants are rowed under cover, they generate higher-quality product. As a result, the grower might get a greater price, which is beneficial to him. If the producer uses protected cultivation, it is also possible to sell the food in the market when there is a high demand for it. In a controlled situation, growers can develop a crop at any time of year as long as they can maintain the temperature, humidity, or light that the plant species needs.

MATERIALS AND METHODS

From September 2016 to September 2017, an experiment was carried at Dr. RPCAU Pusa Hi-Tech Horticulture in Samastipur, Bihar. The spacing among capsicum seedling beds was two rows on a one-metre-wide bed with a 50-centimetre line between the two beds, to three spacing levels S_1 (45 × 30 cm), S_2 (45 × 45 cm), S_3 (45 × 60 cm) and three training levels P_1 (two shoots/plant), P_2 (three shoots/plant), and P_3 (four shoots/plant) as well as three training levels P_1 (two shoots/plant). A three-replication factorial randomized block design was used to set up the experiment. Observations were recorded on five randomly selected tagged fruits from each treatment, and the fruit length was measured from the stem end to the distal end. The maximum breadth, length, and rind thickness of five fruits from every treatment was determined with the help of vernier caliper calculated and express in cm. The volume of fruit was measured using the water displacement method on five randomly selected fruits. The fruits had been dipped into a jar of water, the displaced water was recorded using a measuring cylinder, and the average value was taken and expressed in cubic centimeters (cc). Selected fruits were stored at room temperature until they were still fresh and of acceptable quality. To express the shelf life in days, the number of days was evaluated and recorded.

Fruit grade (%) of capsicum. The capsicum fruits were classified into different quality grades based on their size into the following groups:

Sr. No.	Grade	Fruit weight
1.	A ⁺	More than 200 g
2.	A	150 - 200 g along with four lobes
3.	B	100 - 150 g
4.	C	Less than 100 g

RESULTS AND DISCUSSION

A. Fruit length and Fruit breadth

The relationship among both capsicum spacing with training levels, the largest number of fruit lengths were found under S_3 (45 cm × 60 cm) spacing with P_1 (two shoots) levels of training and that were at par with to $S_2 P_1$ (45 cm × 45 cm + two shoots), $S_2 P_2$ (45 cm × 45 cm + three shoots), $S_2 P_3$ (45 cm × 45 cm + four shoots), $S_3 P_2$ (45 cm × 60 cm + three shoots), $S_3 P_3$ (45 cm × 60 cm + four shoots), and

cm + four shoots), and considerably superior than other treatment. At 90 DAP, among the combination within spacing and training levels resulted in maximum fruit breadth noticed under P_1 (two shoots) training under S_3 (45cm × 60cm) spacing levels that was statistically equivalent to S_2P_1 (45 cm × 45 cm + two shoots), S_3P_2 (45 cm × 60cm + three shoots), and S_3P_3 (45 cm × 60cm + four shoots), and considerably superior to the all treatments. This could be attributed to higher nutrient availability, plant spacing, and fewer shoots compared to another training levels. Same findings in capsicum had been founded by Cebula, (1995).

B. Fruit volume (cc)

There was a substantial interaction between spacing and training levels. Under the spacing level S_3 (45 cm × 60 cm) with levels of training P_1 (two shoots) produced one of most fruit volume (318.75 cc/fruits), which was statistically comparable to S_2P_1 (45 cm × 45cm + two shoots) and statistically superior rest of the treatment. This could be because pruning resulted in highest fruit weight compared to unpruned plants, which is due to a sufficient supply of metabolites to the minimum number of fruits. Similar results have been founded by Patil *et al.*, (1973).

C. Rind thickness (cm)

There was a substantial interaction within spacing and training levels. The largest numeral value of rind thickness (0.85 cm) had been seen in spacing S_3 (45 cm × 60 cm) with levels of training P_1 (two shoots), that was statistically comparable to S_2P_1 (45 cm × 45 cm + two shoots), S_3P_2 (45 cm × 60 cm + three shoots), as well as considerably superior to the rest treatment. This could be attributed to the plant having better nutrient availability, wider spacing, and fewer shoots than other P_2 and P_3 training level. Among different spacing levels of rind thickness of capsicum, the highest rind thickness was recorded, which was significantly superior over other treatments. This might be due to bigger size of fruits under naturally ventilated Polyhouse. The rind thickness of fruit was positively correlated with fruit size (Thakur *et al.*, 2018).

D. Shelf- life (days)

Under spacing S_3 (45 cm × 60 cm) and levels of training P_1 (two shoots) had the maximum number of shelf life, which had been statistically comparable to S_1P_1 (45 cm × 30 cm + two shoots), S_2P_1 (45 cm × 45 cm + two shoots), S_2P_2 (45 cm × 45 cm + three shoots), S_2P_3 (45 cm × 45 cm + four shoots), S_3P_2 (45 cm × 60 cm + three shoots), S_3P_3 (45 cm × 60 cm + four shoots) rest of treatment. It could obtained attributed to increased nutritional availability, wider spacing, fewer shoots than other P_2 and P_3 training level and larger fruits with thicker pericarps.

Table 1: The interaction effect of various level of plant spacing with training of fruit breadth, length of fruit, rind thickness, volume of fruit and Self-life of capsicum at crop growth stage.

Treatment	Fruit length (cm)			Fruit breadth (cm)			Volume of fruit (cm ³)			Rind thickness (cm)			Self-life(days)		
	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃
P ₁	8.75	9.50	9.65	6.85	7.25	7.45	297.50	313.15	318.75	0.62	0.74	0.85	6.60	7.10	7.65
P ₂	8.30	9.35	9.40	6.70	7.00	7.25	290.35	292.60	296.15	0.56	0.65	0.72	6.00	6.80	6.99
P ₃	8.10	9.15	9.20	6.40	6.90	7.10	287.65	290.10	283.90	0.50	0.60	0.67	5.85	6.50	6.90
S.Em (±)	0.20			0.13			6.16			0.04			0.41		
LSD (0.05)	0.59			0.38			18.46			0.13			1.23		
CV%	3.80			3.15			3.59			11.05			10.60		

E. A⁺ and 'A' grade fruits

There was a substantial interaction between spacing and training levels. Under levels of training P₁ (two shoots), the largest number of 'A⁺ fruits (7.10) were recorded under spacing level S₃ (45 cm × 60 cm), which was considerably highly significant to rest treatments. Under various level of spacing S₃ (45 cm × 60 cm) with training levels P₁ (two shoots) produced the highest 'A' quality fruits, which was statistically comparable to S₂P₁ (45 cm × 45 cm + two shoots), S₃P₂ (45 cm × 60 cm + three shoots), and considerably superior to the all over the treatment. This could be attributed to the plant having better nutrient availability, wider spacing, and fewer shoots than other P₂ and P₃ training level. This result has been justified by Thakur *et al.*, (2018).

F. 'B' and 'C' grade fruits

There was a substantial interaction among spacing and training levels. Under P₁ training levels, the highest percentage of 'B' grade fruits (54.75 fruits) were recorded in S₁ (45 cm 30cm) spacing, and that was statistically comparable to S₁P₂ (45 cm 30cm+three shoots) and significantly superior to the rest treatment. Within the various level of, spacing S₁ (45 cm 30 cm) under levels of training P₃ (four shoots) produced the maximum amount of 'C' quality fruit, that was significantly superior to the rest treatment. This could be owing to a lack of more area to spread, including more moisture, nutrients, and solar radiation, as relative to other spacing S₂ and S₃.

Table 2: The interaction effect on various level of plant spacing and training on different type of fruit grade (%) of capsicum.

Treatment	A ⁺ (%)			A (%)			B (%)			C (%)			B : C ratio		
	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃	S ₁	S ₂	S ₃
P ₁	4.25	5.75	7.10	15.50	25.60	28.15	54.75	43.50	45.10	25.50	25.15	19.65	3.12	4.43	4.53
P ₂	4.00	5.00	6.55	13.70	23.90	26.49	47.35	40.60	42.20	34.95	30.50	24.75	3.98	5.43	5.32
P ₃	3.75	4.65	5.80	12.90	22.10	24.90	39.14	38.15	40.10	44.20	35.76	29.28	5.42	6.92	6.30
S.Em (±)	0.41			1.03			2.50			1.66			0.27		
LSD (0.05)	1.23			3.10			7.51			4.98			0.81		
CV%	13.59			8.34			9.99			9.60			10.09		

CONCLUSION

Sweet pepper belongs to the family solanaceae. This is the world's largest second most valuable vegetable, behind the tomato. Plant spacing and sowing date are important aspects of several agricultural production systems. The following results can be obtained from an experiment on the interaction effect of plant spacing and training on fruit quality of capsicum (*Capsicum annuum* L) under protected conditions. A⁺ and 'A' grade fruits were recorded at the highest levels under S₃P₁ (45 cm × 60 cm + two shoots) in terms of many kinds of features such as length as well as width fruit, fruit volume, rind thickness, and shelf life. At all crop growth stages, maximum 'B' grade fruits were recorded in S₁P₁ (45 cm × 30 cm + two shoots), whereas maximum 'C' grade fruits were reported in S₁P₃ (45 cm × 30 cm + four shoots).

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Conflict of Interest. None.

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