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Effect of different doses of biostimulate on the rooting and development of pitaya genotypes cuttings

Efeito de diferentes doses de bioestimulante no enraizamento e desenvolvimento de estacas de genótipos de pitaya

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ABSTRACT

Pitaya exhibits great rusticity and productive potential, in addition to interesting and appealing physical, nutritional, and sensory attributes for a healthy diet. As the main propagation method in the field, cuttings establish early and uniform orchard establishment. To enhance seedling quality, the use of biostimulates is an option to assist in rooting. The aim of this study was to evaluate the rooting and the sprouting of pitaya cuttings concerning different concentrations of a seaweed-based biostimulate, SprintAlga TS® (Biolchim), applied at different time intervals. The research was conducted from September 2022 to January 2023, at the Federal University of Santa Catarina (UFSC) in Florianópolis Brazil. The evaluated genotypes were *Hylocereus polyrhizus*, *Selenicereus undatus*, Golden (S*elenicereus undatus*), *Selenicereus costaricensis* and *Selenicereus setaceus.* The vegetative material used was obtained from the Experimental Station of EPAGRI, in Itajaí, and the cuttings were standardized in 20 cm length. The cuttings were kept in a shaded environment for 21 days and rooted at a depth of 5 cm, individually in two-liter plastic bags filled with substrate. The experiment consisted of three treatments: the first involving only irrigation with water (control), the second with application of biostimulate at 22 and 52 days after cuttings planting, and the third also with application of biostimulate at 10, 22, 36 and 52 days after planting. The use of the seaweed extract-based biostimulate proved effective for the propagation of the genotypes *S. undatus* and Golden. However, four applications negatively affected the root development of the *S. setaceus* genotype. The genotypes S. costaricensis and S. setaceus exhibited lower vigor in vegetative development compared to the genotypes *H. polyrhizus*, *S. undatus*, and Golden. It was concluded that the use of seaweed extract as a biostimulate had varied effects on different genotypes.

KEYWORDS: dragon fruit; cuttings; seaweed extract; SprintAlga TS®.

RESUMO

A pitaya apresenta grande rusticidade e potencial produtivo, além de atributos físicos, nutricionais e sensoriais interessantes e atraentes para uma alimentação saudável. Como principal método de propagação no campo, a estaquia visa o estabelecimento precoce e uniforme do pomar. Para melhorar a qualidade das mudas, o uso de bioestimulantes é uma opção para auxiliar no enraizamento. O objetivo deste estudo foi avaliar o enraizamento e a brotação de estacas de pitaya em relação a diferentes

concentrações de um bioestimulante à base de algas marinhas, SprintAlga TS® (Biolchim), aplicado em diferentes intervalos de tempo. A pesquisa foi realizada de setembro de 2022 a janeiro de 2023, na Universidade Federal de Santa Catarina (UFSC) em Florianópolis, estado de Santa Catarina, Brasil. Os genótipos avaliados foram *Hylocereus polyrhizus*, *Selenicereus undatus*, Golden (S*elenicereus undatus*), *Selenicereus costaricensis* e *Selenicereus setaceus*. O material vegetativo utilizado foi proveniente da Estação Experimental da EPAGRI, em Itajaí, estado de Santa Catarina, e as estacas foram padronizadas em 20 cm de comprimento. As estacas foram mantidas em ambiente sombreado por 21 dias e enraizadas a 5 cm de profundidade, individualmente em sacos plásticos de dois litros preenchidos com substrato. O experimento foi composto por três tratamentos: o primeiro envolvendo apenas irrigação com água (Controle), o segundo com aplicação de bioestimulante aos 22 e 52 dias após o plantio das estacas, e o terceiro também com aplicação de bioestimulante aos 10, 22, 36 e 52 dias após o plantio. A utilização do bioestimulante à base de extrato de algas marinhas foi eficiente para a propagação dos genótipos *S. undatus* e Golden. Entretanto, a aplicação em quatro épocas afetou negativamente o desenvolvimento radicular do genótipo *S. setaceus*. Os genótipos *S. costaricensis* e *S. setaceus* demonstraram ter menor vigor de desenvolvimento vegetativo em relação aos genótipos *H. polyrhizus*, *S. undatus* e Golden. Concluiu-se que o uso de extrato de alga como bioestimulante teve efeitos variados nos diferentes genótipos avaliados.
PALAVRAS-CHAVE: fruta do dragão; estaquia; extrato de algas; SprintAlga TS®.

INTRODUCTION

Dragon fruit is a cactus native to the rainforests of Central and South America. Interest in its consumption has increased due to its physical, nutritional, and sensory appeal, making it a good alternative for producers looking for crop diversification (SATO et al. 2014). It is an exotic fruit of important national production with high commercial value (HA et al. 2014), precocity, quick economic return, and excellent productivity of up to 20 t/ha (IBRAHIM et al. 2018).

The cultivars are distributed among four distinct genera: *Harrisia* (DE MELO et al. *2021), Cereus, Hylocereus, and Selenicereus, with emphasis on the species Hylocereus polyrhizus and Selenicereus* undatus (POLLNOW 2018). Several popular names are used to refer to the species, such as pitahaya, pitaya, red pitaya or "queen of the night" due to the large, pink, or white flowers that bloom at night and close the next morning (ALMEIDA et al. 2014).

The use of asexual propagation by means of cuttings in the production of dragon fruit is mainly aimed at the early fruiting and uniformity of the orchard. Plants grown from seed begin to bear fruit in the fifth year after planting, and they exhibit low uniformity. On the other hand, plants propagated from cuttings already produce fruit in the first year after planting, with uniformity, which is highly advantageous for the producer (CRUZ & MARTINS 2022). Planting with cuttings increases the homogeneity of the orchard, facilitating management, and harvesting. Propagation by cutting is therefore one of the most important steps in the establishment of an orchard, increasing the growth and survival rate of plants, eliminating replanting, reducing maintenance costs, and increasing plant resistance after planting (CRUZ et al. 2006).

For better development and growth of the root system and, consequently, to obtain quality propagation by cutting, it is recommended to use rooting agents during the vegetative propagation process. Rooting agents stimulate root formation and structure, which are directly related to increased productivity (BINSFELD et al. 2019). Bio-stimulants are natural products that contain biological agents that improve the nutritional efficiency of plants, response to abiotic stress, productivity, and production quality. A promising bio-stimulant is seaweed, which contains macro- and micronutrients, as well as cytokinins, auxins, and abscisic acid-like growth-promoting substances, leading to better plant development in treated samples. Seaweed extract also benefits the substrate by increasing its water-holding capacity and promoting the growth of beneficial microorganisms in plants (AREJANO et al. 2022).

For successful pitaya cultivation, the use of high-quality seedlings is essential. To achieve this goal, new practices need to be tested. The objective of this study was to evaluate the rooting and sprouting of dragon fruit seedlings based on the application of a seaweed-based biostimulate at different time intervals.

MATERIALS AND METHODS

The work was carried out between September 25, 2022 and January 9, 2023, in a greenhouse at the Federal University of Santa Catarina (UFSC), at the Center for Agricultural Sciences (CCA), in Florianópolis, state of Santa Catarina, Brazil (27°34'58.1"S 48°30'19.5"W, 5 m altitude). The climate of the region, according to the Köppen-Geiger climate classification, is of the Cfa type (humid subtropical), with an average temperature of 21.5°C and an average annual precipitation of 1,638.2 mm (ALVARES et al. 2013). *The pitaya genotypes evaluated included Hylocereus polyrhizus, Selenicereus undatus, Golden (various Selenicereus undatus), Selenicereus costaricensis, and Selenicereus setaceus*. The vegetative material used was approximately 20 cm long and came from a dragon fruit orchard at the EPAGRI Experimental Station (48°45'50.8"S 26°57'7.9"W), located in the municipality of Itajaí, state of Santa Catarina.

Cuttings of the five genotypes used in the experiment were kept in a shaded environment for 21 days to allow wound healing, reducing the entry of pathogens that could impede rooting and plant development (LONE et al. 2020). The cuttings were separately rooted in 2-L plastic bags containing a layer of substrate (approximately 18 cm high. The substrate consisted of a mixture of sand and commercial substrate Carolina Soil ®, resulting in a formulation of Sphagnum peat (54%), fine sand (18%), roasted rice husk (15%), and expanded vermiculite (13%). The cuttings were inserted at a depth of 5 cm and irrigated once a week for 82 days until the evaluation.

The three treatments applied in this experiment were adapted from those of DE FREITAS et al. (2021). The first consisted only of irrigation with water (Control); in the second biostimulate applications were made at 22 and 52 days after planting (2x Biost); and the third included the use of biostimulate at 10, 22, 36, and 52 days after planting the cuttings (4x Biost). On each watering date, 400 ml of diluted seaweed extract-based biostimulate SprintAlga TS® (Biolchim) at a concentration of 0.4 ml per liter were applied to each of the cuttings of each treatment repeat. The solution was directly applied at the base of the piles on the substrate.

The evaluations were performed 30 days after the last biostimulate application. The survival of the cuttings (%) was determined by visual analysis of the condition of the material, verifying whether the tissues were intact and alive. Phytosanitary health (%) was evaluated through visual observation, with the presence or absence of diseases in the seedlings. The sprouting rate (%) was calculated as the proportion of cuttings that emitted at least one shoot. The total number of shoots from each cut was determined by counting. Shoot length (cm) was calculated by measuring the largest shoot using a graduated ruler. After removing the cuttings from the substrate and washing the roots in running water, the rooting rate (%) was evaluated using the list of cuttings that emitted at least one root. The total number of roots emitted from the base of the cuttings was counted, and the length (cm) of the four longest roots was measured using a graduated ruler. Destructive evaluations were performed in the laboratory, where the fresh and dry masses of the roots were evaluated. Fresh mass was measured using a precision scale, and root dry mass was obtained after drying the material in a forced-air oven at 70 °C for 72 h.

The experimental design was completely randomized with three replications, arranged in a 3 x 5 factorial scheme, involving three treatments to stimulate rooting (control, seaweed extract applied twice and seaweed extract applied four times) associated with five pitaya genotypes — *H. polyrhizus, S. undatus, Golden (S. undatus), S. costaricensis and S. setaceus* — with 8 cuttings per plot, *totaling 120 piles.* All data obtained were statistically analyzed according to test *f* and Tukey's test ($p \leq 0.05$) for comparison between treatments using the RStudio software, version 3.5.1 (R CORE TEAM 2013). The survival and rooting percentages were transformed into arcsine √x/100. The numbers of roots and shoots were transformed into logs (x + 1) and submitted to statistical analysis.

RESULTS AND DISCUSSION

None of the cuttings used in the experiment showed any disease until data analysis, and a survival rate of 100.00% of the material was maintained. This high rate of health is related to its rusticity (POLLNOW 2018), the time between the preparation of the vegetative material and its placement in the substrate, which led to good wound healing and water loss (LONE et al. 2020), and also to the substrate itself, which exhibited high water drainage capacity.

On average, there was no significant difference between the control and the doses of biostimulate application regarding the sprouting rate (Table 1). The non-difference in germination rate can be explained by the reserves in the cladodes and the physiology of the buds. Shoot formation is related to the ability of plant tissues to undergo rapid cell division, freeing buds from apical dominance (BOTIN & CARVALHO 2015). The main phytohormone involved in these activities is cytokinin, which can modify apical dominance and promote the growth of lateral buds (KIEBER & SCHALLER 2018).

The application of seaweed extract twice was effective in increasing the number of shoots in the S. undatus genotype by 60.83% *S. undatus* compared to control. However, the use of four doses of the biostimulatebiostimulate did not express any statistical difference in relation to the other treatments. When comparing the different genotypes, Golden produced twice as many sprouts of *S. setaceus* under twice the application of seaweed extract. A similar result was observed when both genotypes were administered a quadruple dose of the biostimulate.

Previous studies have shown an increase in the number of sprouts for *H. polyrhizus* with the use of seaweed extract compared with the control. However, no difference was identified for the genotype *S. undatus* (DE FREITAS et al. 2021). The increase in shoot numbers with the use of seaweed extract is due to the presence of hormones and/or growth-promoting substances in the seaweed used (PARAĐIKOVIĆ et al. 2019). An increase in humic acids was also observed in the above-ground mass of cuttings from the Paulsen 1103 grapevine rootstock using a seaweed extract biostimulate and IBA (PRIETO et al. 2019). *The use of the brown algae Macrocystis Integrifolia in cactus Lobivia spp.* has led to an increase in the number of new emissions and an increase in the vegetative mass of the plant (PRISA 2021).

The effects of biostimulate doses can be observed when considering the length of the largest shoots in golden cuttings. The application of both treatments was effective in increasing shoot size compared with the control. The two doses of seaweed extract had a better effect on Golden (approximately 25.00%) than the other genotypes tested. In contrast to the results of this study, the use of seaweed extract increased the average length of the seaweed shoots. *S. undatus* (DE FREITAS et al. 2021). In the Crimson Seedless grapevine crop, an increase in shoot size was observed with the use of seaweed extract-based biostimulate (RIBEIRO et al. 2017). The use of a seaweed-based biostimulate also resulted in a longer above-ground length in tamarind seedlings (SALUSTIANO 2017).

The rooting rate showed a significant increase of 133.33% for the genotype *S. costaricensis* with both treatments of seaweed extract application when compared to the control (Table 2). Among the other genotypes tested, no differences were identified regarding the use or not of seaweed extract. Cuttings with higher carbohydrate reserves have higher endogenous auxin levels, allowing them to root better, which could justify the non-interaction between treatments, except for *S. costaricensis* (BASTOS et al. 2006). The genotypes *H. polyrhizus and S. undatus* already have high rooting rates under normal conditions (MARQUES et al. 2012, ALMEIDA et al. 2014) and may not express an increase with the use of seaweed biostimulates (DE FREITAS et al. 2021).

Table 1. Sprouting rate (%), number of shoots, and longest shoot length (cm) in cuttings of different dragon fruit genotypes under application of seaweed extract-based biostimulate. Florianópolis, 2023.

Treatments	Genotypes				
	H. polyrhizus	*S. undatus*	Golden	*S. costaricensis*	*S. setaceus*
Germination rate (%)					
Control	84.21 a AB	100.00 a A	89.47 a AB	62.50 a, B	45.45 a C
2x Biost	89.47 a AB	100.00 a A	100.00 a A	75.00 a AB	63.64 a B
4x Biost	100.00 a A	100.00 a A	100.00 a A	75.00 a AB	45.45 a–B
CV (%)			25.69		
Number of Shoots					
Control	1.32 a B	1.20 b BC	2.32 a A	0.88 a BC	0.45 a C
2x Biost	1.74 a AB	1.93 a A	2.00 a A	1.25 a AB	1.00 a B
4x Biost	1.79 a A	1.60 ab A	1.84 a A	1.36 a AB	0.73 a B
CV (%)			39.78		
Longest Shoot Length (cm)					
Control	17.91 a BC	27.45 a AB	38.02 b A.	15.82 a BC	5.24 a C
2x Biost	22.79 a B	23.53 a B	47.24 a A	22.00 a B	14.70 a B
4x Biost	27.11 a B	24:00 a BC	50.00 a A	22.18 a BC	8.40 a C
CV (%)			31.24		

* Means followed by the same lowercase letter in the column and uppercase letter in the row do not differ from each other according to Tukey's test (p<0,05).

A significant interaction was found between the treatment and genotypes evaluated in terms of the number of roots. This variable increased by 86.30% for *H. polyrhizus* and 126.40% for Golden when compared with the control after four treatments of seaweed extract. On the other hand, S. *setaceus* had a decrease in 37.74% in the number of roots for treatment with 4 applications of seaweed extract. An increase in root volume was observed with the use of seaweed extract-based biostimulate in the grapevine variety Crimson Seedless, although higher volumes of the biostimulate resulted in a reduction in these values (RIBEIRO et al. 2017). The use of the seaweed extract biostimulate and IBA contributed to an increase in the number of roots in cuttings of different grapevine rootstocks (BRIGHENTI et al. 2023). Different biostimulates, such as coconut water and green coconut, also increase the number of roots of *H. costaricensis and H. monocanthus* in dragon fruit (GARBANZO-LEÓN et al. 2021).

No increase in root length was observed in the treatment with seaweed extract. To the genotype *S. costaricensis*, the application of two doses of the biostimulate resulted in a decrease of approximately 34.00% in the length of the largest root compared with the control treatment. The use of four doses of the biostimulate also promoted a 36.56% decrease in this parameter for the species *S. setaceus*, when compared to not using seaweed extract. Regarding the average length, a significant increase in the roots of the genotype was observed *in S. undatus* and its Golden variety compared with the control. For the former condition, increasing doses increased the mean root length (32.17 and 70.03%, respectively). For the second dose, the application of two doses was sufficient to maximize the root size by 29.60%. The root length results in this study are consistent with those of other tests using seaweed-based biostimulates (BINSFELD et al. 2019, SANTOS FILHO 2021). In Crimson Seedless grapevine, an increase in root length was observed with the use of seaweed extract-based biostimulate, but higher doses of the biostimulate reflected in a decrease in the root length (RIBEIRO et al. 2017). The use of coconut water promoted an increase in root length in other species of the genus *Hylocereus* (GARBANZO-LEÓN et al. 2021).

Table 2. Rooting rate (%), number of shoots, maximum and average root length (cm) in cuttings of different dragon fruit genotypes under application of seaweed extract-based biostimulate. Florianópolis, 2023.

Treatments	Genotypes				
	H. polyrhizus	*S. undatus*	Golden	*S. costaricensis*	*S. setaceus*
			Rooting Rate (%)		
Control	84.21 a AB	100.00 a A	89.47 a AB	37.50 b C	63.64 a B
2x Biost	89.47 a A	100.00 a A	100.00 a A	87.50 a A	72.73 a A
4x Biost	94.74 a A	100.00 a A	100.00 a A	87.50 a A	90.91 aA
CV (%)			21.88		
			Number of Roots		
Control	8.53 b BC	15.13 aAB	9.11 b BC:	3.00 a C	19:00 a A
2x Biost	11.95 ab AB	11.53 a AB	9.32 b B	9.13 a, B	16.27 ab A
4x Biost	15.89 a AB	9.67 a – B	20.63 a A	9.00 a B	11.82 b B
CV (%)			39.59		
			Longest Root Length (cm)		
Control	16.92 a–C	23:00 aAB	25.67 a A	1900 aBC	14.73 a C
2x Biost	19.12 a, B	22.47 a AB	24.63 a A	12.56 b C	12.88 ab C
4x Biost	19.06 a BC	24.07 a AB	24.68 a A	18.00 ab C	9.34 b D
CV (%)			12.74		
			Mean Root Lenght (cm)		
Control	6.01 a B	6.47 c AB	9.01 b A	6.13 aAB	5.24 ab B
2x Biost	6.65 aBC	8.55 b B	11.68 aA	5.09 a–C	6.00 a BC
4x Biost	7.06 a, B	11:00 a A	12.21 aA	7.77 a, B	3.00 b C
CV (%)			18.23		

* Means followed by the same lowercase letter in the column and uppercase letter in the row do not differ from each other according to Tukey's test (p<0,05).

The use of doses of a seaweed-based biostimulate was effective in increasing the fresh mass of the roots of three of the genotypes evaluated (Table 3). For *S. undatus* and *S. costaricensis*, four times the dose of the biostimulate promoted an accumulation of more than 1 g of mass compared with the control. For the Golden genotype, two doses were sufficient to increase fresh root mass by 118.60%. When comparing genotypes, *S. undatus* and Golden had better performance when using seaweed-based extract. The use of seaweed extract increased the fresh mass of seaweed root. *S. undatus and H. polyrhizus*, equivalent to the use of indolebutyric acid (BINSFELD et al. 2019, DE FREITAS et al. 2021). In other cactus species, the use of seaweed-based biostimulatebiostimulate and other active ingredients promoted an increase in the parameter. *In Lobivia* spp., the use of brown seaweed *Macrocystis integrifolia* resulted in an increase in plant root mass (PRIS 2021), as well as the use of green coconut water in H. costaricensis and H. monocanthus (GARBANZO-LEÓN et al. 2021).

Table 3. Fresh and dry root mass (g) of cuttings of different dragon fruit genotypes under the application of seaweed extract-based biostimulate. Florianópolis, 2023.

Treatments	Genotypes				
	H. polyrhizus	*S. undatus*	Golden	*S. costaricensis*	*S. setaceus*
			Fresh Root Mass (g)		
Control	0.76 a B*	2.11 b A	1.57 b AB	0.70 b B	1.04 a, B
2x Biost	1.0 a, B	2.24 b A	3.05 aA	0.86 b B	1.26 a, B
4x Biost	1.25 a C	3.56 aA	3.43 a A	1.90 a B	0.90 a C
CV (%)			11.85		
			Dry Root Mass (g)		
Control	0.55 a B	1.42 b A	0.83 b B	0.49 a B	0.78 a B
2x Biost	0.58 a C	1.21 b B	2.01 aA	0.54 a C	0.68 a C
4x Biost	0.94 a B	2.16 a A	1.69 aA	0.83 a B	0.49 a B
CV (%)			12.09		

* Means followed by the same lowercase letter in the column and uppercase letter in the row do not differ from each other according to Tukey's test (p<0,05).

The dry mass of the roots was higher for the genotypes *S. undatus* and Golden varieties than in the control. For the first time, only four doses of the biostimulate was effective, resulting in an additional 52.11%. Compared with the control, treatment with two or four doses of the seaweed-based extract resulted in an increase in the dry mass of Golden (142.17 and 103.61%, respectively). Among the genotypes evaluated, Golden had the best performance with the use of double-dose of the biostimulate. With the application of a quadruple dose, both Golden and *S. undatus* expressed higher values of root dry mass. *The use of seaweed extract*-based biostimulate was capable to increase de *dry mass of H. polyrhizus and S. undatus roots* (DE FREITAS et al. 2021), although in some cases, no difference was identified for the dry root mass of S. undatus under the same treatments (SANTOS FILHO 2021). *When considering species of the genus Hylocereus*, the application of biostimulate with green coconut water improved the dry mass of H. *costaricensis and H.* monocanthus dragon fruit (GARBANZO-LEÓN et al. 2021). In other species, such as grapevines, the use of seaweed-based biostimulate also been shown to improve root dry mass (RIBEIRO et al. 2017).

CONCLUSION

This study demonstrated that the seaweed extract biostimulate positively affected several plant genotypes, particularly *S. undatus* and Golden, by increasing the number of shoots and rooting rates, especially in double applications. Golden and *S. costaricensis* showed improvement in shoot length and root mass at specific doses, whereas *S. setaceus* showed a decrease at higher doses.

Overall, the biostimulate was effective in enhancing growth and health, especially in the Golden genotype. These results suggest the need for customized doses and application frequencies to optimize benefits in different genotypes.

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