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HORTICULTURE

Response of Capsicum (*Capsicum annuum* L. Var. *Grossum*) to Different Levels of Spacing and Training Systems under foot hills of Arunachal Pradesh

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ABSTRACT

The present investigation entitled "Response of capsicum (*Capsicum annuum* L. var. *grossum*) to different levels of spacing and training system under foot hills of Arunachal Pradesh". The experiment was laid out in two factorial RBD using three replications with three levels of spacing and training. The standard cultural practices were done regular interval for better crop growth and good yields. The closer spacing resulted in maximum plant height, LAI, and total yield per plot and wider spacing recorded maximum number of branches, number of leaf, earliness in fruit flowering and fruit set and yield per plant. Among all levels, two shoot training showed maximum plant height, minimum days required to first flowering, first fruit set, days to first harvest and size of fruit and four shoots resulted in maximum number of branches, number of leaf, LAI, fruits per plant (10.06), yield per plant (0.54 kg) and yield (0.75 Kg/m^2). Among all interactions, closer spacing with four shoot training produced more number of branches and leaves per plant resulted in maximum of per plant and per plot yield due to more number of shoots contributed in producing more number of fruits. In contrast, wider spacing with two shoot training produced highest plant height, early flowering and fruit set. The quality parameters and fruiting percentage had not significant to interaction of both training and spacing. It is concluded that for higher yield of capsicum under polyhouse conditions, the closer spacing with four shoots training maybe suggested for foot hills of Himalayas.

Highlights

- Four shoots with closer spacing positively correlated with yield per unit area but wider spacing and less no. of shoots produced higher yield per plant.

Keywords: Training, Spacing, Performance, Morphology, Levels

Capsicum (*Capsicum annuum*L. var. *grossum* Sendt., 2n=24), commonly known as sweet pepper belongs to the family Solanaceae and is believed to be native of Tropical South America (Shoemaker and Teskey 1995). In India, bell pepper occupies an area of 29 thousand hectare with production of 159 thousand mt (Anon 2014). In Arunachal Pradesh, the average production of vegetables is 37.56 thousand mt from an area of 1.52 thousand hectare (Anon 2014). Capsicum attained a status of high value crop in India in recent years and nutritionally bell pepper rich in vitamins particularly vitamin A (180 IU) and vitamin C and minerals.

Protected cultivation of vegetable offers distinct

advantage of quality, productivity increases income in off- season as compared to normal season (Nair and Barche 2014). An attempt has been made to standardize the production technology of capsicum under protected cultivation in NEH region to ensure its regular and off-season supply. The growth, fruit yield and quality attributes profoundly influenced by cultural practices such as spacing and training system. Plant spatial arrangement is a crop management practice that has been used to increase yield per unit area in polyhouse grown sweet pepper. Planting distance plays an important role in checking the growth of plant, improving fruit characteristics and increasing the yield. The Optimum plant spacing ensures proper growth and development resulting maximum yield of crop and economic use of land. The wide row spacing of plants increases per plant yield but decreases crop production per unit area in polyhouse (Islam *et al*. 2011). Higher plant density reduced fruit weight from early yield which is associated with fruit size, is of great importance because it determines prices for sweet pepper.

The training and pruning system also plays an important role for providing better framework to the crop and to minimize the crop load. In commercial polyhouse grown pepper, fruit development is controlled by restricting the branching pattern to 2, 3 or 4 main stems. The reason for pruning sweet pepper under greenhouse condition is for training plant to facilitate light penetration on entire leaf canopybut will help in getting early and higher yields. Moreover, pruning is effective in improving air circulation which reduces relative humidity and limits the spread of diseases (Abdullah *et al*. 2013). It also helps in air circulation to minimize the incidence of pests and diseases for the production of good quality and marketable fruits.

Considering the above facts, the present study was conceded to simplify the optimum plant density, pruning system and their interaction on capsicum grown under protected conditions.

MATERIALS AND METHODS

The present experiment was carried out in Polyhouse Complex, College of Horticulture and Forestry (CAU), Pasighat, Arunachal during 2014-15. The experiment was laid out in Factorial Randomized Block Design (F-RBD) using three levels of spacing (50 × 60cm, 50 × 50cm and 50 × 40cm row to row and plant to plant) and three levels of training systems (2, 3 & 4 main stems) as shown in table 1. The total number of factorial levels combination is replicated into three times each. There were total 40 no. of plots with each plot having a size of 3.6 m^2 (3.6 × 1m). The seedlings were transplanted according to the spacing given and Standard cultural practices adopted, 40-50 days after transplanting to allow crop in vertical manner.

The seeds were sown in plug trays in the month of August. The selected polyhouse has an area of 320 m^2. The land was ploughed properly and brought to a fine tilth. Raised beds of 1m width, 3.6 m length and 20cm height were prepared. The one month to 40 days old seedlings were transplanted into main field of polyhouse complex by ensuring three levels of spacing's (50×60cm, 50×50cm and 50×40cm row to row and plant to plant). The planting system followed was 'V' shaped so as to acquire 11, 15 and 19 plants/plot respectively. The irrigation was given immediately after transplanting and continued 10 days interval for standing crop by using drip irrigation system along with fertilization tank. Thereafter, recommended dose of inorganic and organic fertilizers applied as basal dose and urea at the rate 0.2 Kg/m^2 was given two times to the standing crop at one month interval. The cultural practices were done regular interval to minimize dependence on chemicals for plant protection and weed control.

Primary branches give rise to secondary branches (one primary branch giving rise to two secondary branches) by adopting three levels of training systems (two stem, three stem and four stem) were used for better crop growth and good yields. Training of plant started from 45-50 days after planting. The number of plants five, selected randomly from each plot for analyzing plant growth, and reproductive characters of plants. 10 fruits from each replication were taken to calculate quality characteristics i.e., fruit weight, length, diameter, volume, and yield parameters i.e., yield per plant and yield per plot.

The recorded data of present experiment was analyzed statistically by using procedure suggested by Gomez and Gomez (2010), by using MSTAT software, AGRIS software and WASP 2.0 online analysis.

Table 1: Treatment combinations used in experiment

Sl. No.	Treatment Levels	
1	Spacing levels	(50 × 60) cm row to row and plant to plant (S_1)
		(50 × 50) cm row to row and plant to plant (S_2)
		(50 × 40cm) row to row and plant to plant (S_3)
2	Training levels	Two shoot training (T_1)
		Three shoot training (T_2)
		Four shoot training (T_3)

RESULTS AND DISCUSSION

Vegetative parameters as influenced by different levels of spacing and training

In different levels of spacing, closer spacing (50 × 40 cm) resulted in maximum plant height and leaf area index (Table 2). Similar trends at closer spacing were also obtained by Alam *et al.* (2011); Pandey *et al.* (2012). The wider spacing (50 x 60 cm) produced maximum number of branches and leaves per plant. This is in accordance with Islam *et al.* (2011); Kumar and Chandra (2014).

In different levels of training, two shoot resulted maximum plant height (89.9 cm). This might be due to less competition among trained shoots for sunlight and nutrients. Similar results reported by Kumar and Chandra (2014). The highest training level, four shoots resulted in maximum of number of branches, leaves and leaf area index (Table 2). Similar results were also reported by Dapgan and Abak (2003).

The interaction of spacing and training shows significant results for all vegetative parameters as shown in table-4. The interaction of wider spacing 50 x 60 cm with four shoot training produced more number of branches and leaves per plant but in case of plant height, highest obtained from closer spacing with two shoot training Aminifard *et al*. (2010); Ara *et al*. (2007).

Reproductive parameters as influenced by different levels of spacing and training

The performance of different levels of spacing and training resulted in high significance as shown in table 2.

In different levels of spacing, the highest spacing S1 (50 x 60cm) resulted in minimum days to first flowering (33.35), first fruit set (38.57) and first harvest (44.90). Similar result has also been reported by Aminifard *et al*. (2010). In different levels of training, the lowest level of training T1 (two stem) showed minimum days for first flower initiation (34.12), first fruit set (39.22) and first harvest (45.48) was might be due to early shift in vegetative to reproductive stage in two shoot training. These results are similar with findings of Islam *et al*. (2011). It was found that number of fruits per plant significantly increased with closer spacing and four shoot training (Table 3). This finding is in accordance to Kumar and Chandra (2014).

The interaction of spacing and training shows that wider spacing with two shoot training resulted minimum days required for 1st flowering, fruit set and harvesting (Table 4) compared to other interactions due to competition for mineral nutrients and water in between plants as increasing plant density and number of shoots per plant. This result is in agreement with Jovicich *et al*. 2006.

Quality parameters as influenced by different levels of spacing and training

The data revealed from table 5 shows that performance of different levels of spacing and training, highest spacing (50 × 60 cm) and lowest two shoot training resulted in maximum size of fruit viz. length, diameter, and volume. A similar finding was also reported by Alam *et al.* (2011); Aminifard *et al*. (2010); Goda *et al.* (2014).

The performance of different levels of spacing and training had no significant effect on average weight and shelf life of fruit. However, the wide spacing S1 and lowest two stem training resulted in maximum fruit weight. This is in accordance with Hampton (2012).

Interaction effect of spacing and training levels on quality parameters had no significant effect (Dasgan and Abak 2003).

Table 2: Effect of different spacing and training levels on vegetative and reproductive parameters of capsicum

Treatment interaction	Plant Height (cm)			No. of branches/ plant	No. leaves per plant			Leaf area index (LAI)	Days to 1st flowering	Days to 1st fruit set	Fruit setting percentage	Days to 1st harvest
	90 DAP	120 DAP	150 DAP		30 DAP	75 DAP	120 DAP					
Spacing levels												
50 × 60 cm	59.02	69.4	75.3	49.16	9.86	86.5	127.9	1.036	33.35	38.57	34.59	46.42
50 × 50 cm	64.65	76.1	82.5	45.61	9.46	91.76	118.4	1.333	34.57	39.56	34.80	45.48
50 × 40 cm	72.52	85.9	93.2	41.27	8.51	79.07	109.3	1.645	35.12	40.10	34.33	44.90
SEd±	**1.27**	**1.26**	1.27	1.94	0.39	0.68	0.86	0.029	0.10	0.08	0.32	0.08
C.D. at 5%	3.65	3.63	3.6	5.58	NS	1.97	2.4	0.086	0.29	0.23	NS	0.23
Training levels												
2 shoots	71.14	82.7	89.9	34.72	9.50	43.53	62.8	1.140	34.12	39.22	34.15	45.48
3 shoots	66.02	77.8	84.5	45.5	9.09	86.03	118.2	1.304	34.42	39.51	34.46	45.54
4 shoots	59.02	70.9	76.7	55.83	9.24	127.7	174.6	1.570	34.51	39.51	35.11	45.77
SEd±	**1.27**	**1.26**	**1.27**	**1.94**	0.39	0.68	0.86	0.029	0.10	0.08	0.32	0.08
C.D.(5%)	3.65	3.63	3.6	5.58	NS	1.97	2.4	0.086	0.29	0.23	NS	0.23

i.e., DAP- Days after planting, C.D-Critical difference, SEd-Standard error difference.

Table 3: Effect of different spacing and training levels on quality and yield parameters of capsicum

Treatment	Size of fruit			No. of fruits/ plant	Weight of fruit (gm)	Shelf life (Weight loss in %)	Total yield (kg/plant)	Total yield (kg/plot)	Total yield (kg/m²)
	Length (cm)	Diameter (cm)	Volume (cm^3)						
Spacing levels									
50 × 60 cm	7.64	4.68	73.27	7.73	61.83	21.97	0.47	5.23	0.48
50 × 50 cm	7.59	4.67	69.70	8.13	58.22	19.92	0.46	7.02	0.65
50 × 40 cm	7.50	4.45	64.61	8.20	54.83	19.63	0.43	8.0	0.74
SEd±	**0.16**	**0.08**	2.69	0.20	1.97	1.62	0.15	0.18	0.01
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	0.53	0.04
Training levels									
2 shoots	7.91	4.80	79.70	6.31	61.50	19.31	0.38	5.7	0.52
3 shoots	7.57	4.61	67.38	7.70	58.05	20.04	0.44	6.4	0.59
4 shoots	7.25	4.39	60.50	10.06	55.33	22.16	0.54	8.1	0.75
SEd±	**0.16**	**0.08**	**2.69**	**0.20**	**1.97**	1.62	0.01	0.18	0.01
C.D. at 5%	0.46	0.23	7.74	0.78	NS	NS	0.03	0.53	0.04

i.e., DAP- Days after planting, C.D-Critical difference, SEd-Standard error difference.

Table 4: Interaction effect of different spacing and training levels on vegetative and reproductive parameters of capsicum

Treatment interaction	Plant Height (cm)			No. of branches/ plant	No. leaves per plant			Leaf area index (LAI)	Days to 1st flowering	Days to 1st fruit set	Fruit setting percentage	Days to 1st harvest
	90 DAP	120 DAP	150 DAP		30 DAP	75 DAP	120 DAP					
Spacing × Training												
S1T1	65.64	77.40	84.1	39.16	10.13	43.88	67.50	0.940	33.0	38.34	34.05	46.33
S1T2	64.36	74.66	81.3	50.67	9.45	86.33	126.60	1.023	33.34	38.67	35.14	46.67
S1T3	61.05	71.41	77.2	57.67	10.0	129.2	189.67	1.145	33.73	38.74	35.20	46.26
S2T1	68.67	79.87	86.7	36	9.85	46.25	62.91	1.190	34.30	39.30	33.64	45.30
S2T2	59.63	71.26	76.8	44.5	9.51	92.06	118.54	1.335	34.70	39.70	34.40	45.70
S2T3	51.64	62.39	67.5	56.34	9.03	136.9	173.92	1.475	34.73	39.70	35.73	45.46
S3T1	80.37	93.84	101.8	29	8.53	40.46	58.20	1.290	35.06	40.03	33.98	44.83
S3T2	71.39	84.64	92.31	41.34	8.31	79.71	109.46	1.555	35.10	40.10	34.46	44.96
S3T3	65.79	79.34	85.72	53.3	8.70	117.0	160.30	2.09	35.20	40.16	34.55	44.90
SEd±	2.20	2.18	2.20	3.36	0.68	1.18	1.50	0.044	0.17	0.14	0.56	0.13
C.D. (5%)	NS	NS	NS	NS	NS	3.41	4.32	0.149	NS	NS	NS	NS

i.e., DAP- Days after planting, C.D-Critical difference, SEd-Standard error difference, S1- 50 × 60 cm, S2- 50 × 50 cm, S3-50 × 40 cm, T1-Two shoot, T2-Three Shoot, T3-four Shoot.

Table 5: Interaction effect of different spacing and training levels on quality and yield parameters of capsicum

Treatment Interaction	Size of fruit			No. of fruits/ plant	Weight of fruit (gm)	Shelf life (Weight loss in %)	Total yield (kg/plant)	Total yield (kg/plot)	Total yield (kg/m²)
	Length (cm)	Diameter (cm)	Volume (cm^3)						
				Spacing × Training					
S1T1	7.84	4.88	86.67	6.16	64.83	19.64	0.39	4.39	0.40
S1T2	7.60	4.61	70.34	7.63	61.50	18.67	0.47	5.24	0.48
S1T3	7.48	4.53	62.84	9.40	59.16	27.61	0.55	6.07	0.54
S2T1	7.83	4.93	78.10	6.46	61.16	22.35	0.39	5.93	0.55
S2T2	7.75	4.72	67.0	7.80	58.0	18.43	0.45	6.78	0.63
S2T3	7.18	4.36	64.0	10.13	55.5	18.97	0.56	8.36	0.77
S3T1	8.05	4.59	74.34	6.30	58.50	18.13	0.36	6.79	0.63
S3T2	7.36	4.49	64.83	7.66	54.66	20.84	0.41	7.22	0.67
S3T3	7.09	4.27	54.67	10.65	51.34	19.91	0.54	10.0	0.93
SEd±	**0.28**	**0.14**	**4.6**	**0.35**	**3.41**	2.81	0.02	0.32	0.02
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

i.e., DAP- Days after planting, C.D-Critical difference, SEd-Standard error difference, S1- 50 × 60 cm, S2- 50 × 50 cm, S3-50 × 40 cm, T1-Two shoot, T2-Three Shoot, T3-four Shoot.

Yield parameters as influenced by different levels of spacing and training

The data revealed from table 3 shows that performance of different levels of spacing and training had high significant effect on total yield parameters. However, the highest yield of 0.47 Kg/plant was obtained from the wider spacing (50 × 60 cm). Similar results were also reported by Islam *et al.* (2011); Alam *et al.* (2011). The closest spacing (50 × 40 cm) resulted in highest yield 8.0 Kg/plot due to more number of plants per unit area. These findings are in accordance with Ganjare *et al*. (2013). In different levels of training, the highest four shoot training recorded maximum yield 0.54 Kg per plant and 8.1 kg per plot. Similar results were also reported by Abdullah *et al.* (2013); Kumar and Chandra (2014).

The interaction of spacing and training shows that closer spacing (50 × 40 cm) with four shoot training (S3T3) resulted in maximum yield of 0.56 kg/plant and 10 kg/plot. This might have resulted due to more number of shoots which may have contributed in producing more number of fruits. Some other scientists Jovicich *et al*. (2006); Satpute *et al*. (2013); Rotondo *et al*. (2003) also find similar results.

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REFERENCES

Abdullah, A., Mahmood, W. A., Hesham, A. R. and Abdullah, I. 2013. Effects of pruning systems on growth fruit yield and quality traits of three greenhouse grown bell pepper (*Capsicum annuum* L.) cultivars. *Australian Journal of Crop Science,* 7(**9**): 1309 -1316.

Alam, M.S., Saha, S.R., Salam, M.A., Alam, M.S. and Alam, M.K. 2011. Effect of sowing time and plant spacing on the yield and yield attributes of sweet pepper (*Capsicum annuum*). *Bangladesh Journal of Agricultural Research,* **36**(1): 271-278.

Aminifard, M.H., Aroiee, H., Karimpour, S. and Nemati, H. 2010. Growth and yield characteristics of paprika pepper (*Capsicum annuum*L.) in response to plant density. *Asian Journal of Plant Science,* **9**: 276-280.

Anonymous, 2014. Annual Report of Indian Horticulture Database, National Horticulture Board.

Dasgan, H. Y. and Abak, K. 2003. Effect of plant density and number of shoots on yield and fruit characteristics of peppers grown in glasshouses. *Turkish Journal of Agriculture and Forestry,* **27**: 29-35.

Ganjare, H., Futane, N. W., Dagwar, S. and Kurhade, K. 2013. Growth and yield characters of capsicum in response to planting distance and sources of nutrients. *Journal of Agricultural Science,* **3**(9): 386-390.

Goda, Y., Abd El-Rehim, A.S., Mohamed, A. A., Helaly, A. A. and El-Zeiny, O. A. H. 2014. Effect of shoot pruning on

growth yield and fruit quality of husk tomato (*Physalis pubescence* L.). *Journal of Agricultural Sciences,* **10**(1): 5-10.

Hampton, M.O. 2012. Effect of spacing and variety on yield and fruit quality of pepper grown with seepage irrigation in Florida sandy soils. *21st International Pepper Proceedings*, 40 p.

Islam, M. Saha, S. A. k. and Md, H. and Rahim Md. A. 2011. Effect of spacing on growth and yield of sweet pepper (*Capsicum annuum* L.). *Journal of Central European Agriculture,* **12**(**2**): 328-335.

Jovicich, E., Daniel, J., Cantliffe, G. and Hochmuth, J. 2006. Plant density and shoot pruning on yield and quality of a summer greenhouse sweet pepper crop in North central Florida. *Acta Horticulturae,* 412: 330-334.

Kumar, U. and Chandra, G. 2014. Effect of spacing and training levels on growth and yield of capsicum under polyhouse in North-Bihar conditions. *Journal of Hill Agriculture,* **5**(**1**): 9-12.

Kuroshima, M. 2004. Effects of training shoot number and planting density of sweet pepper on operation of training and harvesting. *Bulletin of Hokkaido Prefectural Agricultural Experiment Stations,* **86**: 83-88.

Nair, R. and Barche, S. 2014. Protected cultivation of vegetables, present status and future prospects in India. *Indian Journal of Applied Research,* **4**(6): 245-247.

Pandey, A.K., Singh, A.K., Kumar, A. and Singh, S.K. 2012. Effect of drip irrigation spacing and nitrogen fertigation on productivity of chilli (*Capsicum annuum* L.). *Environment and Ecology,* **31**(1): 139-142.

Rotondo, R., Mondino, M.C., Ferratto, J.A. Grasso, R. and Longo, A. 2003. Effect of conduction pruning, fruits thinning and planting density on pepper (*Capsicum annuum* L.) productivity under greenhouse. *Horticulturae Argentina,* 22: 5-9.

Satpute, P., Bharad, S.G. and Korde, S. 2013. Effect of spacing and plant architecture on yield and economics of capsicum under net house conditions. *Horti Flora Research Spectrum,* 2: 150–152.

Shoemaker, J. S. and Taskey, B. J. E. 1995. Practical Horticulture-John Wiley and Sons Inc, New York, 30p.