International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(6): 1453-1455

Received: 29-09-2017
Accepted: 30-10-2017

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Influence of different training systems in cucumber under naturally ventilated poly house

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Abstract
To develop a suitable training system in cucumber, experiments were conducted in college orchard, HC&RI, Coimbatore under naturally ventilated poly house during kharif 2014 and summer 2015. F_1 hybrid 'Multi star' was used. Four treatments were followed *viz*., Drape system (The apical meristem is not removed and the plant is draped over the top cable wire at 8 feet height. All other side branches are removed), Pinch system (The apical meristem is removed at 8 feet height and a lateral shoot is trained over the cable wire at 8 feet height and back down to the floor), Allowing only 2 lateral shoots from the basal 2 nodes (@ 1 per each node and the apical meristem is not removed and the plant is draped over the top cable wire at 8 feet height) and the control which includes allowing only 4 lateral shoots from the basal 4 nodes (@ 1 per each node and the apical meristem is not removed and the plant is draped over the top cable wire at 8 feet height). The statistical design followed was RBD with five replications. The pooled analysis of two seasons revealed that, the drape system recorded significantly higher values for number of flowers per plant, percent fruit set, fruit weight, fruit length, fruit circumference, number of fruits per plant, total number of harvests, fruit yield per plant (13.15 kg), fruit yield per m^2 (19.94 kg), estimated yield per ha (199.4 tonnes) and B:C ratio than control. It also recorded significantly lower values for internodal length, days taken for first flowering and days taken for first harvest (41.27) than control. TSS (3.32 %) and ascorbic acid (3.18 mg per 100 g) were highest in this treatment and it did not show any significant differences. It was concluded that, the drape system of training was suitable in cucumber under polyhouse

Keywords: Cucumber, training, yield

Introduction
Cucumber (*Cucumis sativus* L.) is one of the most important member of the family Cucurbitaceae. It is a primary source of vitamins and minerals for human body but its caloric and nutritional value is very low. The total area and production of cucumber in India was 40,900 ha and 6, 40, 990 tonnes, with the productivity of 15.67 t / ha (Indian Horticulture Database, 2013) [5].

Parthenocarpic fruits are common cucumber hybrids that can be grown in off season under protected conditions due to their ability to set fruit without pollination or fertilization even at low temperatures making efficient utilization of the land, water, nutrient and other resources. Protected cultivation, also known as 'Controlled Environment Agriculture (CEA)' is highly productive, environment protective and water and land conservative cultivation practice (Jensen, 2002) [7].

Training methods vary with different growth habits of cucumber cultivars and for different plant densities. Training the plants to two shoots or three shoots will not only facilitate easy training operation, but also permit closer planting, early harvesting of fruits and get higher yields of large sized fruits. 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 plants to reduce risk of fungus and insect problems. The suitable plant spacing with pruning gave higher yield of cucumber. Canopy manipulation through pruning and training together with appropriate spatial arrangements has been identified as key management practices for getting maximum marketable yields from greenhouse crops. Keeping these points in view, the present investigation was carried out.

Materials and methods
Experiments were conducted under poly house during Kharif 2014 (I season) and summer 2015 (II season) at orchard, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu which is situated at an elevation of 426.72 m, between 11° N latitude and 77^0 E longitude.

The rainfall of this district during I season is 107.6 cm (June – December) and 34.2 cm in II season (Jan. to May). The average maximum and minimum temperature is 36 ºC and 19.2 ºC respectively for the I season and 37.5 ºC and 19 ºC respectively for the II season. The relative humidity was 73% in the first season and 62% in the second season**.** The soil type is sandy clay loam with a pH of 7.9 and EC of 0.54 dsm^{-1}.The soil available N, P and K was 175 kg, 15 kg and 1250 kg per ha respectively.

Gynoecious parthenocarpic F_1 hybrid cucumber 'Multi Star' was sown in raised beds on 26.6.14 (I season) and 16.1.15 (II season) at a spacing of 1.2 x 0.45 m in a naturally ventilated polyhouse of size 400 m^2 to study the effect of different training systems. The following 4 treatments were imposed.

T_1 - Drape system (The apical meristem is not removed and the main stem is draped over the top cable wire at 8 feet height and allowed to grow down to the floor. All other side branches are removed).

T_2 - Pinch system (The apical meristem is removed at 8 feet height and one side branch is allowed to grow over the top cable wire at 8 feet height and allowed to grow down to the floor. All other side branches are removed.)

T_3 – Allowing only 2 side branches from the basal 2 nodes (@ 1 per each node) and the apical meristem is not removed. The main stem is draped over the top cable wire at 8 feet height and allowed to grow down to the floor. All other side branches are removed.

T_4 - Allowing only 4 side branches from the basal 4 nodes (@ 1 per each node) and the apical meristem is not removed .The main stem is draped over the top cable wire at 8 feet height and allowed to grow down to the floor. All other side branches are removed (control).

The design followed was Randomized block design with five replications. All the agronomic practices including fertigation were followed as per the recommendations. Twenty five plants were maintained per treatment per replication. Five plants from each replication were tagged for recording observations *viz*., inter nodal length (cm), days taken for first flowering, days taken for first harvest, number of flowers per plant, percent fruit set (%), fruit weight (g), fruit length (cm), fruit circumference (cm), number of fruits per plant, total number of harvests, fruit yield per plant (kg), fruit yield per m^2 (kg) and estimated fruit yield per ha (tonnes), TSS (%) and ascorbic acid (mg per 100 g). Benefit cost ratio was also calculated. The data were statistically analyzed for the comparison of intercrops as per Panse and Sukhatme (1967) [10].

Results and discussion

Effect of training systems on vegetative characters

The data on vegetative characters as influenced by various treatments have been given in Table 1. Training systems had significant influence on inter nodal length. Inter nodal length determines the height and number of nodes per plant. The parthenocarpic cucumber hybrids bear fruits at almost every node. Therefore, plants having less inter nodal length and more number of nodes are desired for getting higher yield. Plants trained in drape system (T_1) produced smaller inter nodal length (9.3 cm) as compared to other training systems. Similar findings were also reported by Nweke *et al*. (2013) [9] in cucumber.

Effect of training systems on reproductive characters

The data on reproductive characters as influenced by various treatments have been given in Table 1. Days taken to first flowering and harvesting are important characters and an indicator of getting early and uniform yield of cucumber grown under protected conditions. Training systems had significant influence on days to initiation of first female flower and harvest. Plants trained on drape system took lesser number of days to initiate first flower (24.23) and harvest (41.27) than other treatments. Control took more number of days for these traits. The most probable reason for early female flower appearance in drape system was that the length of main shoot grew faster than other systems. Plants with drape system 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. The findings of present investigation are in accordance with the findings of Hirama *et al*. (2011) [3] in cucumber who observed early appearance of first pistillate flower and at lower nodes by pruning at one primary shoot in cucumber than many shoots. Early appearance of pistilate 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 Jaffar and Wahid (2014) [6] in cucumber.

Plants trained on drape system produced highest number of flowers (131.12), number of fruits (123.72) and per cent fruit set (96.27) than other treatments. The effect was significantly higher than control. The reason was probably due to the better exposure of the plants to light, enhanced synthesis of photosynthates and more assimilation of carbohydrates. These results are in conformity with the earlier findings of Aniekwe and Anike (2015) [1] in cucumber.

Effect of training systems on fruit characters

The data on fruit characters as influenced by various treatments have been given in Table 1. In this experiment, plants trained on drape system produced highest fruit weight (125.22 g), fruit length (20.36 cm) and fruit circumference (10.4 cm) and the effect was significantly maximum. Control produced lowest values for these characters. A sufficient amount of assimilates were available for young fruits in drape system but the reverse situation prevailed in the other treatments. Similar observations were also recorded by Aniekwe and Anike (2015) [1] and Hoza *et al*. (2015) [4] in cucumber.

Effect of training systems on yield attributes

Table 2 represents the data on yield attributes as influenced by various treatments. Training systems had significant influence on yield attributes. Drape system of training in cucumber produced significantly maximum number of harvests (41.57), fruit yield per plant (13.15 kg), fruit yield per m^2 (19.94 kg) and estimated fruit yield (199.4 tonnes perha). Control registered lowest values for all these characters.

The reason for more yield harvested from drape system was probably due to the adequate air movement around the plants, better exposure of the plants to light and absorbance, enhanced synthesis of photosynthates and more assimilation of carbohydrates. These results are in conformity with the earlier findings of Aniekwe and Anike (2015) [1] and Mamnoie *et al*. (2014) [8]. The higher yield from the plants trained under drape system may be attributed to its better performance in yield per plant which ultimately resulted in increase in yield per ha. Similar results were also reported by Bhatia *et al*. (2012) [2] and Utobo *et al*. (2010) [11] in cucumber. The higher benefit: cost ratio registered by this treatment was attributed to higher fruit yield. Control recorded lowest benefit: cost ratio.

Table 1: Effect of training systems in cucumber on growth and fruit characters (Pooled analysis of two seasons)

Treatments	Inter nodal length (cm)	Days taken for first flowering	Days taken to first harvest	Numbers of flowers per plant	No. of fruits per plant	Percent fruit set (%)	Fruit weight (g)	Fruit length (cm)	Fruit circumference (cm)
T_1	9.3	24.23	41.27	131.12	123.72	96.27	125.22	20.36	10.4
T_2	9.6	27.35	42.33	125.15	117.82	94.34	122.12	19.3	9.4
T_3	9.8	28.31	43.21	121.51	112.36	92.25	120.76	17.8	9.3
T_4	9.9	28.71	44.64	115.43	106.11	91.29	117.34	16.4	8.5
S. Ed	0.2	1.03	1.04	1.60	2.21	1.64	1.62	0.81	0.53
CD(P=0.05)	0.4	2.07	2.09	3.22	4.45	3. 30	3.15	1.63	1.08

Table 2: Effect of training systems in cucumber on fruit characters and quality (Pooled analysis of two seasons)

Treatments	Total number of harvests	Fruit yield per plant (kg)	Fruit yield per m^2 (kg)	Estimated fruit yield (t/ha)	B:C ratio	TSS (%)	Ascorbic acid (mg / 100 g)
T_1	**41.57**	**13.15**	**19.94**	**199.4**	**3.37**	**3.32**	**3.18**
T_2	40.32	12.61	18.96	189.6	3.08	3.04	3.01
T_3	39.63	12.14	18.13	181.3	2.98	3.01	2.94
T_4	37.71	11.26	16.32	163.2	2.91	2.91	2.79
S. Ed	1.64	0.65	1.10	-	-	0.14	0.17
CD(P=0.05)	3.29	1.32	2.22	-	-	NS	NS

Effect of training systems on quality

The data on Total soluble solids (TSS) and ascorbic acid as influenced by different treatments have been presented in Table 2. 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. In this experiment, total soluble solids and ascorbic acid were not significantly influenced by different treatments. But the drape system produced highest TSS of 3.32% and ascorbic acid (3.18 mg / 100 g). The lowest values were registered by control. It may probably be due to more production and translocation of synthesized carbohydrates into fruits.

Conclusion

The drape system recorded highest values for yield and yield attributing characters and it was concluded that, this training method was most suitable in cucumber under polyhouse.

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