# Productivity and commercial classification of pitaya with manual cross-pollination and natural pollination

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## Abstract

Information related to the productivity and classification of pitaya allows the assessment of the need and planning of orchard pollination. This work was developed with the objective of evaluating the productivity and commercial classification of the pitaya *Selenicereus monacanthus* with manual cross-pollination management with the *S. undatus* and natural pollination. The evaluations were carried out on a total of 20 plants from an orchard in Minas Gerais, Brazil. Pollen grains were collected from flowers of the *S. undatus* species plants for cross-pollination with the species *S. monacanthus*. In the plants corresponding to natural pollination, the flowers were pollinated by natural pollinators. The comparison of natural pollination and manual cross-pollination was performed based on the calculation of the orchard productivity. The commercial classification was performed based on the determination of the individual mass of each fruit. With manual cross-pollination, the estimated productivity of *S. monacanthus* was 49.2 Mg $ha^{-1}$, while with natural pollination it reached 14.3 Mg $ha^{-1}$. Therefore, manual cross-pollination management increased productivity by 244 %. Pitaya with manual cross-pollination receive a better classification while with natural pollination most pitaya did not reach the minimum size for commercialization. The commercial classification of pitaya was greater than 50 % in the extra class with manual cross-pollination. With natural pollination, less than 40 % of pitaya reached the standard for commercialization.

**Keywords:** *Selenicereus monacanthus*. *Selenicereus undatus*. Commercial yield. Dragon fruit. Fruit size. Open pollination.

## Introduction

In pitaya species, pollination may occur by self-pollination and cross-pollination (GUIMARÃES et al., 2022). Self-pollination occurs in some clones of the species *Selenicereus undatus* (Haw.) D.R.Hunt and *S. megalanthus* (K.Schum. ex Vaupel) Moran (WEISS et al., 1994; TRAN, YEN, 2014; MENEZES et al., 2015a; MUNIZ et al., 2019). Cross-pollination occurs mainly in species or clones that are self-incompatible, such as *S. monacanthus* (Lem.) D.R.Hunt (synonym: *Hylocereus polyrhizus* (F.A.C.Weber) Britton and Rose) (WEISS et al., 1994; LICHTENZVEIG et al., 2000; MIZRAHI, 2014), with self-incompatibility being considered one of the problems with the cultivation of this species and most genotypes requiring cross-pollination (MIZRAHI, 2014).

The absence of fruiting in pitaya orchards occurs due to several factors that result in flower abortion. Climatic variations at the time of pollination, the lack of supply of pollen grains from compatible clones, the absence of pollinators in the cultivation area and floral morphology are some limitations cited in pitaya production (SILVA et al., 2011; TRAN et al., 2015; MUNIZ et al., 2019). Thus, the supply of pollen grains by pollinators or from manual pollination is important for fruiting and the production of fruits with a greater number of seeds and heavier weight (WEISS et al., 1994; RECH et al., 2018). Therefore, there is a need

to establish strategies to ensure pollination and increase fruiting, such as the introduction of compatible species or clones (DAG, MIZRAHI, 2005; LONE et al., 2017) or the adoption of manual cross-pollination management (ALVES, 2023), recommended to increase the yield of self-incompatible and self-compatible species.

In natural pollination, the action of pollinating agents can be influenced by local weather conditions, since the occurrence of rain, for example, during anthesis, reduces pollinator visitation (SILVA et al., 2015). In addition, the action of some floral visitors, such as the bee (*Trigona spinipes*), which is a very common species in pitaya orchards in Brazil, has interfered with pollination because it attacks other pollinating insects and causes damage to flower buds (ALVES et al., 2018; MUNIZ et al., 2019). In production sites where there is a lack or deficiency of native natural pollinators, optimizing manual pollination acquires economic importance due to increased fruit set (LICHTENZVEIG et al., 2000; LE BELLEC, 2004).

Manual pollination is considered simple due to the morphological characteristics of pitaya flowers (LE BELLEC et al., 2006; GUIMARÃES et al., 2022). Research has shown that manual pollination increases the fruit set index and fruit size (WEISS et al., 1994; LE BELLEC, 2004; PUSHPAKUMARA et al., 2005; SILVA et al., 2011; LONE et al., 2017).

Information related to the management of pollination of pitaya species is essential for the establishment of complementary practices in orchards aiming to increase production and improve fruit quality. There is little research comparing the species *S. monacanthus* with natural and manual pollination. In this context, this work was carried out with the objective of evaluating the productivity and commercial classification of the pitaya *Selenicereus monacanthus* with manual cross-pollination management with the *S. undatus* and natural pollination.

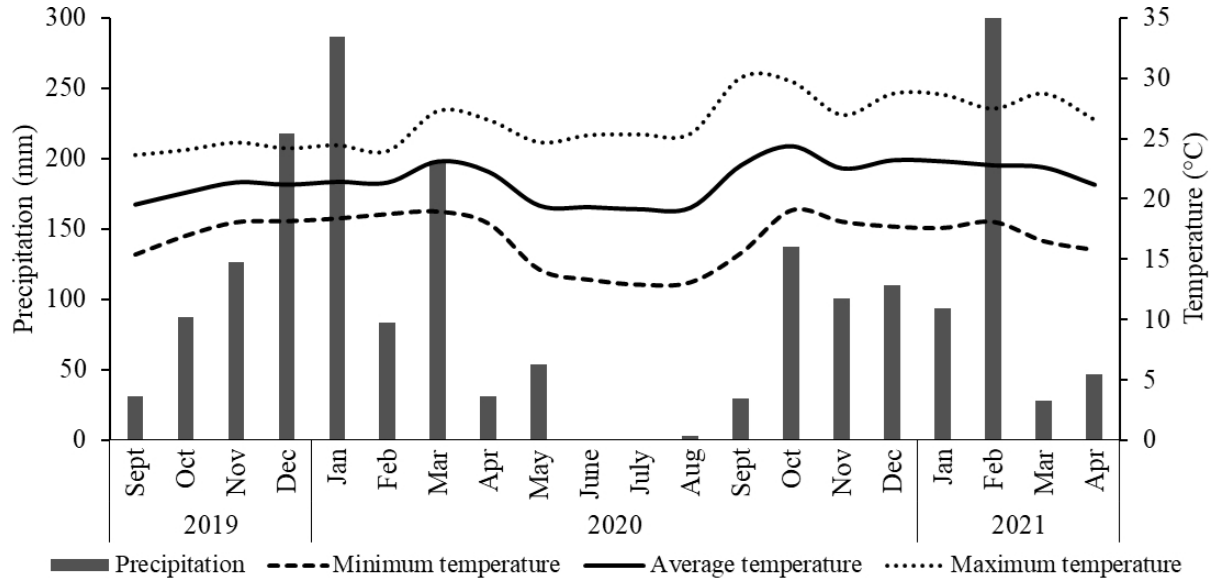
## Material and methods

The study was carried out in an orchard located at 18°04'41"S, 43°27'27"W and 729 m above sea level, in the municipality of Couto de Magalhães de Minas, state of Minas Gerais, Brazil. The climate of the region is Aw, with dry winter and rainy summer, according to the Köppen-Geiger classification. The annual averages of minimum, average and maximum temperatures are 16.1 °C, 21.3 °C and 26.5 °C, respectively; and the average annual precipitation is 1,183 mm. The rainy season occurred between spring and autumn, from October to April, which is the flowering period of the pitaya species evaluated in this study (Figure 1).

The pitaya species evaluated was *S. monacanthus*, propagated by cuttings. The plants were trained on 1.8 m high eucalyptus posts, with 1 m long transversal support forming a "T", cultivated with a spacing of 3 m between plants and 3 m between rows, corresponding to a density of 1,111 plants per hectare.

During the flowering period of the plants, between November and March (2020/2021 harvest), a total of 20 *S. monacanthus* plants were randomly selected in the orchard to carry out manual cross-pollination and natural pollination. In each flowering flush, based on the observation of the development of the flower buds, the day of anthesis was identified, when, from 2 pm onwards, it was possible to observe the increase in the volume of the flower bulb and the beginning of the detachment of the sepals (pre-anthesis) that covered the petals and, thus, perform manual cross-pollination (between 4 pm and 6 pm). During anthesis, pollen grains were collected from the flowers of the pollen grain donor plants of the species *S. undatus*, by cutting the anthers with scissors. The anthers containing the pollen grains were placed in Petri dishes and, immediately after collection, deposited on the stigmas of the flowers of the recipient plants (*S. monacanthus*) with the help of a paintbrush.

**Figure 1.** Monthly averages of minimum, average and maximum temperatures and accumulated monthly precipitation in Couto de Magalhães de Minas, state of Minas Gerais, Brazil.




**Source:** Agritempo (2021)

This procedure was performed to pollinate all the flowers of each selected plant in all flowering flushes (in the pre-anthesis, the flower buds were protected with TNT bags). In the plants corresponding to natural pollination (10 plants), the flowers were counted and kept unprotected to be pollinated by the natural pollinators present in the orchard. The plants of both species were arranged in the orchard in the same proportion, alternately between the planting rows.

The evaluations of the species *S. monacanthus* consisted of determining the percentage of fruiting (ratio of the number of fertilized fruits and the number of flower buds emitted), number of fruits per plant, mass, production per plant, productivity and commercial classification of the pitayas produced.

The comparison between manual cross-pollination and natural pollination was performed based on the calculation of productivity in the sixth year of cultivation of the orchard, estimated from the production per plant, the sum of the fruit mass and the planting density, at a spacing of 3 × 3 m. The commercial classification was performed based on the determination of the individual mass of each fruit, obtained by weighing them individually on a scale. The classification was made according to the standards of Codex Stan 237 (FAO-WHO, 2011), described and separated by classes, categories and masses in Table 2 in the results.

## Results

With manual cross-pollination management, the estimated productivity of *S. monacanthus* was 49.2 Mg ha$^{-1}$, while with natural pollination, it reached 14.3 Mg ha$^{-1}$, a difference of 244 % (Table 1). The difference in productivity in manual cross-pollination is related to the increase in fruit mass (average of 574 g) and the higher percentage of fruit set (92.1 %), which contributed to higher production per plant (44.2 kg) throughout the production cycle (2020/2021 harvest), in the six flowering flushes of the orchard.

Regarding classification, the results are relevant from a commercial point of view, since most fruits from manual cross-pollination were classified in the extra class (54 %), while, in

**Table 1.** Productivity, production per plant, average fruit mass, number of fruits per plant and fruit set of *Selenicereus monacanthus*, with manual cross-pollination and natural pollination.

| Pollination | Productivity (Mg ha$^{-1}$)* | Production (kg per plant)* | Mass (g)* | Number of fruits per plant$^{ns}$ | Fruit set (%)* |
|---|---|---|---|---|---|
| Manual | 49.2 a | 44.2 a | 574 a | 76.8 | 92.1 a |
| Natural[1] | 14.3 b | 13.1 b | 182 b | 71.0 | 59.7 b |
| CV (%) | 17.7 | 17.2 | 11.6 | 8.2 | 16.2 |

[1]Orchard formed by the species *Selenicereus monacanthus* and *S. undatus*. *Averages followed by the same letter in the column do not differ from each other by the F test ($p<0.05$). CV, coefficient of variation. $^{ns}$not significant. Planting density: 1,111 plants per hectare.

**Source:** authors (2024)

natural pollination, less than 1 % achieved this classification (Table 2). With natural pollination, only 38.6 % of the fruits were classified in commercial categories, with 0.66 %, 5.34 % and 32.6 % classified in extra, I and II classes, respectively. It is noted that for the class without commercial standard, manual cross-pollination did not represent the classification and that natural pollination was greater in relation to the other classes with 61.4 %.

**Table 2.** Commercial classification of fruits of the species *Selenicereus monacanthus* with manual cross-pollination and natural pollination.

| Classes | Categories | Mass (g) | Manual[1] | Natural[2] |
|---|---|---|---|---|
| | | | % | |
| Extra | I | >701 | 12.9 | 0.11 |
| | H | >601-700 | 13.6 | 0.22 |
| | G | >501-600 | 27.5 | 0.33 |
| Subtotal 1 | | | 54.0 | 0.66 |
| Class I | F | >401-500 | 24.9 | 1.10 |
| | E | >301-400 | 16.6 | 4.24 |
| Subtotal 2 | | | 41.5 | 5.34 |
| Class II | D | >251-300 | 2.7 | 4.5 |
| | C | >201-250 | 1.8 | 11.2 |
| | B | >151-200 | - | 16.9 |
| Subtotal 3 | | | 4.5 | 32.6 |
| No commercial standard | A | 110-150 | - | 24.2 |
| | SC | <110 | - | 37.2 |
| Subtotal 4 | | | - | 61.4 |
| Total | | | 100.0 | 100.0 |

[1]*Selenicereus monacanthus*♀ x *S. undatus*♂. [2]*S. monacanthus*♀ x open♂. SC, without classification.

**Source:** authors (2024)

## Discussion

Manual cross-pollination is an essential management practice in pitaya cultivation, promoting fruit set rates above 90 % and larger fruit production compared to natural pollination, obtaining commercial-grade fruits with higher profitability for producers. Even though the production cost is higher with manual pollination

management (mainly due to the demand for labor for pollination management and harvesting), profitability is higher compared to orchards with natural pollination (ALVES, 2023), and fruits of the *S. monacanthus* species classified as extra and class I have the best qualities (SANTOS et al., 2023), which is desirable for the consumer market.

The relationship between the quantity of fruits per plant and the size of the fruits is indicated as one of the causes of the reduction in commercial productivity (on average, 46 %) in pitaya orchards of *S. monacanthus* and *S. undatus*, due to the production of small-caliber fruits (not standard for commercialization), making it important to establish management practices that favor the production of larger fruits, such as thinning or artificial pollination, especially when flowering is intense (SANTOS, 2020).

The lower percentage of fruit set and the formation of fruits with lower mass in naturally pollinated plants are associated with pollinator deficiency (number of flowers visited and quantity of pollen grains deposited on the stigma) (GUIMARÃEs et al., 2022), considering that *S. monacanthus* plants had a receptive stigma and the availability of viable pollen grains throughout the anthesis period. In addition, the orchard had a supply of pollen grains from the species *S. undatus*, which presents coincident anthesis. However, the action of pollinators was influenced by the incidence of rainfall during the flowering period, including on the night of anthesis (Figure 1), since the percentage of flower abortion above 90 % was observed in two of the six flowering flushes in the orchard.

Climatic variations are cited as being among the limiting factors for flowering and pollination in pitaya species. Regarding pollination, the occurrence of rain on the day of anthesis is detrimental to natural pollination because it reduces the number of pollinators visiting the fruit and reduces the viability of pollen grains (MENEZES et al., 2015b), contributing to the abortion of flower buds, given the total duration of anthesis, between 14h40min and 16h50min, under the climatic conditions of this study. Thus, even though natural pollination might be performed by nocturnal and diurnal pollinators (MUNIZ et al., 2019), fruit set and fruit size decrease under unfavorable climatic conditions due to the absence or deficiency in the amount of pollen grains deposited on the stigma. The absence or deficiency of pollinators are cited as some of the factors related to low productivity in pitaya orchards (MERTEN, 2003).

In pitaya species, pollination efficiency depends on the number of pollinated flowers and the number of fertilized ovules (GUIMARÃES et al., 2022). Therefore, the amount of pollen grains deposited on the stigma influences the size (mass) of the fruits (CHO et al., 2013). Therefore, the percentage of fruit set and the size of fruits from natural pollination are commonly smaller than those of fruits resulting from manual cross-pollination (LE BELLEC, 2004; DAG, MIZRAHI, 2005; MENEZES et al., 2015a,b; TRAN et al., 2015; ALVES, 2023), which has become a recommended management practice to increase fruit size and, consequently, productivity. In the case of self-incompatible species or genotypes, the flowers need to be pollinated with pollen grains from a different clone or species so that fertilization and the development of fruits with sizes compatible with the commercial standard are possible.

Although manual pollination management represents an additional cost in orchard management, this management practice significantly increases commercial productivity according to the results observed in this study. This is because fruit size is an important characteristic in studies that evaluate productivity, since commercial classification is based on fruit mass, in addition to appearance (absence of defects) (FAO-WHO, 2011).

The need for manual cross-pollination management in *S. monacanthus* may increase depending on the number of flower buds, because the larger the cultivation area and the flowering intensity of the plants in each flowering flush, the greater the requirement for pollen grains, that is, the greater the dependence on pollinators to ensure fruiting and the development of commercial-sized fruits.

## Conclusions

Manual cross-pollination of *Selenicereus monacanthus* with *S. undatus* increased productivity by 244 % in the pitaya orchard.

Pitayas with manual cross-pollination had better classification, while those pollinated naturally did not reach the minimum size for commercialization.

More than 50 % of the pitayas were classified as extra with manual cross-pollination, while less than 40 % of those naturally pollinated met commercial standards.

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