Vegetative growth and flowering of dragon fruit species according to branch pruning management and application of superabsorbent polymer

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Abstract

The cultivation of dragon fruit has been standing out considerably in Brazil, however, although on the rise, information on the cultivation of this fruit, such as pruning management in young orchards and the use of superabsorbent polymer in the crop, is scarce. In this sense, in order to remedy producers' obstacles regarding the management of orchard formation, the objective of this study was to evaluate the influence of pruning management and the efficiency of hydrogel in the vegetative and reproductive development in two different species of dragon fruit (*Selenicereus undatus* and *Hylocereus polyrhizus)*, in addition to defining the best dose of the polymer to be used in the crop. The work was developed at IFSULDEMINAS – Machado Campus. The design used was the randomized block design, in a factorial scheme (2x2x3), the first factor being composed of the two species of dragon fruit, the second, by two cladode pruning levels (with and without pruning), and the third, by three doses of the superabsorbent polymer Hydroplan-EB® (0; 1.5; 4.5 g plant^{-1}). The following characteristics were evaluated: number and length of shoots; total number of flowers; total number of fruits; number of aborted flowers; picking percentage; mean fruit mass; longitudinal and transverse diameter of fruits; peel thickness; pulp yield; peel mass and productivity. The practice of cladode pruning, as well as the application of the superabsorbent polymer, did not influence most of the characteristics evaluated. Further studies should be conducted to delve deeper into the management techniques used in this study.

Keywords: Cactaceae, *Hylocereus*, hydrogel, pruning, development.

Introduction

Some fruits, such as blueberries (*Vaccinum myrtillus*), physalis (*Physalis* spp.) and dragon fruit (*Hylocereus* spp. and *Selenicereus* spp.) (POLLNOW, 2018), have been gaining space in various markets, from large retail chains and supply centers to free markets of direct marketing by farmers.

The dragon fruit belongs to the Cactaceae family, which has approximately 100 genera and 1,500 species native to the Americas. In Brazil, it is considered an exotic and exuberant fruit, and marketed with high value (SANTOS et al., 2022). It is a typical plant of the tropical climate, originating in the region of Mexico. The short period of time from planting to the first harvest, the relatively low maintenance of the orchard and the growing demand by the market have given the dragon fruit a high commercial potential (HONG et al., 2020).

According to the Agricultural Census, conducted by the Brazilian Institute of Geography and Statistics - IBGE, the dragon fruit harvested area was 536 hectares, with the state of São Paulo being the largest producer (IBGE, 2017).

According to the National Supply Company - CONAB, the value of the production of dragon fruit marketed in Brazil in 2021 was R$ 44,896,408.28, which represents an increase of 45.63% in relation to the value marketed in 2019 and 38.57% in relation to the value marketed in 2020 (CONAB, 2022).

The characteristics of the fruit, such as the sweet and mild taste and the firm, full of seeds pulp, have aroused the interest of producers, who take into account its great acceptance by consumers. In addition, the fruit also has bioactive properties, such as vitamins, phenolic compounds and pigments, which are usually related to the defense systems of plants against ultraviolet radiation or the attack of pests, but which in humans, in low concentrations, play an important protective role as antioxidant agents (NUNES et al., 2014; POLLNOW, 2018).

The dragon fruit is a rustic fruit, and can be grown in shallow, sandy and stony soils. In addition, due to its metabolism, it can be grown in areas with low rainfall or with periods of seasonal droughts. However, it is observed that, despite its relative rusticity, this fruit tree suffers from water stress during certain times of the year, either due to water deficit or excess, resulting in low productivity.

Regarding water stress, the use of superabsorbent polymer is an excellent alternative for water retention in periods of low rainfall (NORMURA et al., 2019). The hydrogel absorbs large amounts of water and makes them available for plants, acting as a reserve, minimizing problems related to irregular rainfall availability (DIÓGENES, 2020).

The use of superabsorbent polymers makes it possible to grow fruit trees in periods of water scarcity, thus being a form of production that increases profits. The hydrogel is a water-retaining polymer that, incorporated into the soil or substrate, absorbs and retains large amounts of water, in addition to reducing losses by percolation and leaching of nutrients. It also improves aeration, thus promoting greater vegetable development (NOMURA et al., 2019).

The hydrogel brings great benefits to the vegetable, because in addition to increasing water availability, it is able to provide this disposition greater durability. Thus, the absorption of water by the gel decreases the percolation index for deeper layers, while durability is related to the fact that this storage prevents the loss of excessive water to the environment, gradually releasing water to the plant (VICENTE et al., 2015).

In addition, even if it is in constant growth, for the dragon fruit crops little information is found in the national and international literature on the need to perform pruning management, especially canopy formation pruning (BRITO, 2019). According to Souza (1986), pruning in fruit trees should be carried out to modify the plant's vigor, in order to increase productivity and fruit quality; to keep the plant in adequate size; to alter the natural tendency of the plant to produce more vegetative branches than fruitful ones; and to regulate the alternation of crops.

Pruning is the removal or elimination of parts of the plant. It is a stage of great importance in the management of dragon fruit crops, carried out with the objective of providing the plant an adequate architecture. The type of pruning is closely linked to the type of conduct adopted in the implementation of the crop, in order to provide the plant with a vigorous, well-developed and productive canopy, in addition to aiming at improving phytosanitary conditions (LACERDA, 2022).

According to Taiz et al. (2017), after the removal of the branches' apexes, where the synthesis of auxin occurs, its levels are considerably reduced, favoring the increase of cytokinin levels which, in turn, induces the breakdown of apical dominance and the development of lateral shoots, through the action of cytokinin in the processes of cell division and elongation.

In this sense, the objective was to evaluate the influence of pruning management and the efficiency of hydrogel in the vegetative and reproductive development of two different dragon fruit species; *Selenicereus undatus* and *Hylocereus polyrhizus*, in addition to defining the best dose of the superabsorbent polymer to use in the crop.

Material and methods

This work was developed at the Federal Institute of Education, Science and Technology of the South of Minas Gerais – Machado Campus, Latitude: 24°41'57.09" S and Longitude 45°53'11.01" W, with an altitude of 907 m. The climate of the region is of the Cfa type, according to the Köppen classification, with an average temperature of 19.8 °C and annual precipitation of 1,590 mm. The study was conducted between May 2022 and April 2023.

To carry out the experiment, clones of two dragon fruit (*Selenicereus undatus* and *Hylocereus polyrhizus),* tutored in eucalyptus moors at a spacing of 3 x 2 m, in a conduction system of the "palanque" type, with the orchard one year after planting, were used. The drip irrigation method was adopted, with an irrigation depth of 6 mm plant^{-1} week^{-1} .

The design used was the randomized block design, in a factorial scheme (2x2x3), with 12 treatments, three replications and three plants per plot, totaling 108 plants. The first factor was composed by the two dragon fruit species, the second factor by the management of canopy formation; without cladode pruning (Figure 1) and with pruning (Figure 2); and the third factor by three doses of superabsorbent polymer Hydroplan-EB (0; 1.5 and 4.5 g plant^{-1}) adapted from Diogenes (2020).

Figure 1. Management of canopy formation - Without cladode pruning. Machado-MG, 2022.

Figure 2. Management of canopy formation - With cladode pruning. Machado-MG, 2022.

As soon as the primary cladodes reached the apex of the conduction system, the pruning management was performed with the aid of a pair of pruning scissors (Figure 2). For the application of the superabsorbent polymer, half-moon pits were opened around the plants with the aid of plowshares (Figure 3A). The hydrogel was incorporated dry into the soil, soon after the application of the polymer (Figure 3B), the irrigation system was opened in order to hydrate the product. Rainfall data during the experimental period were obtained by means of a rain gauge installed in the horticulture sector (Figure 4).

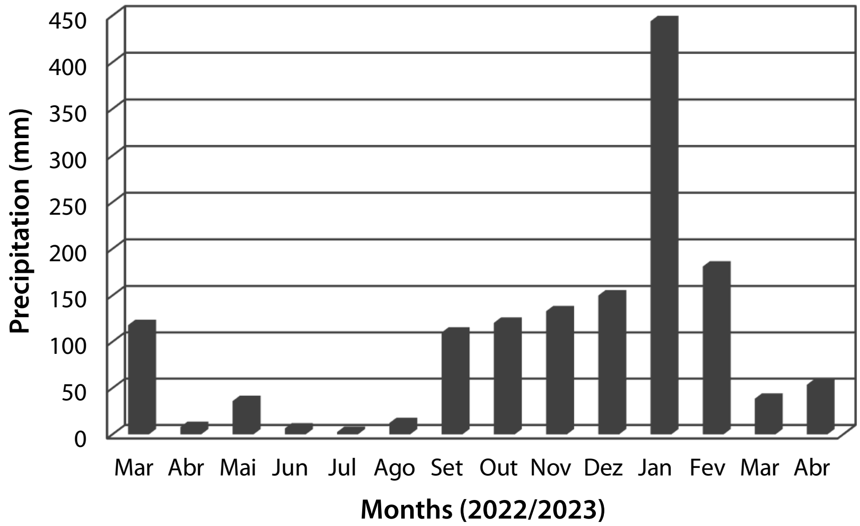
Five applications of the hydrogel polymer were performed, spaced by 40 days, the first application being carried out on March 3 2022, and the last on August 9 2022. The irrigation depth adopted was 6 mm plant^{-1} week^{-1}, in order to rehydrate the hydrogel. Vegetable growth was evaluated periodically from March to June 2022, when morphological characteristics were evaluated: number of shoots, determined by shoot count; and length of the shoots, measured with the aid of a graduated tape.

The flowering evaluation went from November 2022, when the issuance of flowers began, to April 2023, when the last harvest of the fruits occurred. The evaluated characteristics were: total number of flowers (NTF); total number of fruits (NTFr); number of aborted flowers (NFA); picking percentage (%P), obtained by the formula: (NTFr ÷ NTF) x 100; fruit mass mean (MMFr), obtained by weighing on a digital semi-analytical balance; longitudinal diameter (LD), transverse diameter (DT) and peel thickness (CE), measured with the aid of a digital caliper; pulp yield (RP) and peel mass (MC), measured by weighing on a digital semi-analytical balance; and productivity (PROD).

The obtained results were submitted to analysis of variance (ANOVA). The means of the variables were compared by Tukey's test at the level of 5% probability ($p \leq 0.05$), using the SISVAR software (FERREIRA, 2011).

Figure 3. Opening of the half-moon pits (A); Application of the superabsorbent polymer (B). Machado, MG, 2022.


Figure 4. Rainfall index during the development period of the experiment. Machado-MG, 2022.



Results and discussion

The analysis of variance (Table 1)verifies that, in the pruning management, the hydrogel doses and the interaction of the factors under study had no significant effect on the number of shoots and length of the cladodes. This fact may be closely linked to the high rainfall observed during the experiments' conduction period. Vinod et al. (2022) observed, in wheat cultivation, that the use of hydrogel in conditions of low rainfall index was able to increase productivity per area. However, the different species of dragon fruit were not influenced by such variables. These results may be related to the climatic factor, such as, for Marques et al. (2011), temperature, relative humidity and precipitation, which are those that most interfere in the dragon fruit's phenology.

Lopez (2010), while evaluating the effect of pruning on the cultivation of dragon fruit, observed that this practice did not influence the number of shoots, as for Ramos et al. (2018), corroborating the results obtained in the work. The number of shoots was higher in the red pulp dragon fruit (Figure 5A). Regarding the length of cladodes, the highest values occurred in the white pulp dragon fruit (Figure 5B). It can then be inferred that the climatic conditions during the period of the experiment stimulated greater

Table 1. Means of the number of shoots and length of the cladodes (cm) of two dragon fruit species as a result of different management for crown formation and different doses of superabsorbent polymer. Machado-MG, 2022.

Source of Variation	F Test	
	Number of Sprouts	Cladode Lengths
Species (E)	48.21*	7.18*
Management (M)	0.90ns	0.97ns
Hydrogel Doses (DH)	2.37ns	1.75ns
E x M	0.09ns	0.05ns
E x DH	3.07ns	0.19ns
M x DH	0.02ns	0.61ns
E x M x DH	1.45ns	1.62ns
CV (%)	32.6	16.7
Overall Mean	39.25	48.6

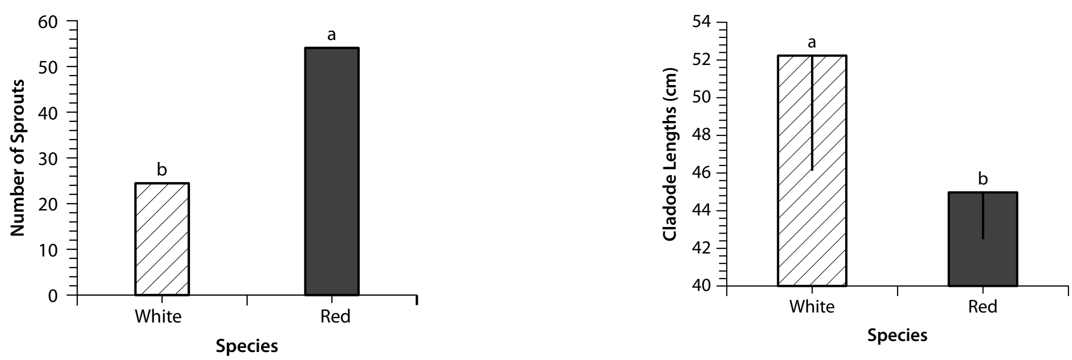
* = Significant at the level of 5% probability by the F . ns test = Not significant at 5%.

emission of shoots in the red pulp dragon fruit, and also directly influenced the growth of cladodes of the white pulp dragon fruit.

An analysis of the variance table (Table 2) verifies that the variables total number of flowers (NTF), number of aborted flowers (NFA), picking percentage (% P) and fruit mass mean (MMFr) had a significant effect for the different dragon fruit species. The pruning management, as well as the hydrogel doses, had no significant effect on both variables under study. However, for Melo et al. (2021), the application of the superabsorbent polymer positively influenced the quality of watermelons, offering greater weight and number of fruits. For Santos et al. (2022), the use of the hydrogel solution significantly increased the average mass of bell peppers. In addition, for the variables total number of flowers (NTF) and number of aborted flowers (NFA), there was a significant interaction of the factors species (E) and hydrogel doses (DH).

According to Figure 6A, the total number of flowers was higher in the red pulp dragon fruit, corroborating the results presented in Figure 6B, where due to the higher emission of flowers, the red dragon fruit also had a higher rate of miscarriage, a rate that, according to Lone et al. (2020), may vary according to

Figure 5. Means of the number of shoots and length of cladodes (cm) in different dragon fruit species. Machado-MG, 2023.



*The means followed by the same letters in the columns do not differ from each other to the 5% probability level, according to the Tukey test.

Table 2. Summary of the variance analysis of the total number of flowers (NTF), total number of fruits (NTFr), number of aborted flowers (NFA), picking percentage (% P), mean fruit mass (MMFr; g), of two dragon fruit species as a result of different management for crown formation and different doses of superabsorbent polymer. Machado-MG, 2023.

Source of Variation	F Test				
	NTF	**NTFr**	**NFA**	**% P**	**MMFr**
Species (E)	51.02*	1.61ns	60.02*	18.10*	8.61*
Management (M)	0.23ns	0.77ns	2.52ns	1.08ns	2.62ns
Hydrogel Doses (DH)	1.97ns	1.49ns	1.71ns	0.12ns	0.62ns
E x M	2.07ns	0.01ns	3.44ns	0.49ns	0.01ns
E x DH	7.56*	2.23ns	5.70*	1.83ns	0.97ns
M x DH	0.86ns	0.21ns	0.59ns	0.20ns	1.21ns
E x M x DH	0.73ns	0.07ns	0.63ns	0.01ns	0.89ns
CV (%)	26.30	44.75	41.51	32.85	23.90
Overall Mean	79.58	40.19	39.38	54.8	257.41

* = Significant at the level of 5% probability by the F . ns test = Not significant at 5%.

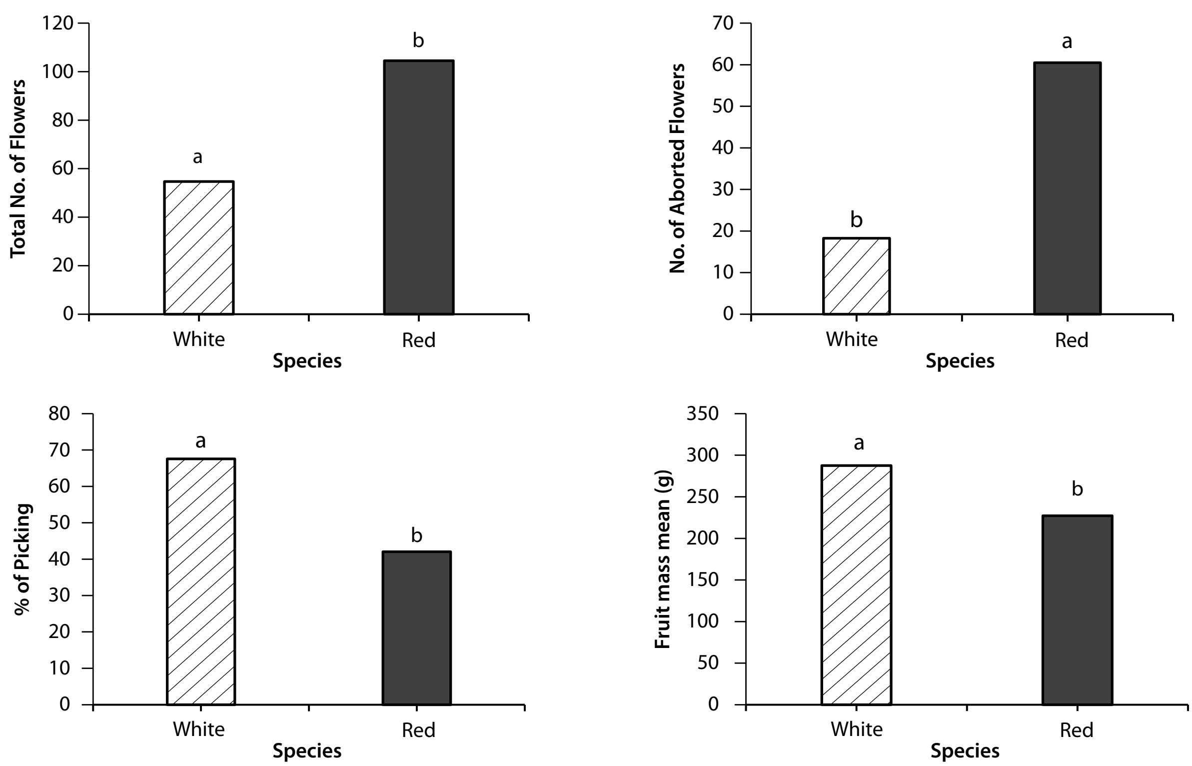
weather conditions. According to Cruz and Martins (2022), the occurrence of rain affects the viability of pollen grains, because even with the performance of manual pollination there are lower fruiting rates. This fact justifies the higher rate of picking and average mass of fruits for the white pulp dragon fruit compared to the red pulp one (Figures 6C and 6D), because empirical observations reveal that the flowering peaks of the white pulp dragon fruit occurred in the month of December, when the rainfall was lower than in the month of January, when the peak flowering of the red pulp dragon fruit occurred, directly influencing the variables analyzed.

In addition, such results may be related to a large intraspecific variability. Lima et al. (2014), working with dragon fruit crops, observed that there are genetic differences between accessions within each species. This genetic variability has been verified in all species of major commercial importance for granting them characteristics of agronomic interest, such as productivity, adaptability, vigor, resistance to diseases, physical and chemical characteristics, self-compatibility, phenology, precocity and sensitivity to photoperiod for flowering induction.

Table 3 shows that for the variable total number of flowers, the application of the different hydrogel doses in the white pulp dragon fruit did not differ from each other, as also observed by Mendonça et al. (2015), where the use of superabsorbent polymer in lettuce crops was not responsible for increasing production. Duarte et al. (2019), researching the effect of the application of hydrogel in the olive crop, observed that the addition of the polymer was not responsive to the evaluated parameters, such as the fruit's weight, length and diameter.

In addition, for the red pulp dragon fruit, applying the doses of 1.5 g plant^{-1} of

Figure 6. Means of the total number of flowers, number of aborted flowers, picking percentage and fruit mass mean in different dragon fruit species. Machado-MG, 2023.



*The means followed by the same letters in the columns do not differ from each other to the 5% probability level, according to the Tukey test.

superabsorbent polymer had better results in relation to not applying them, corroborating with the results presented by Diógenes (2020), who, through studies in dragon fruit crops with the incorporation of superabsorbent polymer in the substrate, concluded that the increase in the dose of polymer had a positive effect on the accumulation of dry biomass, photosynthetic pigments, organic and inorganic solutes.

The application of the 1.5 g plant^{-1} of hydrogel dose gave the red pulp dragon fruit the best results compared to the white pulp dragon fruit, results that were also obtained in the application of 4.5 g plant^{-1} of superabsorbent polymer. Such results may be related to meteorological conditions: for Trindade (2022), the dragon fruit culture's flowering is closely related to temperature, solar radiation and water regime. Santos et al. (2022), studying the use of hydrogel polymer in the cultivation of bell peppers, concluded that the number of commercial fruits was not influenced by the application of the polymer. On the other hand, Kumaran (2016) observed, in tomato cultivation, that throughout the crop cycle the use of hydrogel led to an increase in fruit weight.

According to the result of the relationship between species and hydrogel doses for the number of aborted flowers (Table 4), the application of the different doses of superabsorbent polymer in the white pulp dragon fruit did not result in different outcomes, which may be directly related to the flowering peak of the species, which occurred in the month of December. As for the red pulp dragon fruit, the non-application of the polymer resulted in a lower index of aborted flowers when compared to the other doses, which is directly related to the high emission of flowers at doses 1.5 and 4.5 g plant^{-1}.

The analysis of variance table (Table 5) verifies that the variables analyzed – longitudinal diameter (LD), transverse diameter (DT), peel thickness (CE) and peel mass (CM) had a significant effect for the different dragon fruit species. The pruning management, as well as the hydrogel doses and the interaction of the factors under study, did not have a significant effect on the analyzed variables. These results corroborate those obtained by Cabral (2021), who, working with tomatoes, verified that the application of the hydrogel solution did not influence growth parameters; plant height, transverse and longitudinal diameter.

According to Figure 7, the white pulp dragon fruit achieved the best results in both evaluated variables. However, for the peel mass variable, it is inferred that such results are positive for the red pulp dragon fruit, since due to the lower mass of the peel, more pulp yield occurred, seeing as there was no significant pulp yield difference between the species of dragon fruit. Therefore, the climatic conditions may have directly interfered in the quality of the fruits. Silva et al. (2011), who studied the quality of dragon fruit as a function of the pollination season, concluded that the climatic conditions that occurred during the

Table 3. Result of the breakdown for the means of the total number of flowers of the two dragon fruit species on the effect of different hydrogel doses (g plant-1). Machado-MG, 2023.

Treatments	0 Dose	1,5 Dose	4,5 Dose
White	69.83 Aa	55.50 Ba	38.66 Ba
Red	81.33 ab	123.16 Aa	109.00 aAB

Means followed by equal lowercase letters in the columns and equal uppercase letters in the rows do not differ from each other by Tukey's test at the 5% significance level.

Table 4. Resulting means of the number of the two dragon fruit species' aborted flowers on the effect of different hydrogel doses (g plant^{-1}). Machado-MG, 2023.

Treatments	0 Dose 0	1,5 Dose	4,5 Dose
White	23.16 aA	22.66 bA	9.00 bA
Red	42.00 aB	66.66 aA	72.83 aA

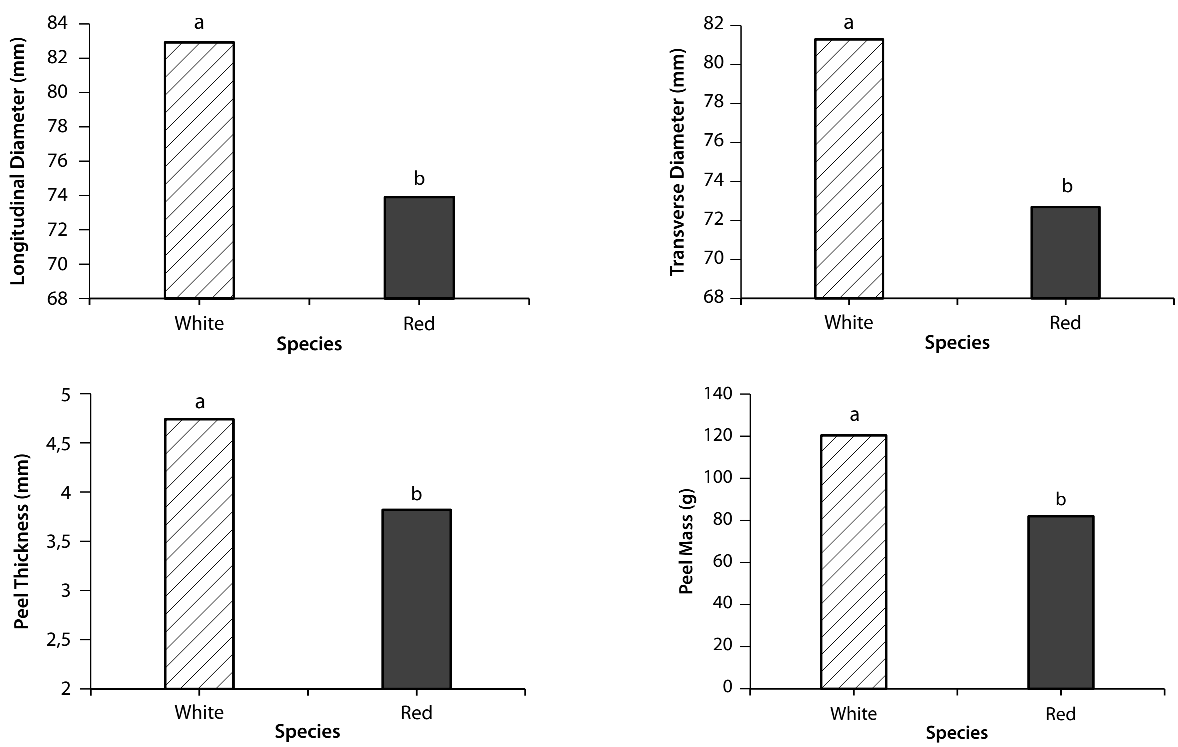
Means followed by equal lowercase letters in the columns and equal uppercase letters in the rows do not differ from each other by Tukey's test at the 5% significance level.

Table 5. Summary of the analysis of variance of the longitudinal diameter (LD; mm), transverse diameter (DT; mm), peel thickness (CE; mm), pulp yield (RP; g), peel mass (MC; g) and productivity (PROD; t ha^{-1}) of two dragon fruit species as a result of different management for crown formation and different doses of superabsorbent polymer. Machado-MG, 2023.

Source of Variation	F Test					
	DL	DT	EC	RP	MC	PROD
Species (E)	12.44*	12.72*	43.18*	1.94^{ns}	27.64*	0.70^{ns}
Management (M)	2.06^{ns}	1.05^{ns}	0.28^{ns}	1.81^{ns}	2.80^{ns}	0.06^{ns}
Hydrogel Doses (DH)	0.74^{ns}	0.23^{ns}	1.12^{ns}	0.18^{ns}	1.76^{ns}	0.13^{ns}
E x M	0.17^{ns}	0.01^{ns}	0.41^{ns}	0.01^{ns}	0.02^{ns}	1.85^{ns}
E x DH	0.42^{ns}	0.36^{ns}	0.43^{ns}	0.37^{ns}	2.25^{ns}	3.06^{ns}
M x DH	0.92^{ns}	0.35^{ns}	1.25^{ns}	1.91^{ns}	0.33^{ns}	0.90^{ns}
E x M x DH	0.08^{ns}	0.99^{ns}	0.47^{ns}	0.98^{ns}	0.30^{ns}	0.12^{ns}
CV (%)	9.77	9.39	9.81	29.95	21.70	33.97
Overall Mean	78.42	76.99	4.28	156.27	101.13	6.74

* = Significant at the level of 5% probability by the F . ^{ns} test = Not significant at 5%.

Figure 7. Means of longitudinal diameter, transverse diameter, peel thickness and peel mass of the fruits as a function of different dragon fruit species. Machado-MG, 2023



*The means followed by the same letters in the columns do not differ from each other to the 5% probability level, according to the Tukey test.

development of the fruits affected their quality. According to Ramos et al. (2018), monitoring annual precipitation is extremely important, because in the absence of rainfall, irrigation is fundamental for productivity and fruit quality. In addition, excessive rainfall during flowering can cause flower buds to fall and influence fruit quality.

Conclusion

The practice of cladode pruning and the application of the superabsorbent polymer and the interaction between the factors under study did not influence the analyzed variables in both dragon fruit species. Further studies should be conducted to delve deeper into the management techniques used in this work.

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