

Original Research Article

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

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ABSTRACT

The present investigation was conducted during off season 2015 at the Research Farm of Department of Agricultural Engineering, College of Agriculture, CSKHPKV, Palampur, Himachal Pradesh to study the effect of different levels of spacing and training on growth and yield of hybrid cucumber under polyhouse. The experiment was laid out following factorial randomized block design (RBD) with three replications. The experiment was comprising of total 18 treatment combinations of two hybrids viz., Kian and Isetis, three level of spacing viz., 60×30 cm (S1), 60×45 cm (S2) and 60×60 cm (S3) with three level of training viz., T1 (removal of one shoot), T2 (removal of two shoots) and T3 (removal of three shoots). Hybrid Isetis was significantly superior over Kian with respect to vine length (261 cm), number of fruits per vine (26.8), fruit length (17.8 cm), fruit weight (173.53 g), harvest duration () and fruit yield per plant (3.68 kg) with maximum net returns (Rs. 28940.5) and benefit: cost ratio (2.34). Spacing S3 was best in regards to vegetative and yield attributing traits. Higher fruit length (17.0 cm), fruit breadth (6.2 cm), fruit weight (187.51 g), number of fruits per vine (27.2), total soluble solids (3⁰brix), fruit yield per plant (3.97 kg) was observed in S3 and also it took lesser number of days for initiation of first female flower (14.17), lower nodal position of first female flower and days to first picking (33.9). Among the treatments of training, T1 was superior resulting in higher fruit length (16.7 cm), fruit breadth (6.0 cm), fruit weight (179.95 g). Maximum total yield per vine (4.96 kg) was recorded in treatment combination S3T3. The highest net return and benefit: cost ratio was recorded for hybrid Isetis with treatment S1T3.

Keywords

Hybrid cucumber,
Growth and yield,
Spacing, Training

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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 thought to have originated in India (Harlan, 1975) because of the fact that *Cucumis sativus* var. *hardwickii* progenitor of

cultivated cucumber is found in the Himalayan foothills of the country. 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 grows well under the condition of high light intensity, humidity, moisture, temperature and fertilizer but is frost

susceptible. 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 hybrid 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 hybrid cucumber under polyhouse.

Materials and Methods

The present investigation was conducted during off season 2015 at the Research Farm of Department of Agricultural Engineering, College of Agriculture, CSKHPKV, Palampur, Himachal Pradesh. The size of the polyhouse was 20×12 m (240 sq.m) covered with aluminate sheet and ultra violet stabilized low density polyethylene sheet having 200 micron thickness. The experiment was comprising of total 18 treatment combinations of two hybrids *viz.*, Kian and Isetis, three level of spacing *viz.*, 60×30 cm (S1), 60×45 cm (S2) and 60×60 cm (S3) with three level of training *viz.*, T1 (removal of one shoot), T2 (removal of two shoots) and T3 (removal of three shoots).

The experiment was laid out following randomized block design (RBD) with three replications. Observations were recorded for 17 different characteristics related to vegetative, yield and quality attributing traits. These observations were vine length (cm), internodal length (cm), number of days taken to anthesis of first female flower, nodal position of first female flower, days to 50 per cent flowering, number of days to first picking, harvest duration, number of fruits per plant, fruit weight (g), fruit length (cm), fruit breadth (cm), fruit yield per vine (kg), fruit yield (kg/100m²), total soluble solids, available nitrogen, available phosphorus and available potassium. 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 Cochran and Cox (1963) method.

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 given below:

Growth and development studies

Results (Table 1) showed that maximum vine length was recorded in hybrid Isetis (261cm), S1 (227.3 cm) and T1 (229.8 cm). Similar observations were also reported by Devi and Gopalkrishnan (2004), Khalid (2010), Bahlgerdi *et al.*, (2014), Jaffar and Wahid (2014) and Rawat *et al.*, (2014). Interaction effects of hybrid, spacing and training showed non-significant effect on vine length. Internodal length determines the height and number of nodes per plant. The parthenocarpic cucumber hybrids bear fruits at almost every node. Therefore, plants having less internodal length and more number of nodes are desired for getting higher yield. Results revealed that the hybrids could not exhibit a significant effect on internodal length while the effect of various levels of spacing and training were significant for intermodal length. Similar findings between the hybrids were also reported by Kumar *et al.*, (2008) and Dogra (2012).

Minimum internodal length (Table 1) was shown by Hybrid Isetis (9.5 cm), S3 (9.4 cm) and T1 training system (9.3 cm). Similar findings were reported by Hao *et al.*, (2010) and Nweke *et al.*, (2013). Interaction effects of hybrid, spacing and training showed non-significant effect on intermodal length. Days taken to initiate first female flower is an important character and an indicator of getting early and uniform yield of cucumber grown under protected conditions. Earliest flower initiation (Table 1) was achieved by Hybrid Isetis (14.17), S3 (14.31) and one shoot i.e. T1

(14.56 days). This might be due to availability of good sunshine and nutrients in the soil resulting in the accumulation of more photosynthates and induction of early flowering compared to closer spacing that the length of main shoot grew faster than two and three shoot plants. Data clearly indicated non-significant influence of interaction effect of hybrid, spacing and training on days taken to initiate first female lower. Nodal position of first female flower is an important character in cucumber. Appearance of first female flower at the lowest node signifies early entry of cucumber into reproductive phase with capability of longer harvest duration by the plant and further gives early yield. Results revealed that the nodal position of first female flower was significantly influenced by the hybrids.

Female flower appeared at lower nodes (Table 1) in hybrid Isetis (3.88), S3 (4.32) and in plants trained to only one shoot i.e. T1 (4.17). The effect of interactions was not significant for nodal position of first female flower. Results indicated that hybrid Isetis was earliest in achieving 50 per cent flowering stage (26.8 days). Days to 50 per cent flowering (Table 1) was earliest at S3 (26.4 days) and T1 (26.6 days). The results are in close conformity with the findings of Jaffar and Wahid (2014).

The effect of interaction was not significant for days to 50 percent flowering. Number of days to first picking (Table 1) was significantly lesser for hybrid Isetis (33.9) and T1 (35.1). The significant differences among the hybrids for days to first picking have also been observed by Bisht *et al.*, (2010), Gaikwad *et al.*, (2011), Rawat *et al.*, (2014) and Singh *et al.*, (2012) in greenhouse who reported varietal variation among the cucumber hybrids. Plant spacing did not have any significant effect on days to first picking. The interaction under study could not influence number of days to first picking.

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

Treatment	Vine length (cm)	Internodal length(cm)	Number of days taken to anthesis of first female flower	Nodal position of first female flower	Days to 50 per cent flowering	Number of days to first picking	Harvest duration	Number of fruits per plant	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Fruit yield per vine (kg)	Fruit yield (kg/100m ²)	Total soluble solids (°Brix)	Available nitrogen	Available phosphorus	Available potassium
Hybrid																	
Kian (V1)	169.9	9.6	16.37	5.79	28.8	38.2	48.4	20.3	161.81	14.6	5.5	2.60	932.8	2.69	266.74	17.80	217.80
Isetis (V2)	261.0	9.5	14.17	3.88	26.8	33.9	55.5	26.8	173.53	17.8	6.2	3.68	1378.6	3.12	266.61	17.51	217.51
CD at 5%	2.1	NS	0.71	0.57	1.0	0.5	0.5	0.3	1.74	0.1	0.08	0.15	45.3	0.03	NS	NS	NS
Spacing (S)																	
S1 (60x30cm)	227.3	9.7	16.67	5.43	28.6	35.9	51.7	19.5	149.32	15.5	5.5	2.37	1305.5	2.80	264.30	16.97	216.97
S2 (60x45cm)	220.1	9.6	14.83	4.75	28.3	36.0	51.8	23.9	166.18	16.1	5.9	3.07	1105.5	2.91	266.90	17.62	217.62
S3 (60x60cm)	199.0	9.4	14.31	4.32	26.4	36.2	52.2	27.2	187.51	17.0	6.2	3.97	1056.1	3.00	268.83	18.36	218.36
CD at 5%	2.6	0.2	0.86	0.70	1.2	NS	NS	0.3	2.13	0.2	0.09	0.18	55.4	0.03	1.05	1.01	1.01
Training (T)																	
T1	229.8	9.3	14.56	4.17	26.6	35.1	52.8	20.7	179.95	16.7	6.0	2.27	820.7	2.88	268.83	18.37	218.37
T2	214.7	9.6	14.72	4.83	27.4	35.9	51.9	23.6	166.62	16.3	5.9	3.22	1196.0	2.92	265.65	17.65	217.65
T3	201.9	9.8	16.53	5.50	29.3	37.1	50.9	26.3	156.44	15.6	5.6	3.92	1450.4	2.91	265.55	16.94	216.94
CD at 5%	2.6	0.2	0.86	0.70	1.2	0.6	0.7	0.3	2.13	0.2	0.09	0.18	55.4	NS	1.05	1.01	1.01

Table.2 Interaction effect of hybrid and training systems on harvest duration

Hybrid	Training system		
	One shoot	Two shoots	Three shoots
Kian	49.9	47.8	47.4
Isetis	55.7	56.1	54.4
CD(P=0.05)	0.94		

Table.3 Interaction effect of plant spacing and training systems on number of fruits at final harvest

Spacing	Training system		
	One shoot	Two shoots	Three shoot
60 cm x 30 cm	17.7	19.4	21.5
60 cm x 45 cm	20.9	23.8	27.1
60 cm x 60 cm	23.7	27.6	30.3
CD(P=0.05)	0.6		

Table.4 Interaction effect of plant spacing and training systems on fruit weight (g)

Spacing	Training system		
	One shoot	Two shoots	Three Shoots
60 cm x 30 cm	159.31	146.66	142.01
60 cm x 45 cm	179.19	168.05	151.29
60 cm x 60 cm	201.35	185.16	176.02
CD(P=0.05)	3.69		

Table.5 Interaction effect of plant spacing and training systems on fruit length (cm)

Spacing	Training system		
	One shoot	Two shoots	Three Shoots
60 cm x 30 cm	15.8	15.6	15.1
60 cm x 45 cm	16.5	16.3	15.6
60 cm x 60 cm	17.8	17.0	16.2
CD(P=0.05)	0.3		

Table.6 Interaction effect of plant spacing and training systems on fruit yield per plant (kg)

Spacing	Training system		
	One shoot	Two shoots	Three Shoots
60 cm x 30 cm	1.71	2.36	3.03
60cm x 45 cm	2.33	3.11	3.78
60 cm x 60 cm	2.76	4.20	4.96
CD(P=0.05)	0.31		

Table.7 Interaction effect of hybrid, plant spacing and training systems on fruit yield/100m² (kg)

Hybrid	Spacing								
	60 cm x 30 cm			60 cm x 45 cm			60 cm x 60 cm		
	One shoot	Two shoots	Three shoots	One shoot	Two shoots	Three shoots	One shoot	Two shoots	Three shoots
Kian	569.8	1100.9	1304.6	524.4	903.9	1198.4	758.4	901.8	1134.3
Isetis	1243.6	1536.4	2078.6	1097.6	1419.9	1490.0	731.6	1313.1	1497.3
CD (P=0.05)	135.7								

Prolonged harvest duration is an important aspect to catch an early market in one hand and to avoid gluts in the market on the other hand to ensure maximum returns. Results indicated that longer harvest duration (Table 1) was observed in hybrid Isetis (55.5) and T1 (52.8).

Harvest duration was not influenced significantly by plant spacing. Further results reveal that longest harvest duration was recorded from interaction effect (Table 2) of hybrid Isetis×T1 (55.7).

Yield attributes and yield

Highest number of fruits per vine (Table 1) was recorded in hybrid Isetis (26.8), S3 (27.2) and T3 (26.3). These results are in conformity with Lebedeva and Turlakova (1985), Mohamedien *et al.*, (1993), Muhammad *et al.*, (1998) and Bisht *et al.*, (2010). Further results revealed that maximum number of fruits per vine was recorded from interaction effect (Table 3) of S3T3 (30.3).

Fruit weight plays an important role in fruit production. Higher fruit weight (Table 1) was observed in hybrid Isetis (173.53 g), S3 (187.51 g) and T1 (179.95 g). These results are in conformity with Bisht *et al.*, (2010), Singh *et al.*, (2012), Umekwe (2015) and Aniekwe and Anike (2015). Further results revealed that maximum fruit weight was recorded from interaction effect (Table 4) of S3T1 (201.35).

Longer and broader fruits (Table 1) were observed in hybrid Iseti, S3 and T1. Further results indicated that interaction effect of spacing and training systems was found to be significant for fruit length. Maximum fruit length (17.8 cm) was obtained in S3T1 combination (Table 5). Interactions under study could not influence fruit breadth significantly.

Higher fruit yield per plant (Table 1) was obtained in hybrid Isetis (3.68 kg), S3 (3.97 kg) and T3 (3.92 kg). These results are in close conformity with Bisht *et al.*, (2010), Oga and Umekwe (2015) and Lopez *et al.*, (2015).

The interaction effect (Table 6) between spacing and training systems was found to be significant. Higher fruit yield per plant was observed in S3T3 (4.96 kg).

Higher fruit yield/m² (Table 1) was obtained from hybrid Isetis (1378.6 kg/m²), S1 (1305.5 kg/100m²) and T3 (1450.4 kg/100m²). Further results indicated that interaction effect (Table 7) of hybrid Isetis with S1T3 produced higher fruit yield/m² (2078.6 kg/m²).

Quality evaluation

Total soluble solids content signifies the amount of sugars present in the fruit juice. Hence high total soluble solids content is desirable for processed products. Higher total soluble solids (Table 1) were recorded in

hybrid Isetis (3.12⁰brix) and S3 (3.00⁰brix). These results are supported by the work of Nerson (1998). Neither training system nor the interaction effect of hybrids, spacing and training systems had any influence on the TSS content.

Soil analysis

Hybrids could not exhibit any significant effect on available nitrogen, phosphorus and potassium in soil after the harvest of cucumber crop. Maximum available nitrogen, phosphorus and potassium in soil (Table 1) were observed in S3 and T1.

Similar results were also reported by Chand (2014). The interaction between hybrids, plant spacing and training systems failed to significantly influence the available nitrogen, phosphorus and potassium in soil.

Economic studies

Economic evaluation of treatments revealed that maximum gross returns, net returns and benefit: cost ratio was recorded (Table 1) in hybrid Isetis (Rs. 41358.3, Rs. 28940.5 and 2.34, respectively), S1 (Rs. 39166.3, Rs. 25092.6 and 1.89, respectively) and T3 (Rs. 43513.0, Rs. 30187.9 and 2.33, respectively).

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 of hybrid Isetis with S1T3. Hence, treatment combination S1T3 was recommended for getting maximum economic returns. Based on above findings, transplanting of cucumber hybrid Isetis at a spacing of 60×30 cm (S1) and plants trained to three shoots (T3) can be recommended for growing cucumber in cost effective naturally ventilated polyhouse for higher fruit yield and economic returns.

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