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Effect of pruning on apical dominance, agronomic traits, and post-harvest quality of pitaya in the Amazon forest biome

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Abstract
This study aimed to evaluate the influence of cladode pruning on apical dominance in the production and post-harvest of pitaya fruits. The experiment was carried out at the Sítio das Pitaya do Pará, which is in the city of Tomé-Açu, State of Pará, Brazil. A randomized block design (RBD) in a 3 x 2 factorial scheme was used, with four replications for each treatment. Treatments consisted of three stand positions in the field (beginning, middle, and end of row) and two pruning regimes (with and without pruning). The interaction of factors Pruning and Stand position (P*SP) inhibited sprouting, while the Pruning factor provided heavier fruits and with a better pulp/peel ratio. Thus, cladode pruning provided benefits to plant management, production parameters, and post-harvest quality.

Keywords: fruit; quality; Amazon biome; degrees brix; fruit production; dragon fruit; exotic fruit.

Efecto de poda sobre la dominancia apical, características agronómicas y postcosecha de pitaya en el bioma de la selva Amazónica

Resumen
El objetivo de este estudio fue evaluar la influencia de la poda de cladodios sobre la dominancia apical en la producción y poscosecha de frutos de pitaya. El experimento se llevó a cabo en el Sitio Pitaya do Brasil, ubicado en el municipio de Tomé-Açu, Estado de Pará, Brasil. Se utilizó un diseño de bloques al azar (RBD) en un esquema factorial 3 x 2 con cuatro repeticiones de cada tratamiento. Los tratamientos consistieron en tres posiciones de rodales en campo (inicio, medio y final de hilera) y dos tipos de poda (con y sin poda). La interacción de los factores Poda y Posición del Stand (P*SP), inhiben la brotación, mientras que el factor Poda proporciona frutos con mayor masa y mejor relación pulpa/cáscara. Así, la poda de cladodios proporcionó beneficios para el manejo de la planta, los parámetros de producción y la calidad poscosecha.

Palabras llave: fruta; calidad; Amazon biome; grados brix; producción de frutas; dragon de fruta; fruta exótica.

1 Introduction

Pitaya is a plant originating in Central and South America, more precisely in Mexico [1]. It is among the various species of epiphytic cacti [2], belonging to the botanical family *Cactaceae* and being divided into four main genera: *Stenocereus*, *Cereus*, *Selenicereus* and *Hylocereus* [3]. According to [3], the most well-known species of the genera are: *Selenicereus megalanthus* (yellow bark and white pulp); *Hylocereus polyrhizus* (red bark and red/purple pulp); *Hylocereus* sp. (red bark with white or red/purple pulp).

Brazilian pitaya production is currently about 1,493.19 tons per year, with the Southeast region being responsible for the largest share, around 812.64 tons in 2017 [4]. Data from the 2017 Agricultural Census [4] reveal that pitaya production in the state of Pará is equivalent to 156.39 tons, with production concentrated northeastern, mainly in the city of Tomé-Açu, where it reaches 92.70 tons per year.

Among agricultural practices pitaya cultivation, pruning is

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used to stimulate plant production and prevent some pests and diseases. For [5], pruning is the selective removal of plant parts providing advantages such as production stimulation, correcting physical damage caused.

A proper fruit handling is essential to ensure quality and market acceptance. Therefore, care must be taken with harvesting, storage, and transport conditions. [6] summarized pitaya post-harvest processes as follows: transport to the processing line, pre-cooling, washing and disinfection, selection, and classification, drying, waxing, packaging, box labeling and storage.

[7] examined postharvest changes in pitayas picked commercially immature pitaya and observed increased respiratory after harvest and, six days after harvest, fruit characteristics were similar to those of on-plant ripened fruits. They also noted that fully ripe harvested fruits have soluble solids/titratable acidity ratio, as well as betacyanin and ascorbic acid content, similar to those of fruits harvested commercially immature. This information can guide farmers on the most suitable fruit destination.

For pitaya (*Hylocereus sp*.) cultivation, there are few studies on pruning and its influence on agronomic and post-harvest traits. This species has been commercially grown for a short time in Brazil. As a result, producers often rely only on empirical information from management of other species, also known as pitaya [8]. Accordingly, this study aimed to evaluate the influence of pruning on apical dominance in pitaya cladodes and its influence on fruit agronomic and postharvest traits.

2 Material and methods

2.1 Experimental area

The present experiment was carried out in a red pitaya (*Hylocereus polyrhizus*) cultivation from July to October 2020, at the Sítio das Pitaya do Pará located in the city of Tomé-Açu, Pará State, Brazil.

The pitaya orchard was 4 years old, grown under full sun, non-irrigated, and visually healthy. Cladodes from the upper region, without physical or biological damages, were chosen to conduct the experiment.

2.2 Experimental design

A randomized block design (RDB) in a 3 x 2 factorial scheme was used, with four replications for each treatment. Treatments consisted of three stand positions within the field (beginning, middle, and end of plant row) and two pruning regimes (1-cm pruning from the tip and no pruning). The experiment was carried out in triplicate, with each block consisting of an average of three replications. Each block comprised 9 fence posts with pruning at the cladode tip and 9 platforms without it, in each platform 5 cladodes were chosen for the evaluations.

2.3 Agronomic characteristics

Fruit diameter and length were measured with the aid of a 0.01-mm precision digital caliper and a measuring tape. The number of flowers, number of abortions, and number of sprouts were also counted. These parameters were evaluated weekly for 3 months.

Pitaya fruits were characterized in the UFRA postharvest laboratory, before and after harvest, in terms of: length and diameter, mass, water content, peel thickness, pulp/peel ratio, titratable acidity, soluble solids (Brix), hydrogen potential (pH), and production per cladode.

2.4 Statistical analysis

The data obtained were subjected to analysis of variance using the F-test at 5% probability and, when relevant, the means were compared using the Tukey's test at 5% probability. The statistical analysis was performed using the SISVAR 5.0 software [9].

3 Results and discussion

Table 1 displays the results of the analysis of variance of the factors: stand position (SP), pruning (P), and their interaction (SP x P).

Table 2 shows that the characteristic number of sprouts was significantly influenced by the factors Position (P) and Pruning (PD), as well as by their interaction Position * Pruning (P*PD).

According to the second criterion of [10], coefficients of variation above 30% are considered high for agricultural experiments. In this study, this can be explained by the fact that pitaya has not yet undergone significant plant breeding, leaving plant stands unequal in terms of many parameters related to production.

Table 1.
Summary of the analysis of variance for the effect of the factors: stand position (SP), pruning (P), and their interaction (SP*P) on the number of flowers (NFL), number of abortions (NA), number of sprouts (NS), number of fruits (NFR), fruit diameter before harvest (FDBH, in mm), fruit length before harvest (FLBH, in mm).

Factor	DF	Mean Square					
		NF	NA	NB	NFR	DFAC	CFAC
Block	3	2.63^{ns}	1.45^{ns}	0.02^{ns}	0.25^{ns}	106.90^{ns}	76.58^{ns}
Stand Position (SP)	2	2.17^{ns}	1.55^{ns}	**0.24****	0.06^{ns}	4.87^{ns}	29.70^{ns}
Pruning (P)	1	6.01^{ns}	2.26^{ns}	**0.23****	0.92^{ns}	1.138.22^{ns}	1.255.12^{ns}
SP*P	2	1.78^{ns}	1.24^{ns}	**0.23****	0.92^{ns}	762.80^{ns}	700.43^{ns}
Error	15	2.08	2.44	0.029	0.29	373.98	454.76
Total	23	-	-	-	-	-	-
CV(%)	-	58.41	55.88	175.81	66.90	59.35	59.87

**significant at 1% probability level ($p<0.01$); *significant at 5% probability level ($0.01\leq p<0.05$); ^{ns} non-significant ($p\geq0.05$); Coefficient of Variation (CV); Degree of Freedom (DF).
Source: own authors.

Table 2.
Summary of the analysis of variance for the post-harvest effects of the factors: stand position (SP), pruning (P), and their interaction (SP*P) on the parameters: fruit diameter after harvest (FDAH, in cm), fruit length after harvest (FLAH, in cm), fruit mass (FM, in g), fruit production per cladode (PC, in kg/cladode), peel thickness (PT, in mm), pulp/peel ratio (PPR), titratable acidity (AT, in %), soluble solids (Brix), and hydrogen potential (pH).

Factor	DF	Mean Square								
		DFAC	CFAC	MF	PC	EC	RPC	AT	Brix	pH
Block	3	158.55^{ns}	193.86^{ns}	1685.35^{ns}	154.33^{ns}	4.45^{ns}	0.02^{ns}	222.82^{ns}	1.04^{ns}	0.66^{ns}
Stand Position (SP)	2	3.42^{ns}	1.72^{ns}	48.09^{ns}	54.12^{ns}	0.35^{ns}	0.00^{ns}	33.98^{ns}	2.26^{ns}	0.17^{ns}
Pruning (P)	1	1,460.74^{ns}	1,628.72^{ns}	**22.500***	2,488.80^{ns}	8.63^{ns}	**0.28****	1,515.27^{ns}	27.95^{ns}	3.39^{ns}
SP*P	2	795.66^{ns}	818.79^{ns}	10,933.86^{ns}	1,689.94^{ns}	10.35^{ns}	0.07^{ns}	949.22 ^{ns}	13.96^{ns}	2.44^{ns}
Error	15	420.50	446.60	456.20	619.60	8.89	0.03	656.50	6.21	2.02
Total	23	-	-	-	-	-	-	-	-	-
CV(%)	-	59.69	58.06	59.55	70.82	61.28	71.54	59.75	63.46	60.35

**significant at 1% probability level ($p<0.01$); *significant at 5% probability level ($0.01\leq p<0.05$); ^{ns} non-significant ($p\geq0.05$); Coefficient of Variation (CV); Degree of Freedom (DF).
Source: own authors.

Table 3.
Mean values of number of shoots for position x pruning interaction.

Factor	With pruning	No pruning
Beginning	0.00 Aa	0.00 Ba
Middle	0.00 Aa	0.58 Ab
End	0.00 Aa	0.00 Ba
Mean	0.00	0.19

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ statistically from each other, by the Tukey's test at 5% probability.
Source: own authors.

Table 2 highlights that fruit mass and pulp/peel ratio at postharvest were significantly influenced by the pruning factor. This effect was proven by [11], who stated that pruning, in addition to stimulating new flower and bud branches, also increases fruit quality and size.

Table 3 shows the means of number of sprouts for SP*P interaction, in which pruning inhibited sprouting at the beginning, middle, and end of plant rows, while no-pruning showed significant differences among stand positions, and the middle of the line showed a significant difference for this characteristic.

The results presented in Table 3 are contrary to those found by [12] in a study with white-pulp pitayas. Such divergence may suggest variations derived from different genetic materials, as well as other conditions such as physiological factors, as well as climatic and nutritional conditions [13].

The position in the middle of the line showed increased sprouting (Table 4), which may have been caused by a greater exposure to light. [14] reported that pitaya is a long-day plant, requiring more than 12 hours of light, which may stimulate the growth of secondary cladodes.

Table 5 demonstrates that the number of sprouts was smaller in pruned plants. This result corroborates [6], who reported that apical meristem removal in lateral phyto-cladodes inhibits sprout emergence and stimulates cladode thickening and fruiting.

Table 4.
Means of number of sprouts for each position factor.

Position	Sprouts
Beginning	0.00 b
Middle	0.30 a
End	0.00 b
Mean	0.10

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ statistically from each other, by the Tukey's test at 5% probability.
Source: own authors.

Table 5.
Means of number of sprouts, fruit mass, and pulp/house ratio for pruning factor.

Pruning	Sprouts	Fruit Mass	Pulp/peel
With pruning	0.0 a	144.03 a	0.36 a
No pruning	0.20 b	82.79 b	0.14 b
Mean	0.10	185.42	0.25

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ statistically from each other by Tukey's test at 5% probability.
Source: own authors.

Still in Table 5, pruned plants had heavier fruits than non-pruned ones, corroborating the results found for other fruit trees such as bark nut [15] and *Physalis peruviana* L. [16].

Finally, pitaya fruit pulp increased with pruning, which corroborates the results found by [8], who observed that fruit tree pruning increases and improves the quality of fruits.

4 Conclusions

1. Cladode pruning reduces sprouting in pitaya plants.
2. Plant positioning within the field influences the number of sprouts.
3. Cladode pruning increases fruit mass and pulp/peel ratio.
4. In brief, cladode pruning is recommended to reduce sprouting, increase production, and improve the post-harvest quality of pitaya fruits.

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