EFFECT OF VARIOUS DEGREE OF CANOPY PRUNING ON PLANT GROWTH, YIELD, AND CONTROL OF CANKER DISEASE OF DRAGONFRUIT CROP

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Dragonfruit (*Hylocerus undatus*) is one of the most important tropical crops in the southern part of Vietnam. 'Mop Top' (concrete post) is a traditional production system which is associated to many inherent issues to the industry such as old unproductive cladodes and support instability, management constraints, providing a haven for pests and diseases, poor quality fruit, etc. The Mop Top plant structure itself presents challenges for orchard hygiene and poor management leads to significant pest and disease problems, particularly canker disease caused by *Neoscytalidium dimidiatum*. This newly emerging disease can quickly spread during the wet season and heavy infection can reduce plant growth, marketable production, and induce a high dependency on fungicides which could lead to food safety issues due to intensive and inappropriate chemical applications. This investigation showed that high degrees of canopy pruning on Mop Top systems ranging from 40% to 60% could support new vegetative shoots (1.6–16.1 shoots/plant) and reduce disease incidence (%) and disease severity (%) on cladodes as compared to control (un-pruned). Moreover, treatments of pruning significantly increased numerous flower formations from 15.4% to 20.1% while stimulating the number of effective cladodes (bub formation) on the first layer, second layer, and third layer. This method also reduced disease severity on fruits up to 26.2%–32.2% as compared to un-pruned treatments. There were no evidences on fruit weight and yield affected by pruned treatments.

Keywords: dragonfruit, pruning, canker disease, *Neoscytalidium dimidiatum*

INTRODUCTION

Dragonfruit (*Hylocerus undatus*) is a native American cactus of varied habitats, widely distributed in many nations and territories such as Mexico, Colombia, Costa Rica, Nicaragua, Israel, Taiwan, Thailand, Philippines, Sri Lanka, Malaysia, China, etc.[1, 2]. In Vietnam, dragonfruit is considered one of the most important tropical fruits. The growing area of dragonfruits is approximately 44,200 ha with a production of about 140,000 tons and an average yield of 30–40 tons/ha[3]. It is mainly cultivated at Binh Thuan, Tien Giang, and Long An provinces and in other areas in the South East and Northern regions. The majority of the varieties are white flesh (*Binh Thuan* and *Cho Gao*) and red flesh (*Long Dinh 1*) which are popularly grown and exported to more than 40 countries in the world. However, there are many challenges to production and exportation, i.e., canker disease caused by *Neoscytalidium dimidiatum* which is known as a new destructive disease and causes loss at the pre-harvest stage leading to another subsequent issue—high pesticides residues on fruit products due to intensive and inappropriate chemical applications[4].

Reports from Taiwan and Vietnam show that to avert infection, affected plant organs in the canopy should be removed to reduce the inoculum[5, 6]. However, the Mop Top plant structure itself presents challenges for orchard hygiene and poor management leads to significant pest and disease problems, particularly canker disease. This newly emerging disease quickly spreads during the wet season and heavy infection reduces plant growth, marketable production, and induces a high dependency on fungicides which leads to food safety issues due to intensive and inappropriate chemical applications[6].

MATERIALS AND METHODS

The experiment was carried out at a farm in Thanh Binh village, Cho Gao district, Tien Giang province, during the off-season in 2017. In the experimental plots, dragonfruit plants were illuminated through artificial lighting to induce flowering. It was laid out in a Completely Randomized Block Design (CRBD) and replicated ten times (5 plants for each replication). Five treatments of canopy pruning were tested on five-year-old white flesh dragonfruit plants as mentioned below. For each treatment, canopy was pruned after harvesting (main season). The priority was to remove old (unproductive) and infected cladodes—particularly pycnidia. The number of cladodes before and after prunning were counted for all treatments.

Table 1: Pruning treatments used in the study

Treatment	Number of cladodes remain before pruning (cladode/post)	Number of cladodes left after pruning (cladode/post)
T1 - 60% of canopy pruned	205	128
T2 - 50% of canopy pruned	245	163
T3 - 40% of canopy pruned	256	183
T4 - 30% of canopy pruned	286	220
T5 - Control (untreated)	296	296

Intercultural operations such as irrigation, fertilization, disease, and insect management were done as per necessary and were uniform for all treatments. Data on new shoots formed after pruning, canker disease, yield, and yield contributing characters were duly taken.

To assess disease incidence and disease severity, the following formula and grade[7] were used:

Disease incidence (%) = (Number of infected shoots/Total of shoots observation) × 100

Disease severity (%) = Σ [(ni × vi)/(K × N)] × 100

ni × vi: Number of fruit infected correspondent to disease index

K: Highest disease index

N: Total number of infected fruit observed

Disease index:
Grade 1: Disease spot area occupied <1% total area of infected cladodes
Grade 3: Disease spot area occupied 1 to <10% total area of infected cladodes
Grade 5: Disease spot area occupied 10 to <25% total area of infected cladodes
Grade 7: Disease spot area occupied 25 to <50% total area of infected cladodes
Grade 9: Disease spot area occupied ≥50% total area of infected cladodes

Statistical analysis of data: Data was subjected to statistical analysis after proper transformation wherever required as described by Gomez and Gomez[8] using MSTATC software.

RESULTS

Effects of canopy pruning on new shoots and floral bubs formed during off-season:

After pruning, the number of new shoots formed was significantly higher on all treatments as compared to control (untreated), with the exception of T4 (30% of canopy pruned). Particularly, T1 (60% of canopy pruned) was the most effective and significant in stimulating the number of new shoots formed with 42.1/

post, whereas T4 (30% of canopy pruned) and T5 (control) resulted in minimum new shoots formed 27.8/post and 26.0/post, respectively (Table 2).

Table 2. Effects of canopy pruned categories on new shoots and floral bubs formed during off-season

Treatment	Number of new shoots formed/ post	At 4 days after lighting was stopped		At 4 days after lighting was stopped	
		Total floral bub/post	Shoots transformed into flowering (%)	Total floral bub/post	Shoots transformed into flowering (%)
T1	42.1 a	67.2 a	15.4 a	91.9 ab	25.4 a
T2	36.2 ab	52.3 b	9.7 bc	83.6 bc	19.3 b
T3	35.1 b	71.9 a	12.6 ab	96.2 a	19.1 b
T4	27.8 c	49.5 b	7.9 c	73.0 d	13.4 c
Control (untreated)	26.0 c	51.8 b	6.7 c	73.7 cd	10.8 c
Significant Coefficient of Variation	**	**	**	**	**
CV (%)	12.31	19.3	18.5	15.1	11.9

Data values were transformed by using the square root transformation before analysis. Mean values in a column having dissimilar letter/letters indicate significant differences at 0.01 levels of significance (DMRT).

Total of emerged floral bubs were found to be superior in treatments T1 and T3 with 67.2 bubs/post and 71.9 bubs/post at 4 days after lighting was stopped. The same results were also observed in T1 and T3 with 91.9 bubs/post and 96.2 bubs/post, respectively; at 10 days after lighting was stopped. Treatment T2 (83.6 bubs/post) and T4 (73 bubs/post) were at par with T1 and T3 in this investigation. Similarly, the proportion of shoots that transformed into flowering shoots were highest at both treatments T1 and T3 in 4 days and 10 days after lighting was stopped, with 15.1% and 25.4%; 12.6% and 19.1%, respectively, as compared to others (Table 3). However, there were no significant increases in the proportion of shoots that transformed into flowering shoots at different layers of cladode between treatments (Table 3).

Proportion of floral bubs formed on the different categories of pruning treatments didn't significantly increase as compared to the control treatment. However, a high number of bubs formed on the third layer of cladodes of treated canopies. A high degree of pruning revealed that this could support the plants to form more floral bubs, whereas there were less bub formation in the control treatment (Table 3).

Table 3. Proportion of shoots that transformed into flowering shoots (per post)

Treatment	At 4 days after lighting was stopped			At 4 days after lighting was stopped		
	1st layers formed(a)	2nd layers formed(b)	3rd layers formed(b)	1st layers formed(a)	2nd layers formed(b)	3rd layers formed(b)
T1	61.8	33.4	4.8	59.9	36.1	4.0
T2	71.2	26.8	2.0	63.9	31.5	4.7
T3	57.2	40.3	2.6	62.3	35.1	2.6
T4	70.8	27.9	1.3	66.9	30.1	3.0
T5-Control (untreated)	73.4	24.4	2.2	66.7	31.4	1.8
Significant	ns	ns	ns	ns	ns	ns
CV (%)	17.2	27.6	28.6	9.1	17.5	21.1

Data values were transformed by using the acrsin$(x)^{1/2}$ (a) and square root (b) transformations before analysis. Mean values in a column having dissimilar letter/letters indicate significant differences at 0.01 levels of significance (DMRT).

Effect of canopy pruning on canker disease management

On cladodes, a high degree of pruning resulted in the lowest number of canker disease incidence and disease severity due to better air movement by opening up the canopy. Pruning at 60% (T1) was the most effective; disease incidence and severity were observed at 4.1% and 1.4% respectively, as compared to control. Similarly, treatments T2 and T3 had lower disease incidences and severity at 8.0% and 2.2%; 7.8% and 2.9%, respectively, as compared to control where the disease incidence was at 15.2% with a disease severity of 6.3% (Table 4).

Table 4: Effect of canopy pruning on the development of canker disease on new cladode formations

Treatment	Disease incidence (%)	Disease severity (%)
T1	4.1 c	1.4 c
T2	8.0 b	2.2 b
T3	7.8 b	2.9 b
T4	11.3 ab	5.2 a
T5 - Control (untreated)	15.2 b	6.3 a
Significant	**	**
CV (%)	15.7	14.12

Data values were transformed by using the square root transformation before analysis. Mean values in a column having dissimilar letter/letters indicate significant differences at 0.01 levels of significance (DMRT).

For disease incidence, all categories of pruning treatments could reduce disease infection at many sensitive stages of fruit development. At the flower removal stage, the least disease incidence was observed in treatment T1 (31.0%) followed by T2 (39.0%), T3 (43.0%), and T4 (50.0%). At 7 days after removing the petals, treatment T1 had significantly lowest disease incidence at 51.0% as compared to other treatments. However, the remaining treatments did not differ among themselves significantly in terms of disease incidence, except the control treatment (Table 4).

Disease severity on fruit diminished with an increasing degree of pruning. At the flower removal stage, the least disease incidence was observed in all treatments and the values were significantly lower than the control. At 7 days after petal removal, out of the four categories of pruning, the lowest disease severity was recorded in treatment T1 (10.2%) followed by T2 (14.4%), T3 (14.6%), and T4 (15.4%). At 28 days after petal removal, both treatments T1 and T2 were significantly reduced disease severity at 24.2% and 24.4% as compared to the other treatments. There were no significant differences between T3 (31.4%) and T4 (30.2%) in terms of disease incidence (Table 5).

Table 5. Effect of canopy pruning on canker disease management (fruit only)

Treatment	Disease incidence (%)[a]			Disease severity (%)[b]				
	At flower removal stage	7 days after removing petal	14 days after removing petal	At flower removal stage	7 days after removing petal	14 days after removing petal	21 days after removing petal	28 days after removing petal
T1	31.0 b	51.0 c	96.0	6.2 b	10.2 c	19.8 b	22.6 b	24.2 c
T2	39.0 b	73.0 b	99.0	7.8 b	14.4 b	20.0b	23.0 b	24.4 c
T3	43.0 b	72.0 b	98.0	8.6 b	14.6 b	23.0 b	26.6 b	31.4 b
T4	50.0 b	77.0 b	100.0	10.0 b	15.4 b	25.0 ab	27.8 b	30.2 b
T5 (Control)	91.0 a	100.0 a	100.0	18.2 a	20.0a	29.6 a	40.4 a	56.4 a
Significant	**	**	ns	**	**	**	**	**
CV(%)	27.0	17.3	7.0	22.7	11.1	8.7	8.4	7,8

Data values were transformed by using the acrsin$(x)^{1/2}$ (a) and square root (b) transformations before analysis. Mean values in a column having dissimilar letter/letters indicate significant differences at 0.01 levels of significance (DMRT).

Effect of canopy pruning on yield

Total number of fruit and yield per post were not affected by pruning; however, pruning tended to increase fruit weight. Heavy pruning in T1 significantly increased fruit weight at 481 g/fruit as compared to other treatments (Table 6).

Table 6. Effect of canopy pruning on yield

Treatment	Total number of fruit/ post[1]	Fruit weight (g)	Yield/post (kg)
T1	29.5	481.0 a	124.721.0
T2	31.4	424.6 b	125.570.0
T3	27.6	403.3 b	113.415.5
T4	28.8	410.7 b	124.198.5
T5 - Control (untreated)	25.1	433.3 b	121.101.0
Significant	ns	**	ns
CV(%)	8.0	7.9	24.7

Data values were transformed by using the square root (b) transformation before analysis. Mean values in a column having dissimilar letter/letters indicate significant differences at 0.01 levels of significance (DMRT).

DISCUSSION

In tropical climes like Vietnam, new flush of *H. undatus* occurs throughout the year. Mop Top (concrete post) is a traditional production system of *H. undatus* which is associated to many inherent issues to the industry such as old unproductive cladodes and support instability, management constraints, a haven for pests and diseases, poor quality fruit, etc. The Mop Top plant structure itself presents challenges for orchard hygiene and poor management leads to significant pest and disease problems, particularly canker disease caused by *Neoscytalidium dimidiatum*. The main reason for this is that growers assume that a high number of cladodes present on the canopy will increase the potential yield. Each cladode will complete flowering for 12–18 months. Old cladodes may not flower during off-season so growers continuously maintain canopy with young cladodes without removing unproductive ones.

The findings of this study reveal that removal of uneffective and infected cladodes with canker disease could support dragonfruit plants to produce new effective shoots and increases the number of floral bub formation while increasing the proportion of shoots that transformed into flowering shoots, especially on the 3rd layer of the canopy. Canopy pruning at 40%, 50%, and 60% (correspondent from 128–183 cladodes/post) recorded the best treatments under field testing (Tables 1 & 2). Dragonfruit only creates floral bubs on the outer canopy where it could receive direct light, moreover full growth of cladodes is known as the other key factor for manipulation by lighting support technique during off-season. Previous reports conducted by many scientists showed that pruning techniques contributed to success stories on many tropical crops. In the case of mangosteen (*Garcinia mangostana*), pruning the top of the tree and branches stimulated proportions of floral bub formation up to 5%–18%[9]. Pruning 10–20 cm from the top of mango branches was recorded to be the best treatment to produce new shoot formation and increased panical lengths up to 1.7–2.7 shoots and 3–6 cm, respectively[8]. Similarly, earlier research showed canopy pruning level at 25% could expose the canopy to receive direct light and improved yield in Tom Atkins mango var.[9]. Heavy pruning of star apple tree canopy (*Chrysophyllum cainito*) up to 60%–70% could create new healthy shoots and improve productivity and fruit quality in less productive trees (old trees)[10]. Pruning also tended to increase the percentage of canes (*Vaccinium corymbosum*) in the smaller-size categories, and reduce the percentages in the intermediate- and large-size categories[11].

Canker disease is known as internal black rot in Israel[12]; stem canker in Taiwan and Malaysia[13, 14]; and brown spot in China and Vietnam[15, 4]. In Vietnam, it was reported since 2009 and became a devastating disease infesting areas of approximately more than 10,000 ha. Losses ranged from 30%–70% in individual fields, as growers were unable to harvest fruits during continuous rainy days or tropical low pressures. Heavily infected fruits are not able to be sold even in domestic markets[4]. In this study, all treatment categories of pruning reduced disease infection at the many sensitive stages of fruit development. The lowest disease incidence and severity were recorded in treatments T1 and T2 where 60% and 50% of the canopy was pruned (Tables 4 and 5). Some reports have shown that among the management tools for disease control, field hygiene was one of the most important to reduce inoculum of *N. dimidiatum* and prevent the disease from spreading during wet seasons[5, 6]. By pruning the canopy and removing infected plant parts, disease incidence is reduced because moisture and temperature greatly affects spore germination as well as inducing the spread from infected cladodes to heathy ones by rain splash (Hieu, 2016, data unpublished).

CONCLUSION

Based on the study, the effects of various degrees of canopy pruning on plant growth, yield, and control of canker disease of dragonfruit crop revealed that pruning of unproductive and infected cladodes by 40% to 60% of the canopy was able to induce the plants to produce and increase a proportionate amount of shoots that transformed into flowering shoots. This also increased fruit weight and minimized canker disease infestion (26.2%–32.2%) during off-season.

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