Original Research Article   https://doi.org/10.20546/ijcmas.2017.608.040

Effect of Spacing and Training on Growth and Yield of Polyhouse Grown Cucumber (*Cucumis sativus* L.)

Vikram Kumar Kapuriya*, K.D. Ameta, Suresh Kumar Teli, Akshay Chittora, Suman Gathala and Satveer Yadav

Department of Horticulture, Rajasthan College of Agriculture, MPUA&T, Udaipur, Rajasthan 313001, India
*Corresponding author

A B S T R A C T

The present investigation was conducted during 2015-2016 at Hi-Tech Horticulture Unit, Department of Horticulture, Rajasthan College of Agriculture, Udaipur to study the effect of different levels of spacing and training on growth and yield of cucumber under polyhouse. The experiment was laid out following factorial completely randomized design (CRD) with three replications. The experiment was comprising of total twelve treatment combinations of four level of spacing *viz.* 45×20 cm (S_1), 45×30 cm (S_2), 45×45 cm (S_3) and 45×60 cm (S_4) with three level of training *viz.* T_1 (removal of all branches up to 45 cm stem height), T_2 (up to 90 cm stem height) and T_3 (up to 135 cm stem height). Spacing S_4 was best in regards to vegetative and yield attributing traits. The maximum numbers of fruit per vine (40.19), fruit weight (119.69 g), yield per vine (4.74 kg) were recorded in S_4. Among the treatments of training, T_1 was superior resulting in maximum numbers of fruit per vine (38.17), fruit weight (118.04 g) and yield per m^2 (17.71 kg). Maximum total yield per vine (4.97 kg) was recorded in treatment combination S_4T_3 (45x60 cm and up to 135 cm stem height). The highest net return (Rs. 41405.2 per 1000 square meter) and benefit: cost ratio (1.60) was recorded for treatment S_1T_1 (45x20 cm and up to 45 cm stem height).

Introduction

Cucumber (*Cucumis sativus* L.) belonging to family Cucurbitaceae is a warm season vegetable, grown throughout the world under tropical and subtropical conditions. It is said to be the native of northern India (Pursglove, 1969). Cucumber is commonly a monoecious annual (one can encounter with androecious, gynoecious, hermaphrodite and andromonoecious sex types also), trailing or climbing vine (Bailey, 1969).

Cucumber is a highly cross pollinated crop and preferring warm weather and bright light

for its better growth and development. However it can be grown in both summer and rainy season, but it can't tolerate cold injury.

Production of cucumber in India is mainly restricted to open field cultivation. Nevertheless, biotic and abiotic stresses are the main factor responsible for low yield and poor quality under open field cultivation particularly during rainy season crop. The protected vegetable cultivation technology can be utilized for year round production of high value quality vegetable crops, with high

yield. Increased harvesting efficiency and greater yields, improved pest management, straighter fruits and more number of plants per acre due to closer rows are major advantages of adequate spacing and training; these are of vital importance for healthy and luxuriant growth of crop plants.

Greenhouse production technology of cucumber emphasizes the need for proper density in order to boost up the production per unit area by utilizing the available space and nutrients applied. There is need to assess the optimum plant density for its cultivation in polyhouses in various regions. An appropriate training system will not only facilitate better management and uniform light to the plants but also permit closer planting, early ripening of fruits, higher yield of larger sized fruits and higher yield of good quality seeds (Lal *et al.,* 2014). Training methods vary with different growth habits of cucumber cultivars and for different plant densities. Plant density and shoot pruning contribute to marketable yield in the various ways such as plant's ability to obtain the sun light needed for growth and adequate air movement around the plant to reduce risk of fungus and insect problems. Manipulation of canopy architecture through pruning and training together with appropriate spatial arrangements has been identified as key management practices for getting maximum marketable yields from greenhouse crops (Premalatha *et al.,* 2006).

Therefore, keeping above mentioned facts in view the present study was carried out to study the effect of different levels of spacing and training on growth and yield of cucumber under polyhouse.

Materials and Methods

The present investigation was conducted during 2015-2016 at Hi-Tech Horticulture Unit, Department of Horticulture, Rajasthan College of Agriculture, Udaipur. The size of the polyhouse was 28 m $\times$ 32 m (896 sq.m) covered with aluminate sheet and ultra violet stabilized low density polyethylene sheet having 200 micron thickness. The experiment was comprising of total twelve treatment combinations of four level of spacing *viz.* 45$\times$20 cm (S_1), 45$\times$30 cm (S_2), 45$\times$45 cm (S_3) and 45$\times$60 cm (S_4) with three level of training *viz.* T_1 (removal of all branches up to 45 cm stem height), T_2 (up to 90 cm stem height) and T_3 (up to 135 cm stem height). The experiment was laid out following factorial completely randomized design (CRD) with three replications. Observations were recorded for fifteen different characteristics related to vegetative, yield and quality attributing traits. These observations were vine length (cm), number of branches per vine, leaf area (cm^2), days to flowering, days to first harvest, number of fruits per vine, fruit weight (g), fruit length (cm), fruit volume (cc), fruit diameter (cm), yield per vine (kg), yield per square meter (kg), specific gravity (g/cc), TSS (°B), moisture content (%). The economics of different treatments were determined on the basis of prevailing market price of inputs and produce. The data recorded for various characters were subjected to statistical analysis using analysis of variance (ANOVA) under factorial CRD and interpretations of the data were carried out in accordance to Panse and Sukhatme (1985).

Results and Discussion

The data pertaining to various yield and yield contributing traits used for evaluation of the treatments were statistically analyzed to test their significance and results of these data have been given in tables 1 and 2.

Results showed that maximum vine length (325.19 cm) was recorded in S_4 (45$\times$ 60 cm) while T_3 (removal of all branches up to 135

cm stem height) resulted in maximum vine length (315.23 cm). Interaction effects of spacing and training showed non-significant effect on vine length.

Results revealed that the effects of various levels of spacing and training were significant on number of branches per vine of cucumber. Maximum number of branches per vine (12.54 cm) was recorded in S_4 (45×60 cm). Maximum number of branches per vine (12.97) was exhibited by T_1 (removal of all branches up to 45 cm stem height).

Further, results revealed that maximum number of branches per vine (13.87) was recorded in S_4T_1 (45 × 60 cm and up to 45 cm height) whereas minimum (10.30) in S_1T_3 (45 × 20 cm and up to 135 cm height) treatment combination. Plants at widest spacing (45 x 60 cm) resulted in maximum vine length and number of branches per vine than closer spacing. This may be due to the availability of more space for the plants. Significant linear increase of main vine length and number of branches per vine were also reported with increased spacing by Ban *et al.,* (2006) in melon and Ara *et al.,* (2007) in tomato. A perusal data revealed that the leaf area was significantly influenced by various levels of spacing and training. Data indicated that maximum value of leaf area was observed in in S_4 (442.84 cm^2) treatment. Maximum leaf area (435.49 cm^2) was recorded in T_3 (up to 135 cm stem height). Results showed that maximum leaf area (445.47 cm^2) was reported in S_4T_1 (45 × 60 cm and 45 cm height) as compared to minimum (425.87 cm^2) in S_1T_1 (45 × 20 cm and 135 cm height) treatment combination.

The data (Tables 1 and 2) indicated that the days to flowering of cucumber were significantly influenced by various levels of spacing and training. The minimum days taken for flowering (30.80) were noticed in the treatment S_4 (45 × 60 cm). On other hand,

minimum days for flowering (31.98) were taken in treatment T_1 (up to 135 cm stems height). Further, results showed that minimum days for flowering (30.17) were taken by S_4T_1 (45 × 60 cm and 45 cm height) whereas maximum days for flowering (33.70) were taken by treatment combination S_1T_1 (45 × 20 cm and 45 cm height). It is explicit from data that the days to first harvesting of cucumber was not significantly influenced by various levels of spacing while it was significantly influenced by various levels of training. Minimum days for harvesting (37.98) were taken by treatment T_1 (up to 45 cm stem height). Interaction effects of spacing and training had significant influence on days to first harvesting. Minimum days taken for first harvesting (36.17) were observed for S_4T_1 (45 × 60 cm and up to 45 cm height) whereas maximum number of days (39.70) for first harvesting was observed in S_1T_1 (45 × 20 cm and up to 45 cm height).

Results indicated that the number of fruit per vine was significantly influenced by various levels of spacing and training. The maximum number of fruits per vine (40.19) was recorded in spacing S_4 (45×60 cm) followed by S_3 (37.17), S_2 (35.49) whereas T_1 resulted in maximum number of fruits per vine (38.17). There was non-significant influence of interaction of spacing and training on number of fruits per vine. Fruit weight was significantly influenced by various levels of spacing and training. Results showed that maximum fruit weight (119.69 g) was observed for treatment S_4 (45×60 cm). Maximum fruit weight (118.04 g) was found in the first level of training T_1 (up to 45 cm stem height). Data clearly indicated non-significant influence of interaction effect of spacing and training on fruit weight. The maximum number of fruits per vine and fruit weight were reported for widest spacing *i.e.* treatment S_4 (45×60 cm), this might be due to more fruit set and more photosynthesis as it produce more vine length at wider spacing.

Table.1 Effect of spacing and training on vegetative, yield and quality attributes of polyhouse grown cucumber

Treatment	Vine length (cm)	Number of branches per vine	Leaf area (cm²)	Days to flowering	Days to first harvest	Number of fruits per vine	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Total yield per vine (kg)	Yield per m²	Moisture content (%)	Total soluble solids (°Brix)	Fruit volume (cc)	Specific gravity (g/cc)
Spacing (S)															
S₁ (45x20 cm)	306.67	11.63	426.26	32.91	38.69	33.82	114.19	15.20	2.44	2.33	20.03	92.00	4.03	125.31	0.91
S₂ (45x30 cm)	312.67	12.19	430.83	32.62	38.73	35.49	115.88	16.51	2.60	2.61	17.16	92.67	3.66	125.78	0.92
S₃ (45x45 cm)	317.64	12.27	435.57	32.48	38.48	37.17	116.43	17.78	3.01	3.57	15.69	93.60	3.48	126.30	0.92
S₄ (45x60 cm)	325.19	12.54	442.84	30.80	36.80	40.19	119.69	18.33	3.30	4.74	15.40	94.59	3.32	126.92	0.94
SEm±	0.848	0.153	0.234	0.109	0.160	0.230	0.250	0.128	0.054	0.042	0.148	0.109	0.026	0.124	0.002
CD at 5%	1.413	0.446	0.684	0.319	NS	0.673	0.730	0.374	NS	0.123	0.432	0.319	0.075	0.361	0.005
Training (T)															
T₁	314.83	12.97	432.38	31.98	37.98	38.17	118.04	17.32	2.93	3.07	17.71	93.70	3.75	127.34	0.93
T₂	315.23	12.34	433.75	32.08	38.08	36.58	116.14	16.89	2.86	3.37	16.98	93.30	3.62	125.85	0.92
T₃	316.57	11.17	435.49	32.54	38.46	35.25	115.46	16.66	2.74	3.50	16.52	92.64	3.50	125.04	0.92
SEm±	0.419	0.132	0.203	0.095	0.138	0.200	0.216	0.111	0.047	0.036	0.128	0.095	0.022	0.107	0.002
CD at 5%	1.224	0.386	0.592	0.276	0.404	0.583	0.632	0.324	0.137	0.106	0.374	0.277	0.065	0.312	0.005

Table.2 Interaction effects of spacing and training on vegetative, yield, quality and economics of polyhouse grown cucumber

Treatment	Vine length (cm)	Number of branches per vine	Leaf area (cm²)	Days to flowering	Days to first harvest	Number of fruits per vine	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Total yield per vine (kg)	Yield per m²	Moisture content (%)	Total soluble solids (°Brix)	Fruit volume (cc)	Specific gravity (g/cc)	Net return per 1000 m²	B:C ratio
S₁T₁	306.13	12.50	425.87	33.70	39.70	35.13	115.20	15.80	2.20	2.17	20.90	92.63	4.33	126.67	0.91	41405.2	1.60
S₁T₂	306.23	12.40	426.17	32.03	38.03	33.70	113.83	15.03	2.60	2.35	19.87	92.17	4.00	125.13	0.91	37688.00	1.41
S₁T₃	307.63	10.30	426.73	33.00	38.33	32.63	113.53	14.77	2.23	2.46	19.33	91.20	3.77	124.13	0.91	35580.00	1.31
S₂T₁	312.33	12.40	429.37	32.37	38.37	37.33	117.23	16.90	2.73	2.50	17.86	93.40	3.74	127.17	0.92	34362.60	1.46
S₂T₂	312.80	12.30	430.67	32.60	38.60	35.27	115.57	16.53	2.43	2.59	17.20	92.67	3.65	127.67	0.92	31855.00	1.33
S₂T₃	312.87	11.87	432.47	32.90	39.23	33.87	114.83	16.10	2.63	2.75	16.43	91.63	3.57	124.50	0.92	28991.00	1.20
S₃T₁	316.90	13.10	434.23	31.70	37.70	38.43	118.73	17.97	3.00	3.27	15.90	93.87	3.52	127.53	0.93	28991.00	1.33
S₃T₂	317.60	12.50	435.17	32.33	38.33	37.37	115.77	17.80	3.17	3.60	15.60	93.70	3.49	126.03	0.92	28064.00	1.25
S₃T₃	318.43	11.20	437.30	33.40	39.40	35.70	114.80	17.57	2.87	3.83	15.57	93.23	3.43	125.33	0.92	28064.00	1.21
S₄T₁	323.93	13.87	440.07	30.17	36.17	41.77	121.00	18.60	3.47	4.33	16.20	94.90	3.40	128.00	0.95	32308.00	1.57
S₄T₂	324.30	12.47	443.00	31.37	37.37	40.00	119.40	18.20	3.23	4.93	15.27	94.67	3.35	126.57	0.94	28904.00	1.41
S₄T₃	327.33	11.30	445.47	30.87	36.87	38.80	118.67	18.20	3.20	4.97	14.73	94.20	3.21	126.20	0.94	26796.00	1.28
SEm±	0.839	0.265	0.406	0.189	0.277	0.399	0.433	0.22	0.94	0.073	0.256	0.190	0.045	0.214	0.003	830.3835	0.0349
CD at 5%	NS	0.1722	1.185	0.552	0.807	NS	NS	NS	NS	0.2128	NS	NS	0.130	NS	NS	2423.7179	0.1018

The similar findings of increase average fruit weight and number of fruits per vine with wider spacing were also reported by Mantur *et al.,* (2007) and Ameta *et al.,* (2014) in capsicum.

Fruit length of cucumber was significantly influenced by various levels of spacing. Results showed that highest fruit length (18.33cm) was recorded in widest level of spacing S_4 (45×60 cm) followed by S_3 (17.78 cm). Mamnoie and Dolatkhahi (2013) and Jaffer and Wahid (2014) also recorded more fruit length at wider spacing. Maximum fruit length (17.32 cm) was observed in T_1 (up to 45 cm stem height) followed by T_2 (16.89 cm). Results revealed that interaction of spacing and training exhibited non-significant effects on fruit length. The data indicated that the fruit diameter of cucumber was significantly influenced by various level of training. Maximum fruit diameter (2.93 cm) was observed in treatment T_1 (up to 45 cm stem height). Maximum fruit length, fruit diameter, fruit volume (127.34 cc) and specific gravity (0.93 g/cc) were reported in treatment of minimum pruning *i.e.* T_1 (up to 45 cm stem height). This is in conformity with the findings of Muhammad and Singh (2007) while working with tomato. Interaction effects of spacing and training was non-significant on fruit diameter.

Various levels of spacing and training imparted significant influence on total yield per vine (kg). Maximum total yield per vine (4.74 kg) was obtained for treatment S_4 (45×60 cm) while third level of training T_3 (up to 135 cm stems height) resulted in the highest total yield per vine (3.50 kg). Similarly maximum total yield per vine (4.97 kg) was obtained in S_4T_3 (45 × 60 cm and 135 cm height). It is evident from data that the total yield per m^2 (kg) of cucumber was significantly influenced by various levels of spacing and training. The maximum total yield per vine was recorded at widest spacing *i.e.* S_4 (45×60 cm) whereas least yield was recorded when plants were accommodated at closer spacing (45×20 cm). These findings are in conformity with findings of Abubaker *et al.,* (2010) in cucumber. The data showed that the highest total yield per m^2 (20.03 kg) was observed in treatment S_1 (45×20 cm) followed by S_2 (17.16 kg). First level of training *i.e.* T_1 (up to 45 cm stem height) exhibited maximum total yield per m^2 (17.71 kg) followed by T_2 (16.98 kg). Interaction effects of spacing and training presented in table 2 showed non-significant effect on total yield per m^2 (kg). However, maximum total yield per m^2 (20.90 kg) was observed for S_1T_1 (45 × 20 cm and 45 cm height).

It is explicit from data that the moisture content (%) of cucumber was significantly influenced by various levels of spacing and training. maximum moisture content (94.59 %) was recorded for S_4 (45×60 cm) while at other hand, maximum moisture content (93.70 %) was observed for treatment T_1 (up to 45 cm stems height). A critical examination of data showed that interaction effects of spacing and training were non-significant on moisture content of fruit (%). Total soluble solids of cucumber were significantly influenced by various levels of spacing and training. Data showed that maximum total soluble solids (4.03 ^{o}B) was recorded in treatment S_1 (45×20 cm) while at other hand, maximum total soluble solids (3.75 ^{o}B) was recorded in treatment T_1 (up to 45 cm stem height). Maximum TSS (4.33 ^{o}B) was exhibited by treatment combination S_1T_1 (45 × 20 cm and 45 cm height).

It is explicit from data that the fruit volume (cc) of cucumber was significantly influenced by various levels of spacing and training. Maximum fruit volume (126.92 cc) was reported in S_4 (45×60 cm) followed by S_3 (126.30 cc). First level of training T_1 (up to 45 cm stem height) was reported to result maximum fruit volume (127.34 cc). A critical review of data showed that interaction effects of spacing and training on fruit volume (cc) was non-significant. The data with regard to specific gravity of fruit was significantly influenced by various levels of spacing and training. Data showed that maximum specific gravity (0.94 g/cc) was exhibited in S_4 (45×60 cm) while treatment T_1 (up to 45 cm stems height) resulted maximum specific gravity (0.93 g/cc).

Interaction effects of spacing and training on specific gravity were non-significant during experimentation.

Economic evaluation of treatments revealed that maximum net returns (Rs. 41405.2 per 1000 square meter) and benefit:cost ratio (1.60) was recorded in the treatment combination S_1T_1 (45x20 cm and up to 45 cm stem height) whereas, minimum net returns (Rs. 26796 per 1000 square meter) and B:C ratio (1.28) was recorded in treatment combination S_4T_3 (45x60 cm and up to 135 stem height).

On the basis of results obtained in the present investigation it was concluded that among the various treatment combinations, highest yield and benefit: cost ratio were recorded by treatment combination S_1T_1 (45x20 cm and up to 45 cm stem height). Based on above findings, S_1T_1 was recommended for getting maximum yield.

References

Abubaker, S., Al-Zubi1, Y. and Aburayan, A. 2010. The influence of plant spacing on yield and fruit nitrate concentration in greenhouse cucumber (*Cucumis sativus* L.). *Jordan J. Agric. Sci.,* 6(4): 527-533.

Ameta, K. D., Kaushik, R. A., Dubey, R. B. and Pareek, S. 2014. Effect of training and crop geometry on yield attributes and yield of polyhouse grown "Natasha" red capsicum. *Int. J. Innovat. Hort.,* 3(1): 67-70.

Ara, N., Bashar, M. K., Begum, S. and Kakon, S. S. 2007. Effect of spacing and stem pruning on the growth and yield of tomato. *Int. J. Sustain. Crop Prod.,* 2(3): 35-39.

Bailey, L. H. 1969. *Mannual of Cultivated Plants.* Macmillan Company, New York.

Ban, D., Goreta, S. and Borosic, J. 2006. Plant spacing and cultivar affect melon growth and yield components. *Sci. Hort.,* 109: 238-243.

Jaffer, A. and Wahid, F. 2014. Effect of row spacing on growth, yield and yield components of cucumber varieties. *Science Letters,* 2(1): 33-38.

Lal, M., Kanwar, H.S. and Kanwar, R. 2014. Impact of spacing and training on seed yield of capsicum, *Capsicum annuum* L. under protected conditions. *Int. J. Farm Sci.,* 4(3): 42-48.

Mamnoie, E. and Dolatkhahi, A. 2013. Plant spacing and cultivar affects yield components, qualitative traits and early ripening of tomato (*Lycopersicon esculentum*). *Notulae Scientia Biologica,* 5(4): 494-498.

Mantur, S. M. and Patil, S. R. Biradar, S.R., Patil, S.R. and Patil, D.R. 2007. Effect of plant geometry and nutrient source for capsicum under shade house during summer and kharif. *Karnataka J. Agric. Sci.,* 21(1): 97-98.

Muhammad, A. and Singh, A. 2007. Yield of tomato as influenced by training and pruning in the Sudan savanna of Nigeria. *J. Plant Sci.,* 2(3): 310-317.

Panse, V. G. and Sukhatme, P. V. 1985. Statistical Methods for Agricultural Workers. ICAR, New Delhi, pp. 145-155.

Premalatha, M.G.S., Wahundeniya, K.B., Weerakkody, W.A.P. and Wicramathunga, C.K. 2006. Plant training and spatial arrangement for yield improvements in greenhouse cucumber (*Cucumis sativus* L.) varieties. *Trop. Agric. Res.,* 18: 346-357.

Pursglove, J. W. 1969. Tropical Crops Dicotyledons Longmans. Green and Corporation Limited London and Herlow.