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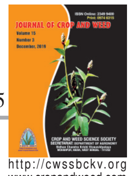

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Studies on the intensity of cladode pruning on vegetative and reproductive behaviour of dragon fruit (*Hylocereus costaricensis*)

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ABSTRACT

The present investigation was conducted on dragon fruit (Hylocereus costaricensis [F.A.C. Weber] Britton & Rose) at the premises of the Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India during the years 2017-2019 comprising seven treatments viz. retention of 30 (T_1), 50 (T_2), 70 (T_3), 90 (T_4) and 110 (T_5) number of downward hanging primary cladodes, the retention of only upright cladodes (T_6) and control (T_7). Randomized Block Design was used in the experiment along with four replications. The lowest yield of 5.96 kg/ pillar was observed with retention of only upright cladodes. As the total yield per pillar was the highest (10.01 kg) [Table 7] with the retention of 50 (fifty) primary downward hanging cladodes with average fruit weight ranged from 245.30 to 257.18g (Table 6), it can be recommended as better treatment over the others.

***Keywords*:** Canopy, cladode, dragon fruit, pruning, vegetative, reproductive

Dragon fruit (*Hylocereus costaricensis* [F.A.C. Weber] Britton and Rose) is a fruit bearing member of the cactus family and one of the most beautiful and nutritious fruit crops in the world. It has originated in tropical and sub-tropical forest regions of Mexico and Central and South America and mainly cultivated in Thailand, China, Mexico, Australia, Cambodia, Guatemala, Malaysia, Sri Lanka, Taiwan, Japan and other countries (Britton and Rose, 1963; Morton, 1987 and Mizrahi *et al*., 1997). Dragon fruit was introduced in India (mostly in Andaman & Nicobar Islands, Andhra Pradesh, Gujarat, Karnataka, Kerala, Maharashtra, Orissa, Tamil Nadu and West Bengal) during the late '90s and the area under cultivation is increasing (Karunakaran *et al*., 2019).

It is an epiphytic plant consisting of dark green coloured and profusely branching stems that requires a peat land and a warm and humid environment. Unlike other members of the Cacti which originated in the desert, dragon fruit requires an adequate amount of water for its growth and development. The stems may reach 6 m or more in length and 10-12 cm thick (Gunasena *et al*., 2007) and the growth of the cladodes under optimum conditions is so vigorous that within 3-4 years the pillar can get overcrowded and make it difficult for harvesting and other cultural operations and also it encourages spider web to grow within the canopy leading to disease and pest infection. Moreover, the unmanaged pillars tend to produce very small and malnourished fruits that are unmarketable and are more prone to falling in strong winds in cyclone-prone areas. Barbera *et al.* (1991) noticed overshading within the canopy to be detrimental for improving yield and fruit quality in Prickly pear [*Opuntia ficus indica* (L.) Miller]. Therefore, for commercial exploitation of this crop, it is necessary to know the response of the dragon fruit plant towards the pruning of the cladodes to manage and find the optimum canopy on the pillar to sustain productivity for a longer period of its economic life.

MATERIALS AND METHODS

The experiment was carried out at the premises of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal in a Randomized Block Design comprising seven treatments (including control) and four replications. Dragon fruit cv. Royal Moroccan Red was the selected type for the present experiment where the pillars were spaced at 2.5m × 2.5m distance with four plants per pillar. The age of the orchard was 4 years and was situated in the Gangetic Alluvial Zone. The treatment consisted of T_1 – retention of 30 numbers of hanging cladodes, T_2 – retention of 50 numbers of hanging cladodes, T_3 – retention of 70 numbers of hanging cladodes, T_4 – retention of 90 numbers of hanging cladodes, T_5 – retention of 110 numbers of hanging cladodes, T_6 – retention of only upright cladodes and T_7 – Control. A uniform fertilizer dose of 450g N, 350g P_2O_5, 300g K_2O and 5kg FYM per pillar was provided for all the treatments during the investigation with the following schedule (Perween *et al*., 2019).

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Stages	Per cent nutrient application		
	N_2	P_2O_5	K_2O
After pruning	30	20	30
Before flowering	10	10	30
At fruit set	20	40	25
3 months after harvest	40	30	15

Pruning was done after completion of the harvesting in the second fortnight of November, the cladodes were removed from the main stem, and the older stems were selectively removed from the underneath (cut branches back to the node) which were lying on the ground or spreading in between the cultural operational space, the tertiary and quarterly branches were cut back to the original stem, the primary branches were allowed on the pillar having at least 1-2 sub-branches and immediately after pruning cut ends of stems were sprayed with copper fungicide. Newly developing cladodes could be competitive sinks for resource allocation during the growth stage of the fruits in Cactus pear (Inglese *et al*., 1999). The cut portions of cladode were removed from the field to avoid contamination. Gunasena *et al*. (2007) reported a well-grown plant can produce 130 branches or more in the fourth year and therefore pruning is necessary to avoid interference with cultural operations and harvesting.

Forty numbers of cladodes were randomly selected and tagged from each treatment per replication for the record of observations on different growth parameters, yield and quality related parameters. Days required to produce new sprouts on the pruned branches and the length and width of the sprouts were recorded at fifteen days intervals. Flower length, petal length, stamen length and anther length were measured with a digital vernier calliper. The harvested fruits were dried at 70^{0}C in a forced-air oven until they come to constant weight for calculating their dry matter content. Days taken to harvest from each flush were recorded on the selected plants. The number of fruits per pillar in each flush were counted manually from the selected pillars along with their total yield per pillar per year. Five fruits from each treatment per replication were taken for the investigation of the length and breadth of fruit, bract length and distal width and fresh fruit weight.

The total soluble solids content of the harvested fruits was measured with the help of a digital hand refractometer having a range of 0-32^{0}Brix. The ascorbic acid content in the fruits was quantified by 2, 6-dichlorophenol indophenol dye titration method (A.O.A.C., 2006). The titratable acidity of the fruits was estimated by titrating the aqueous extract of a known quantity of fruit juice against (N/10) NaOH solution using phenolphthalein as an indicator (A.O.A.C., 2006). The total sugar content of the fruit was determined by gravimetric procedures. The reducing sugar content of the aqueous extract was determined by titrating against Fehling's solution as stated above (A.O.A.C., 2006) and expressed in percentage.

Percentage of non-reducing sugar =

(Total sugar – Reducing sugar) × 0.95

As 0.95 gram of sucrose on hydrolysis gives 1 gram of monosaccharides *i.e.* glucose + fructose. (A.O.A.C., 2006)

RESULTS AND DISCUSSION

Maximum time taken (55.09 days) to produce new sprouts was observed in control (T_7) and the lowest (51.69 days) with retention of 30 downward hanging cladodes (Fig. 1). The shoot emergence was found earliest in severely pruned plants followed by lightly pruned and late in unpruned plants (Fig. 1). The pruned plants started new vegetative growth earlier after pruning with stored carbohydrates that provided sufficient boost for growth as there was less sink as compared to the unpruned pillars where there were lots of growing points with a limited amount of stored carbohydrate.

The observations on the growth of cladode length were taken at an interval of 15 days starting from the day of pruning. The most vigorous growth in cladode length was noted with retention of 30 (thirty) primary downward or hanging cladodes (T_1) throughout the period of investigation and the lowest growth in cladode length was observed in the control (T_7) [Table 1]. Because of the huge numbers of growing points (cladodes) in control, there was more competition for nutrients among the existing cladodes which might have resulted in the lowest average growth in cladode length. The growth of cladode width was also taken at an interval of 15 days and the highest value was observed with retention of 50 (fifty) numbers of hanging cladodes (T_2) [Table 2]. Inglese *et al*. (1994) conducted a similar experiment in Cactus Pear (*Opuntia ficus indica* (L.) Miller) and found that the primary and secondary, one-year old terminal cladodes accounted for most of the yield while thicker and older cladodes were less fruitful. The cladode moisture and dry matter content were measured from the matured cladodes and the highest moisture level was observed 89.78% with the retention of 30 (thirty) numbers of hanging cladodes (T_1) and the lowest value (87.69%) in the control pillars (T_7) [Table 3]. The dry matter content of matured cladodes was observed the lowest (10.22%) with the retention of 30 hanging cladodes (T_1) and the highest (12.32%) in control (T_7) [Table 3].

The observations recorded for the days taken to produce flower buds after pruning show that retention of 30 (thirty) numbers of hanging cladodes per pillar

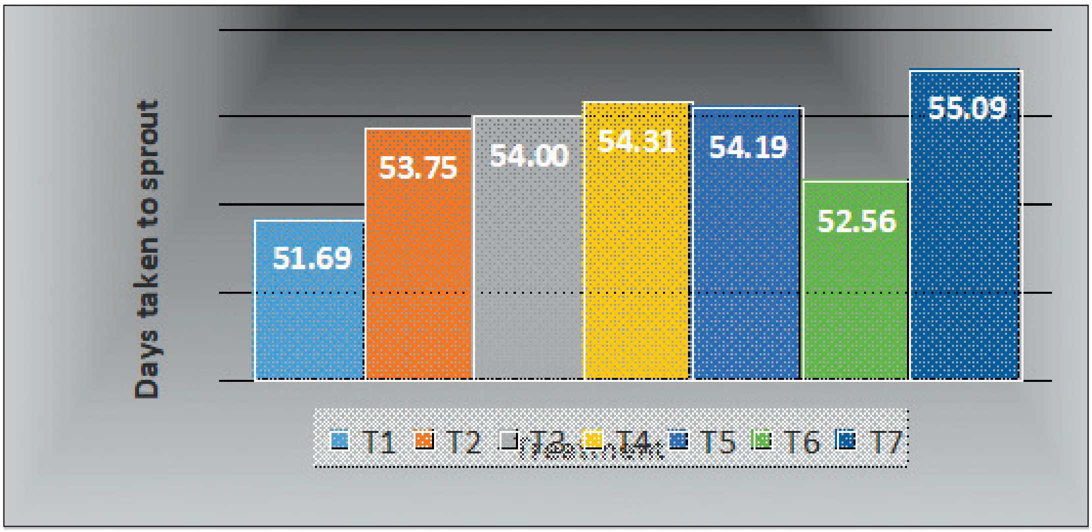

Fig.1 : Days taken to produce new sprouts in different treatments

Table 1: Effect of intensity of pruning on cladode length (cm) in different flushes

Treatment	Days after sprouting					
	15	**30**	**45**	**60**	**75**	**90**
T_1	7.86	18.24	27.65	36.29	42.98	48.65
T_2	7.79	17.69	26.81	35.23	41.38	47.21
T_3	6.75	15.73	25.27	33.55	39.97	45.60
T_4	6.94	16.10	26.01	34.71	41.10	47.06
T_5	6.93	17.14	26.47	34.88	41.74	47.47
T_6	7.40	16.02	25.34	33.50	39.67	45.61
T_7	6.47	14.30	23.66	32.23	39.84	45.12
SEm (±)	**0.32**	**0.53**	**0.51**	**0.63**	**0.76**	**0.76**
LSD(0.05)	**0.95**	**1.59**	**1.53**	**1.89**	**NS**	**2.27**

Table 2: Effect of pruning intensity on the cladode width (cm) in different flushes

Treatment	Days after sprouting					
	15	**30**	**45**	**60**	**75**	**90**
T_1	1.66	2.29	3.00	3.74	4.45	4.79
T_2	1.75	2.37	3.12	3.88	4.56	4.92
T_3	1.49	2.16	2.86	3.56	4.30	4.64
T_4	1.45	2.46	3.15	3.84	4.52	4.87
T_5	1.37	1.98	2.68	3.39	4.11	4.45
T_6	1.61	2.10	2.83	3.46	4.21	4.56
T_7	1.29	2.09	2.81	3.49	4.22	4.56
SEm (±)	**0.08**	**0.08**	**0.08**	**0.08**	**0.09**	**0.09**
LSD(0.05)	**0.26**	**0.25**	**0.25**	**0.26**	**0.27**	**0.28**

Table 3: Effect of intensity of pruning on cladode moisture and dry matter content (%) in dragon fruit

Treatments	Percentage	
	Moisture	Dry matter
T_1	89.78	10.22
T_2	89.38	10.62
T_3	88.83	11.17
T_4	87.87	12.13
T_5	87.81	12.19
T_6	88.46	11.54
T_7	87.69	12.32
SEm (±)	**0.41**	**0.39**
LSD(0.05)	**1.22**	**1.18**

NOTE: *Retention of number of primary cladodes in different treatments, T_1 – 30, T_2 – 50, T_3 – 70, T_4 – 90, T_5 – 110, T_6 – only upright cladodes, T_7 – Control.*

Table 4: Effect of retention of cladode on floral characters in dragon fruit

Treatment	Days to flower	Flower length (cm)	Petal length (cm)	Petal number	Stamen length (cm)	Anther length (mm)	Anther diameter (mm)
T_1	123.00	29.77	11.57	22.00	11.08	8.60	0.94
T_2	121.75	30.15	11.68	21.00	11.00	8.42	0.95
T_3	119.75	29.89	11.67	21.50	10.69	8.68	0.95
T_4	118.25	30.12	11.58	22.50	10.37	8.54	0.94
T_5	118.00	29.63	11.43	21.25	11.18	8.49	0.95
T_6	119.50	29.88	11.38	21.50	10.73	8.46	0.94
T_7	118.75	30.07	11.44	21.50	10.84	8.59	0.95
SEm (±)	**1.13**	**0.34**	**0.13**	**0.45**	**0.21**	**0.14**	**0.00**
LSD(0.05)	**3.35**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 5: Effect of cladode retention on the days taken to harvest after pruning in different flushes

Treatment	Number of flushes				
	1st	2nd	3rd	4th	5th
T_1	151.00	178.50	206.25	234.75	263.50
T_2	149.75	177.25	205.25	234.50	263.00
T_3	147.75	176.00	205.75	233.25	261.75
T_4	146.25	176.50	205.00	235.00	264.25
T_5	146.00	177.25	204.75	235.25	264.25
T_6	147.50	177.00	205.00	235.50	264.00
T_7	146.75	177.75	205.25	236.25	265.00
SEm (±)	**1.13**	**0.62**	**0.57**	**0.70**	**0.75**
LSD(0.05)	**3.35**	**NS**	**NS**	**NS**	**NS**

Table 6: Effect of retention of cladodes on the length (cm) of fruits after harvest in dragon fruit

Treatment	Number of flushes				
	1st	2nd	3rd	4th	5th
T1	8.44	7.86	7.49	6.78	6.96
T2	8.43	7.84	7.31	6.62	6.77
T3	8.39	7.80	7.20	6.60	6.75
T4	8.37	7.79	7.17	6.57	6.72
T5	8.33	7.73	7.18	6.56	6.71
T6	8.27	7.67	7.10	6.51	6.70
T7	7.94	7.47	7.06	6.45	6.45
SEm (±)	**0.09**	**0.07**	**0.08**	**0.05**	**0.07**
LSD(0.05)	**0.29**	**0.22**	**0.25**	**0.17**	**0.22**

Table 7: Effect of retention of cladode on the breadth (cm) of the fruits after harvest in dragon fruit

Treatment	Number of flushes				
	1st	2nd	3rd	4th	5th
T_1	7.88	7.31	6.83	6.02	6.14
T_2	7.69	7.20	6.64	5.69	5.98
T_3	7.67	7.12	6.48	5.69	5.84
T_4	7.66	6.88	6.36	5.68	5.81
T_5	7.60	6.87	6.35	5.68	5.81
T_6	7.58	6.87	6.33	5.67	5.77
T_7	7.31	6.84	6.26	5.66	5.76
SEm (±)	**0.10**	**0.09**	**0.10**	**0.05**	**0.07**
LSD(0.05)	**0.30**	**0.27**	**0.32**	**0.16**	**0.21**

Notes: Retention of number of primary cladodes in different treatments, T_1– 30, T_2– 50, T_3– 70, T_4– 90, T_5– 110, T_6 – only upright cladode, T_7– Control.

Table 8: Effect of intensity of pruning of cladode on the fruit weight (g) in different flushes

Treatment	Number of flushes				
	1st	2nd	3rd	4th	5th
T_1	267.67	262.84	262.48	255.82	252.24
T_2	257.18	257.05	251.35	245.30	250.76
T_3	224.09	219.84	215.34	209.85	215.69
T_4	206.43	200.21	198.02	191.72	192.23
T_5	179.19	175.05	174.55	173.81	170.34
T_6	199.40	197.01	196.69	205.95	198.21
T_7	139.14	138.36	135.35	136.21	131.37
SEm (±)	**3.21**	**1.96**	**3.31**	**3.25**	**3.04**
LSD(0.05)	**9.55**	**5.84**	**9.83**	**9.68**	**9.04**

Table 9: Effect of pruning of cladodes on number of fruits per pillar in different flushes

Treatment	Number of flushes				
	1st	2nd	3rd	4th	5th
T_1	8.10	7.23	7.00	6.26	5.95
T_2	8.86	8.52	8.09	7.15	7.00
T_3	9.48	9.21	9.09	8.38	8.16
T_4	10.08	9.86	9.55	9.14	9.06
T_5	11.55	10.84	10.45	10.01	9.88
T_6	6.35	6.47	6.44	5.09	5.54
T_7	15.16	14.09	13.18	11.16	10.17
SEm(±)	**0.06**	**0.16**	**0.11**	**0.07**	**0.11**
LSD(0.05)	**0.18**	**0.49**	**0.33**	**0.23**	**0.34**

Table 10: Effect of intensity of pruning on the total yield (kg pillar^{-1})

Treatment	Number of flushes					Total
	1st	2nd	3rd	4th	5th	
T_1	2.17	1.90	1.84	1.60	1.50	9.00
T_2	2.28	2.19	2.03	1.75	1.76	**10.01**
T_3	2.12	2.02	1.96	1.76	1.76	9.62
T_4	2.08	1.97	1.89	1.75	1.74	9.43
T_5	2.07	1.90	1.82	1.74	1.68	9.21
T_6	1.27	1.28	1.27	1.05	1.10	5.96
T_7	2.11	1.95	1.78	1.52	1.34	8.70
SEm (±)	**0.03**	**0.04**	**0.04**	**0.02**	**0.03**	
LSD(0.05)	**0.09**	**0.11**	**0.12**	**0.06**	**0.11**	

Notes: Retention of number of primary cladodes in different treatments, T_1 – 30, T_2 – 50, T_3 – 70, T_4 – 90, T_5 – 110, T_6 – only upright cladode, T_7 – Control.

(T_1) took longer time (123 days) to flower than other treatments and the shortest time (118 days) was observed in pillars retained with 110 number of primary hanging cladodes (T_5) [Table 4]. Pruned cladodes started new vegetative growth immediately after pruning and almost the entire amount of carbohydrates might have been used in the vegetative growth of cladodes instead of forming flower buds resulting in a late start of flowering in pruned trees (Dhaliwal and Singh, 2004). There was no significant difference in flower length, petal length, petal number, stamen length, anther length and anther diameter with respect to the various intensities of pruning.

The variation in days taken to harvest after pruning differed significantly in the first flush only. The longest time taken for harvest in the first flush was 151 days after pruning in the pillars retained with 30 (thirty) numbers of hanging cladodes (T_1) and the earliest (146 days) harvesting was observed with the retention of 110 downward cladodes (T_5) which was at par with control (T_7) [Table 5].

The length of the fruits significantly increased with the higher intensity of pruning. The retention of 30 (thirty) numbers of primary hanging cladodes gave the highest length of the fruits while control (T_7) showed the lowest values (Table 6). This might be due to the nutrient availability per fruit (sink) being more in the severely pruned pillars than the unpruned or control pillars. The effect of the intensity of pruning was also significant in terms of the breadth of the fruits. The retention of 30 primary hanging or downward cladodes (T_1) showed the maximum breadth of the fruits and the least value under control (T_7) [Table 7].

The increasing intensity of pruning resulted in the highest fruit weight and the pillars with no pruning *i.e.* control (T_7) showed the lowest fruit weight (Table 8). Similar results were observed by Hieu *et al.* (2018). This might be due to more competition among the fruits for the available nutrients in the unpruned pillars than in the pruned ones. The number of fruits was greatly influenced by the intensity of pruning. The lowest number of fruits was observed with the retention of only upright cladodes

(T_6) without having any hanging or downward cladodes (Table 9). So, it is evident that the cladodes hanging downward are significantly more productive than the upward cladodes while the highest number of fruits was observed in control (T_7) throughout the season.

Total yield was calculated based on the total number of fruits harvested from each flush and their respective weight. It was evident that the maximum yield (10.01 kg) per pillar from five flushes altogether was observed with the retention of 50 (fifty) numbers of primary hanging or downward cladodes (T_2) [Table 10]. The lowest yield (5.96 kg/ pillar) was recorded with the retention of only upright cladodes (T_6) at the end of the fifth harvest as the productivity was very less in the upright cladodes compared to the other treatments with the retention of primary hanging or downward cladodes. The total production with control pillars (T_7) was significantly less (8.7 kg) compared to the other treatments with downward hanging cladodes [Table 10].

Altogether, the pillars with the retention of 50 (fifty) primary downward hanging cladodes showed the best results in terms of yield with marketable fruit size.

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