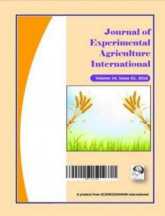

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Influence of Training on Vegetative Growth Characteristics and Yield of Polyhouse Grown Cucumber (*Cucumis sativus* L.)

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Authors' contributions

This work was carried out in collaboration between all authors. Author PS designed the study. Author NSD conducted the experiment data. Author PK managed the analyses of the study. Author HS cited the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To study the influence of various training techniques on vegetative growth characteristics and yield of cucumber grown under protected cultivation.
Study Design: Randomized Block Design with three replications.
Place and Duration of Study: Research farm, Department of Vegetable Science and Floriculture, CSK HPKV, Palampur during spring summer season 2016.
Methodology: The experiment consists of seven different training methods. The observations were recorded *viz.,* days to 50 per cent flowering, days to first harvest, fruit weight (g), number of fruits/plant, fruit yield/plant (kg), harvest duration (days), inter-nodal length (cm) and vine length (m). Observations were recorded from 5 plants chosen at random in each replication and then average was worked out for each parameter.
Results: Treatment comprised of single stem (T_1) recorded least number of days to 50 per cent flowering (23.67), minimum days to first picking (35.00 days), highest fruit weight (136.23 g),

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harvest duration (56.00 days), vine length (2.26 m) and minimum inter nodal length (9.34 cm) which was statistically similar with treatment comprising of single stem with side shoot training after 3 leaves (T_2) to all these characters respectively. Whereas the treatment comprised of three stems with side shoot training after 3 leaves (T_6) obtained maximum number of fruits/plant (28.23) which was significantly superior to all other treatments and maximum fruit yield/m^2 area (8.27 kg) which was statistically at par with treatment comprising of three stems (T_5).

Conclusion: It was concluded that plants trained to single stem had better vegetative characters but plants trained to three stems with side shoot training after three leaves had higher yield/m^2 area.

Keywords: Cucumber; growth; protected environment; training; yield.

1. INTRODUCTION

Cucumber (*Cucumis sativus* L.) is a member of the gourd family cucurbitaceae, which comprises of 117 genera and 825 species in warmer parts of the world [1]. It is thought to be one of the oldest vegetable crops and has been found in cultivation for over 3000 years in India [2]. It is a warm season crop and has little or no tolerance to frost. Growth and development are favoured by temperature above 20°C. The optimum temperature for growing is between 20°C and 30°C [3].

Under open environment cucumber is being grown in both summer and rainy seasons, with varying success due to various abiotic (low temperature and unpredictable weather) and biotic (red pumpkin beetle, fruit fly and incidence of downy/powdery mildew) stresses [4]. Under the protected environment we can grow good quality cucumber throughout the year in hills as compared to the open cultivation. The type of cucumber grown in polyhouses is parthenocarpic. The fruits are mild in flavour and have a thin edible skin that requires no peeling [5].

In protected cultivation, profits are greatly dependent on the quantity and quality of the produce [6]. Shoot training of plants contributes to the ultimate yield in various ways. Shoot training maximizes the plant ability to obtain the sunlight needed for growth and development [7]. It is also important to maintain adequate air movement around the plant to reduce risk of fungus and other insect problems [8]. On the other hand, dense canopy of leaves shade the fruits, causing them to be pale [9]. The suitable training method gave higher yield of cucumber [10]. Relatively high perishability has made cucumber plants to be more vulnerable to intensive crop management and unfavorable environmental conditions [11]. Excessive shoot training sometimes causes the plants to cease producing flowers [12]. Therefore, it is important to maintain optimum foliage as well as shoots on the plant for adequate rates of photosynthesis.

2. MATERIALS AND METHODS

The experiment was conducted under a modified naturally ventilated polyhouse having 250 m^2 area, well equipped with essential features like double door, side and top ventilation, drip and fogging facility and internal shading with 50 per cent green agro UV stabilized shade net at Experimental Farm of Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palmpur during spring-summer season in 2016. Seeds of parthenocarpic F_1 hybrid Kian were sown in plastic plug trays of 50 cells each, by using soilless media having cocopeat, perlite and vermiculite in the ratio of 3:1:1, respectively inside the growth chamber to get healthy and disease free seedlings of cucumber. The seedlings were ready for transplanting after 21 days of seed sowing.

The experiment was laid out in a Randomized Block Design with seven treatments which replicated thrice. About 26 healthy seedlings of uniform growth pattern were selected randomly per treatment at three leaf stage and transplanted at 70 × 60 cm spacing. Before transplanting the seedlings to the respective pits, these were thoroughly filled with FYM, neem cake, carbofuran and 12:32:16 N:P:K. The treatments were comprised of various shoot training systems *viz*., single stem (T_1), single stem with side shoot training after three leaves (T_2), two stems (T_3), two stems with side shoot training after three leaves (T_4), three stems (T_5), three stems with side shoot training after three leaves (T_6) and control (no training) (T_7). The seedlings after transplanting were trained to the

different training systems at the desirable growth according to the treatments.

The observations were recorded on five plants taken randomly for the characters *viz;* days to 50 per cent flowering, days to first picking, fruit weight (g), number of fruits/plant, fruit yield/plant (kg), harvest duration (days), inter-nodal length (cm) and vine length (m). The data pertaining to the present investigation were statistically analyzed using the standard procedures of the Randomized Block Design (RBD). The treatment effects were tested at 5% level of significance.

3. RESULTS AND DISCUSSION

A cursory glance at Table 1 clearly indicates that shoot training had significant affect on the vegetative growth characteristics of cucumber. Shoot training had significant influence on days to flowering. Plants trained to single stem took least 23.67 days from transplanting to produce 50 per cent flowering and was statistically at par with treatment comprising of single stem with side shoot training after three leaves (24.00 days) as compared to control (29.00). The reason for early flowering in plants having single stem could be as a result of the fast growth of main shoot as compared to the rest of the treatments. Plants with single stem appeared to have quick absorption and utilization of nutrients and the various physiological processes boosted up at faster rate with a favorable balance between synthesis and utilization in flower induction [13]. These results are in conformity with the findings of [12] and [14] who had also reported that the plants single stem took minimum days to flowering initiation.

In cucumber the early crop produce fetch higher returns in the market [15] and shoot training of plants also had significant influence on days to first picking. Plants trained to single stem took least number of days (35.00) to first picking which was statistically at par with treatment comprising of single stem with side shoot training after three leaves (35.33 days). Early appearance of flowers at lower nodes coupled with exposure of fruits to sunlight and aeration could be the reasons for early picking in plants trained to single stem. Similar results were also reported by [13,15] and [16].

The shoot training had also significant influence on the internodal length. Minimum inter-nodal length (9.34 cm) was noticed when plants were trained to single stem, which was statistically at par with treatment comprising of single stem with side shoot training after three leaves (9.39 cm). Maximum inter-nodal length (9.78 cm) was observed in control (no training). The reason for minimum inter-nodal length of single stemmed plants was probably due to the better exposure of the plants to light, enhanced synthesis of photosynthates and more assimilation of carbohydrates. Similar finding was also reported by [6].

Among various training methods, maximum vine length (2.26 m) was noticed when plants were trained to single stem, which was statistically at par with treatment comprising of single stem with side shoot training after three leaves (2.21 m). This increase in vine length by training of side branches may be due to the restriction of flow of nutrients to the axillary branches which in turn lead to the flow to the apical tissues and thereby increasing the shoot length significantly [17]. These results are in line with the findings of [4] and [18].

Shoot training also had significant affect on harvest duration. Maximum harvest duration (56.00 days) was noticed when plants were trained to single stem, which was statistically at par with treatment comprising of single stem with side shoot training after three leaves (55.67 days). Extended harvesting duration was also due to early appearance of pistilate flowers at lower nodes coupled with exposure of fruits to sunlight and aeration could be the reasons for early pickings and longer harvest duration in plants trained to single stem. The findings of [12] and [19] corroborates the above results.

The yield characteristics of cucumber also significantly affected the different shoot training systems. Shoot training also had significant influence on number of fruits per plant. Plants trained to three stems with side shoot training after three leaves recorded maximum number of fruits per plant (28.23) followed by plants with three stems (26.17). However, minimum number of fruits per plant (16.17) was recorded in single stem treatment. More fruits/plant in plants with three stems than the plants trained to one stem and two stems could be attributed to availability of more number of fruit producing shoots, which resulted into higher number of fruits per plant. In case of untrained plants there was excessive vegetative growth, so number of fruits per plant was lesser than in plants with three stems. Similar results were also recorded by [19] and [17].

Table 1. Influence of shoot training on vegetative growth and yield characteristics of cucumber

Treatment	Vegetative growth characteristics					Yield characteristics		
	Days to 50% flowering	Days to first picking	Internodal length (cm)	Vine length (m)	Harvest duration (days)	Number of fruits per plant	Fruit weight (g)	Fruit yield per m^2 (kg)
T_1	23.67a	35.00a	9.34a	2.26a	56.00a	16.17g	136.23a	5.23c
T_2	24.00a	35.33a	9.39a	2.21a	55.67a	17.77f	135.17a	5.73b
T_3	25.67b	37.00b	9.50b	2.10b	53.33b	19.83e	131.47b	6.20b
T_4	26.00b	38.00b	9.52b	2.05b	52.67b	21.57d	129.80b	6.58b
T_5	27.33c	39.00c	9.63b	1.93c	51.00c	26.17b	126.23c	7.77a
T_6	27.67c	39.33c	9.66c	1.89c	50.33c	28.23a	124.57c	8.27a
T_7	29.00d	41.00d	9.78c	1.76d	47.33d	23.13c	120.97d	6.70b
CD (p=.05)	1.45	1.58	0.15	0.14	0.69	0.92	2.74	1.01

**CD (p =.05) means critical difference among treatments at 5 per cent level of significance*
(T_1) single stem, (T_2) single stem with side shoot training after three leaves, (T_3) two stems, (T_4) two stems with side shoot training after three leaves, (T_5) three stems, (T_6) three stems with side shoot training after three leaves and (T_7) control (no training)

Fruit weight in parthenocarpic cucumber also plays important role and training of plants also had significant affect on fruit weight. Plants trained to single stem recorded highest fruit weight (136.23 g) which was statistically similar with treatment comprising of single stem with side shoot training after three leaves (135.17 g) and were significantly higher ($p<0.05$) than rest of the treatments. Highest fruit weight from single stem plants was probably due to the better exposure of the plants to light, enhanced synthesis of photosynthates and more assimilation of carbohydrates. The above findings are supported with the conclusions drawn by [11,18] and [14].

It is apparent from the data presented in Table 1 that shoot training also had significant effect on fruit yield per m^2 area. Treatment comprising of three stems with side shoot training after three leaves had highest fruit yield per m^2 area (8.27 kg) and was statistically at par with treatment comprising of three stems (7.77 kg). The higher yield from the plants trained to three stems might be attributed to its better performance in number of fruits/plant which ultimately resulted in increase in fruit yield per m^2 area. Similar results were also reported by [4,6] and [19].

4. CONCLUSION

It was concluded that parthenocarpic cucumber plants trained to single stem had better vegetative characters whereas, plants trained to three stems with side shoot training after three leaves produced higher yield/m^2 area.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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