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SUBSTRATE FERTILIZATION TECHNOLOGIES FOR THE PRODUCTION OF JUÇARA SEEDLINGS FOR ORNAMENTAL PURPOSES

TECNOLOGIAS DE FERTILIZAÇÃO DE SUBSTRATO PARA A PRODUÇÃO DE MUDAS DE JUÇARA COM FINS ORNAMENTAIS

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ABSTRACT

The sustainable management of forest resources, the high demand for ecological restoration and the productive and ornamental potential of *Euterpe edulis* make it a key species for the Atlantic Forest conservation. The production of quality seedlings of native species stands out among the propagation strategies. Different products and processes are emerging and being incorporated into the agricultural substrates used by forest nurseries. Three fertilization technologies were tested for the production of *Euterpe edulis* seedlings: Controlled-Release Fertilizer (CRF), agro-industrial organic compost (FCO) and bokashi (FBO) in four different doses. The experiment used was completely randomized with four replications of thirteen treatments and nine plants as a sample unit, being evaluated at 270 days. The development was measured through the variables shoot height, stem diameter, aboveground fresh matter, and total dry matter, root dry matter, total dry matter. From these, seedling quality indices, stem height and diameter ratio, Dickson quality index and maximum technical efficiency dose were calculated. It was observed that *E. edulis* seedlings responded positively to the use of CRF and to the use of FCO, however, they did not present satisfactory results for FBO under the tested conditions. The maximum technical efficiency dose found for the FCO was 167.36 Kg.m-3. For CRF a dose of at least 12 Kg.m-3 can be recommended.

Keywords: *Euterpe edulis*; controlled-release fertilizer; organic compost; bokashi; quality of seedlings.

RESUMO

O manejo sustentável de recursos florestais, a alta demanda por restauração ecológica e o potencial produtivo e ornamental de *Euterpe edulis* fazem dela uma espécie chave para a conservação da Mata Atlântica. A produção de mudas de qualidade de espécies nativas se destaca dentre as estratégias de propagação. Diferentes produtos e processos estão surgindo e sendo incorporados aos substratos agrícolas utilizados por viveiristas florestais. Foram testadas três tecnologias de fertilização para a produção de mudas de *Euterpe edulis*: fertilizante de liberação controlada (CRF), composto orgânico agroindustrial (COA) e bokashi (FBO) em quatros doses diferentes. O delineamento utilizado foi inteiramente casualizado com quatro repetições de treze tratamentos e nove plantas como unidade amostral, sendo avaliadas aos 270 dias. O desenvolvimento foi mensurado através das variáveis altura da parte aérea, diâmetro do coleto, matéria fresca da parte aérea, matéria seca da parte aérea, matéria seca da raiz, matéria seca total. A partir destes foram calculados os índices de qualidade de mudas, relação altura e diâmetro do colo, índice de qualidade Dickson e a dose de máxima eficiência técnica. Observou-se resposta positiva ao uso do CRF e ao uso de COA, porém não apresentaram resultados satisfatórios para o FBO nas condições testadas. A dose de máxima eficiência técnica encontrada para o COA foi de 167,36 Kg.m^{-3}. Para o CRF uma dose de pelo menos 12 Kg.m^{-3} pode ser recomendada.

Palavras-chave: *Euterpe edulis*; fertilizante de libertação lenta; composto orgânico; bokashi; qualidade de muda.

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INTRODUCTION

Belonging to the Arecaceae family and popularly known as içara, palmito-doce, palmito-juçara, juçara, palmiteiro, ripeira, the *Euterpe edulis*, Mart. (Juçara) is present in the list of edible species, prioritized among several fruit trees under the “plants for the future” project. In addition, it presents a wide adaptation to the various tropical and subtropical edaphological conditions (PEREIRA et al., 2022), configuring itself as species fit for ornamental use with a landscape effect (Figure 1).

At the same time, demand for species with potential for use in gardens or productive landscape projects and educational or therapeutic gardens grows widely (MOSQUE, 2019). Moreover, several studies have highlighted that the consumption of derivatives produced from the *E. edulis* fruit represents a great nutritional benefit to health, so considering its its high nutritive and organoleptic properties it could be classified among the functional food (LIMA et al., 2019; COPETTI et al., 2020; VANNUCHI et al., 2022; CARVALHO et al., 2022; PEREIRA et al., 2023; SIQUEIRA et al., 2023).

Furthermore, it should be noted also that even being a plant with a wide distribution, its conservation status is considered vulnerable due to the intense process of exploration to obtain the palm, which necessarily leads to the death adult individuals (REIS et al., 2000). In order to reverse this situation, an environmentally and economically viable strategy is needed to encourage a rational exploitation of the palm tree (FANTINI et al., 1997), and the use of these species for landscape or ornamental purposes is a contributing factor to their preservation.

Sustainable management of forest species will contribute to the success of conservation efforts and often farmers are willing to participate if they can obtain further income from the forest resources they have (REIS et al., 2000).

In this scenario, the production of quality native seedlings, including *E. edulis*, becomes a key factor to meeting future demands. To this end, many fertilization technologies for the production of seedlings are emerging and being used in forest nurseries in the state of Santa Catarina. The technologies for the composition of the substrate are wide-ranging, including both the use of products of local origin (dung, poultry/pig/cattle litter, carbonized rice husk, ash, organic residues) and high-tech industrial products (e.g. Controlled-Release Fertilizer (CRF)).

Among the sustainable technologies, it is worth emphasizing the use of organic compounds derived from agricultural or agro-industrial production systems, which present great potential as alternative substrates in the production of seedlings (SILVA et al., 2015). Other organic compounds that include the use of microorganisms and carbohydrates to accelerate fermentation processes are also being spread. This is the case of bokashi, which was adapted by Japanese immigrants around the year 1980, considering the conditions and materials available in Brazil (VICENTE et al., 2020).

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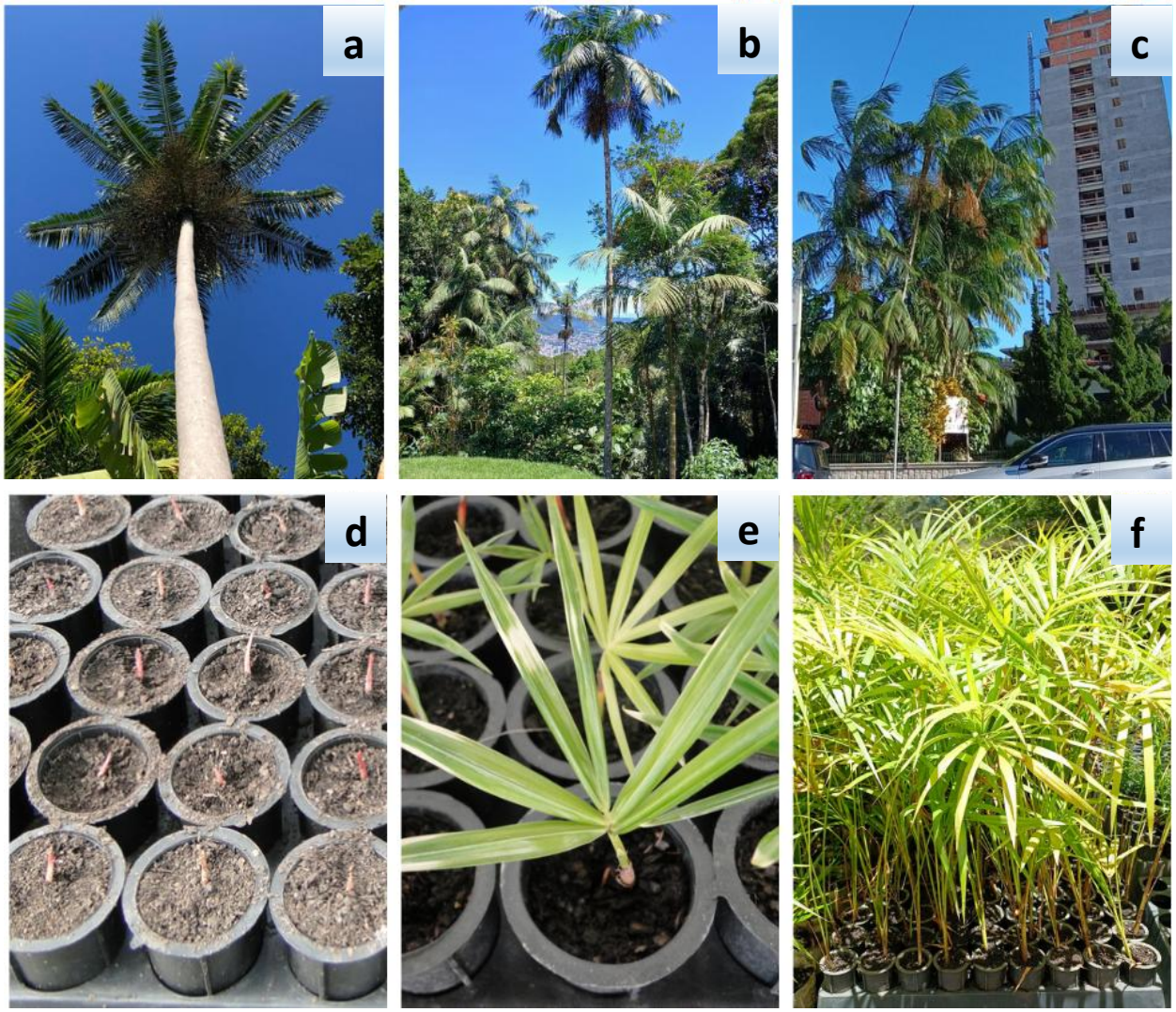

Figure 1. Landscape and ecological aspects and characteristics of *E. edulis* (a, b, c). Morphometric development stages of plants produced in a seedling nursery for landscaping and urban forest purposes (d, e, f).

Figura 1. Aspectos e características paisagísticas e ecológicas de *E. edulis* (a, b, c). Estádios de desenvolvimento morfométrico de plantas produzidas em viveiro de mudas para fins de paisagismo e arborização urbana.

Another fertilization technology for the seedlings production used in Santa Catarina state nurseries is the supply of controlled, slow or gradual release fertilizers. These are encapsulated fertilizers that release nutrients to soil or growing substrate during a longer period than conventional/readily soluble fertilizers , increasing the time of nutrients availability to plants.

The knowledge advancement in the propagation of a native species with high ecological and economic value, using of appropriate fertilization technologies to produce quality seedlings is indispensable to enable the conservation and sustainable use of forest resources of the Atlantic Forest. In this context, the present study aimed to evaluate the effects different fertilization technologies on the production of *E. edulis* seedlings in a forest nursery.

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MATERIAL AND METHODS

The experiment was carried out from July 2019 to April 2020, and was conducted at Horto Universitário of UNIDAVI, located in the city of Rio do Sul SC (27º15'24,15" S; 49º38'55,69" O) at 360 m height above mean sea level. According to the Köeppen climate classification (1928), the area is located in a region of constantly humid subtropical climate, without a dry season, with hot summer - Cfa. Average annual temperature of 19.3 °C, with mean annual rainfall of 1529 mm. The garden has an agricultural plastic greenhouse and sprinkler irrigation system.

Three commercial substrate fertilization technologies were used to evaluate the production of *E. edulis* seedlings: controlled-release fertilizer (CRF); organic compost from agro-industrial residues (FCO); and bokashi (FBO). The chemical and physical characteristics are presented in Table 1.

Table 1. Chemical and physical analysis of the substrate and the three tested fertilizers for the production of Juçara seedlings.
Tabela 1. Analise química e física do substrato base e dos fertilizantes testados na produção de mudas de Juçara.

Commercial Substrate		**Controlled-Release Fertilizer (CRF)**		**Organic Compost (FCO)**		**Bokashi (FBO)**	
pH (H_2O)	6	Granule diameter (mm)	2.5 to 3.5	pH ($CaCl_2$ 0,01 mol/l)	6.40	pH	7.54
NPK (%)	0.6	N (%)	16	N (%)	2.37	N (%)	0.057
Natural phosphate (%)	0.5	P_2O_5 [Sol. in CNA+H_2O] (%)	8	P_2O_5 [Sol. in CNA+H_2O] (%)	1.93	P (mg l^{-1})	1143.15
Density (kg/m^3)	310	K_2O (%)	12	K_2O sol. in H_2O (%)	0.79	MO (%)	3.93
Water retention capacity (%)	195	S (%)	5	Ratio C/N	15.33	C (%)	2.28
Electrical conductivity (mS/cm)	0.4+/- 0.30	B (%)	0.02	CO (%)	36.13		
Moist (%)	50	Mo (%)	0.015	Moisture (%)	65		
				C (%)	19.5		
		MgO (%)	2	Mg (%)	10.64		
		Mn (%)	0.06	Mn (%)	0.05		
		Cu (%)	0.05	Cu (%)	0.06		
		Zn (%)	0.02	Zn (%)	0.10		
		Fe (%)	0.4	Fe (%)	0.87		
				Ca (%)	3.51		

Source: The Author (2022)

The mixing of the fertilizers with the substrate was performed in a concrete mixer for one minute, guaranteeing a good homogenization of the fertilizers to the base substrate. The 280 cm^3 polypropylene pots were filled and submitted to a compact table for 10 seconds, aiming the volumetric uniformity and density of the root environment.

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The seedlings were acquired after the processing of juice pulp, from fruits collected from plants located in the municipality of Presidente Getúlio SC, Brazil. The sowing was carried out in a plastic tray filled with a commercial substrate without any additional fertilization. At 30 days after emergence, the seedlings had the mean characteristics: height (H) of 1.69 cm; stem diameter (DC) of 0.70 mm and total dry matter (BST) of 0.42 grams. The seedlings were seeded in the pots, containing the mixture of the base substrate and the fertilizers tested, and were then accommodated in a greenhouse at 50 % shade.

The experimental design was completely randomized (IHD) with four replicates of thirteen treatments, with nine plants as the experimental unit. The treatments consisted of a control without fertilization and four doses of each fertilizer tested, 3, 6, 9 and 12 $kg.m^{-3}$ of CRF; and 50, 100, 150 and 200 $kg.m^{-3}$ of FCO and FBO.

Considering a minimum time 4 to 6 months necessary for the production of *E. edulis* seedlings, data were collected at 270 days after transplant. Biometric data such asthe aerial part height (H), stem diameter (DC), fresh matter of the aerial part (BFPA), dry matter of the aerial part (BSPA), dry matter of the roots (BSR) and total dry matter (BST) were collected. From these, two seedling quality indices were calculated: ratio between plant height and neck diameter (H/DC) and Dickson quality index (IQD=BST/(H/DC+BSPA/BSR)).

The height of the aerial part of the seedling (H) was measured with ground level ruler up to the apex. The stem diameter (DC) using a digital vernier caliper at 0.5 cm from the ground. For the BSR determination, the roots were destroyed and washed on 2 mm sieves to avoid possible losses of radicles. For the determination of BSPA and BSR, the materials were packed in identified paper bags and dried in a air circulation oven at 65 °C for at least 72 hours or until constant mass was reached. BFPA and the other matter were obtained using a millesimal precision scale.

The data obtained were submitted to analysis of variance (ANOVA) and the means compared by the Scott-Knott test at 5% probability and then submitted to polynomial regression analysis. The coefficients were used to calculate the maximum technical efficiency dose (DMET) of the fertilizers for each variable tested. The DMET values calculated on regressions with $R^2 \geq 0.7$ were used to calculate an average DMET of each fertilizer.

RESULTS AND DISCUSSION

Analysis of the biometric and quality parameters of the seedlings of *E. edulis* using different fertilization technologies

Data analysis showed that the highest growth in height of the aerial part (H) was observed in the 12 $kg.m^{-3}$ dose of CRF, corresponding to 15.18 cm (Table 2). The best results for the FCO were obtained at a dose of 150 $kg.m^{-3}$, with 12.15 cm of mean height. FBO presented

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results similar to the control. In the general scenario, the dosages used did not allow *E. edulis* seedlings to reach the minimum height values, between 20 and 35 cm , recommended for native species (GONÇALVES; BENEDETTI, 2000) or 30 to 40 cm proposed as the marketing standard for *E. edulis* by Silva et al. (2015).

It was observed that the low level of nitrogen availability present in the FCO and FBO compounds, with 2.37 and 0.057 % respectively, may be the main contributing factor for the low average height of the seedlings, measured between 10.21 and 4.94 cm respectively for FCO and FBO. In a study carried out with the same species by Molina and Botrel (2009), it was evaluated the initial plant development in different substrates without the addition of mineral fertilizers, and similar average plant heights (10.46 cm) were obtained seven months after emergence.

It can be inferred that the lack of available nitrogen in the composition of forest substrates was the main limiting factor, as they did not provide the necessary nutritional support for the development of the *E. edulis* seedlings, as pointed out by several authors (BUTZKE et al., 2023; ILLENSEER; PAULILO 2002; BEZERRA et al., 2018), resulting in the production of short seedlings that are generally undesirable in urban forest projects.

It can be seen that in the results obtained with the highest FLL dosages, the height of the plants reached 15.8 cm, a value considered close to the ideal for this plant age, according to Gonçalves and Benedetti (2000), and so these are the most suitable for the implementation of urban forest projects that require greater plant heights.

Table 2. Mean values of biometric parameters and seedling quality indices for all treatments in *E. edulis*.
Tabela 2. Valores médios dos parâmetros biométricos e índices de qualidade para todos os tratamentos de fertilização para a produção de mudas de *E. edulis*.

		Biometric Parameters						Quality Indexes	
Doses ($Kg.m^{-3}$)		**H (cm)**	**DC (mm)**	**BFPA (g)**	**BSPA (g)**	**BSR (g)**	**BST (g)**	**H/DC**	**IQD**
TES	0	4.78 f	3.52 e	1.14 f	0.32 f	0.25 d	0.55 f	1.37 c	0.21 d
CRF	3	7.88 e	4.60 d	2.65 e	0.73 e	0.38 d	1.13 e	1.71 b	0.31 d
	6	10.75 d	5.49 c	4.24d	1.28 d	0.58 c	1.85 d	1.6 a	0.45 c
	9	13.18 b	6.95 b	6.32 b	1.95 b	0.71 b	2.68 b	1.0 a	0.57 b
	12	15.8 a	8.02 a	9.13 a	2.95 a	1.15 a	4.10 a	1.90 a	0.93 a
FCO	50	7.65 e	4.56 d	2.1e	0.89 e	0.35 d	1.23 e	1.68 b	0.29 d
	100	10.53 d	5.83 c	3.39 e	0.99 e	0.42 c	1.43 e	1.81 b	0.34 c
	150	12.15 c	6.24 c	5.27 c	1.56 c	0.57 c	2.13 c	1.95 a	0.45 c
	200	10.53 d	5.92 c	4.27 d	1.27 d	0.50 c	1.76 d	1.78 b	0.40 c
FBO	50	4.90 f	3.59 e	1.18 f	0.31 f	0.19 d	0.48 f	1.37 c	0.16 d
	100	4.70 f	3.23 e	1.08 f	0.31 f	0.24 d	0.58 f	1.47 c	0.21 d
	150	5.23 f	3.64 e	1.39 f	0.40 f	0.28 d	0.68 f	1.45 c	0.24 d
	200	4.95 f	3.58 e	1.29 f	0.37 f	0.25 d	0.63 f	1.41 c	0.22 d
	CV (%)	8.25	8.17	20.09	23.26	25.17	22.41	6.93	24.95

Where: H = height of the aerial part; DC = stem diameter; BFPA = fresh matter of the aerial part; BSPA = dry matter of the aerial part; BSR = dry matter of the root; BST = total dry matter; H/DC = ratio height and stem diameter; IQD = Dickson Quality Index. Averages followed by the same letter do not differ by the Scott-Knott test at 5% probability.
Source: The Author (2022)

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The species is preferentially sciophyte in early stages and the high level of irradiance seems to be the main limiting factor for the growth of young plants in a shaded environment (ILLENSEER; PAULILO, 2002). Therefore, height may not be the determining factor to be considered for initial establishment and development. Seedlings with the highest height is not exactly the best in terms of field survival, especially when they are etiolated, but for ornamental purposes where care is constant, etiolation is a desirable feature for projects that aim for a vertically structured landscape. This parameter (H) has a lower relationship with IQD than other simple variables.

The stem diameter is indicated as one of the parameters that express the best performance, corresponding in a better development of the plant after its transfer to the final planting site. A larger stem diameter may mean greater plant resistance to toppling, an undesirable effect in urban landscaping projects, but very common when plants are exposed to environmental conditions such as strong winds, causing a higher incidence of mortality after definitive planting on roads or public squares. This parameter is considered the best practical indicator for estimating the IQD values in seedlings of forest species of the Atlantic Forest (AVELINO et al., 2021). Therefore, considering the ease in obtaining these data, DC can be a more appropriate parameter to indicate the quality of the change and itcould effectively assist in decision making during projects, both involving use of forest species and for conservation purposes, without requiring destructive sampling. In general, seedlings of palm trees are expected to have larger increments in diameter development than in height (SILVA et al., 2015).

In a research with *E. edulis* testing different phosphorus doses, Lima et al. (2008) obtained seedlings with mean stem diameter of 7.9 mm at 12 months of cultivation. In the present study, the highest DC, 8.02 mm, was obtained with the maximum dose of CRF (12 $kg.m^{-3}$) , followed by the CRF dose of 9 $kg.m^{-3}$ (6.95 mm). It is possible to infer that higher dose of fertilizers provided greater development of this species, given the greater nutritional supply to the plant, supporting a better growth performance and consequently greater DC. Stem diameters of 5.49 mm (at 6 $kg.m^{-3}$ of CRF) and and 5.83 mm, 6.24 mm and 5.92 mm of DC, respectively for FCO doses of 100, 150 and 200 $kg.m^{-3}$, were not statistically different (Table 2). These results are in accordance with the recommendations of Gonçalves and Benedetti (2000) that suggest DC between 5 and 10 mm for native seedlings to be used on field planting.

For the FBO, the results presented similar responses to the control with a mean diameter of 3.5 mm, which, although satisfying the recommendations of a stem diameter greater than 2 mm for palm-juice after six months of cultivation, presented little expressive values for other parameters, so these seedlings cannot be considered suitable for marketing or field planting.

The highest matter values (BST) were obtained at a dose of 12 $kg.m^{-3}$ with a result of 4.10 $g.plant^{-1}$, followed by 2.68 $g.plant^{-1}$ at a CRF dose of 9 $kg.m^{-3}$. The highest value for FCO was 2.13 $g.plant^{-1}$ at a dose of 150 $kg.m^{-3}$. The FBO presented matter data that did not differ from the control values, the highest value being 0.68 $g.plant^{-1}$.

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The FCO produced increasing BST values up to the 150 kg.m^{-3} dose and showed a decrease with 200 kg.m^{-3}. For the CRF, there was a production of BST with a growing response, associated positively with the dose increase.

The best result for BSR was found at the dose of 12 kg.m^{-3} CRF, with 1.15 g.plant^{-1}, followed by 0.71 g.plant^{-1} at a dose of 9 kg.m^{-3}. The doses of 6 kg.m^{-3} of CRF and 100, 150 and 200 kg.m^{-3} of FCO did not differ from each other and presented the values of 0.58, 0.42, 0.57 and 0.50 g.plant^{-1}, respectively (Table 2). Therefore, the best results for BSR in *E. edulis* are presented as a response to higher doses of CRF.

The H/DC ratio values obtained in this study vary from 1.37 to 1.96 cm.mm-^{1} (Table 2). Similar values, below 2.9 cm.mm^{-1}, were found by Silva et al. (2015) in five-month juçara seedlings. Altoughall treatments tested met still the recommendations of Carneiro (1995) with values less than 10 cm.mm-^{1} for quality seedlings,they did not meet the criteria established by Gonçalves and Benedetti (2000) that suggest indices between 2 and 7 cm.mm-^{1}, for native species of the Atlantic Forest. In this study, the highest values of H/DC obtained were with doses of 6, 9 and 12 kg.m^{-3} of CRF and 150 kg.m^{-3} of FCO, with values of 1.96; 1.90; 1.90; and 1.95 cm.mm-^{1}, respectively, and they did not differ statistically among them (Table 2). It is important to note that, in general, lower values are expected for the H/DC ratio in palm species because they have smaller increments in height than in stem diameter (SILVA et al., 2015).

IQD is considered a more robust index because it considers matter values beyond the height and diameter of the stem and it has a suggested minimum value of 0.20 (CARNEIRO, 1995). The values found in this study varied from 0.16 for minimum dose of FBO to 0.93 for maximum dose of CRF (Table 2). For the dose of 9 kg.m^{-3} CRF, an IQD of 0.57 was obtained. The IQD results for doses of 100, 150 and 200 kg.m^{-3} of FCO did not differ from the 6 kg.m^{-3} of CRF, being 0.34; 0.45; 0.40 and 0.45, respectively. Similar values were found by Silva et al. (2015) in works with 150-day juçara seedlings produced with agro-industrial compost and sewage sludge, which reported a maximum of 0.4 for the IQD. Higher IQD values were found for other species of the *Euterpe genus*. Araújo et al. (2019) in studies with 240 days seedlings of *Euterpe oleraceae* measured maximum values of 3.92, and Almeida et al. (2018) in studies with 360-day seedlings of *Euterpe precat*oria indicated maximum values of 2.33 for IQD. This confirms what was proposed by Almeida et al. (2018) that suggest that the IQD values are very variable according to *Euterpe* species and cultivation conditions.

Among the tested fertilizers, the CRF presented the best seedling quality indices, the FCO produced seedlings with satisfactory quality and the FBO did not differ from the control, but nevertheless produced seedlings with mean values of 0.21 for IQD, above 0.20 recommended by Carneiro (1995). Considering that matter is the most IQD-related variable, the average values found for the control and for the FBO may not be derived from fertilization but linked to the energy reserves present in the seeds, indicating that IQD values of 0.20 do not necessarily indicate seedlings of quality or suitable for field implantation for *E. edulis*.

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In general, higher doses of CRF have provided an increase in the values of all biometric parameters and have pointed to better patterns of seedling quality, corroborating data from Rossa et al. (2011, 2015) in studies with native forest species of the Atlantic Forest. Under the tested conditions, the FCO presented increasing results in all parameters and quality indices up to the dose of 150 kg.m^{-3}, producing seedlings of satisfactory quality, but lower than those produced with CRF. The FBO did not differ from the control in any of the parameters and indices measured, producing seedlings that cannot be considered adequate for field planting. However, it should be emphasized that bokashi-like compounds are very varied and there are still gaps in scientific knowledge about this fertilizer (VICENTE et al., 2020). The composition of the organic material used in the elaboration of the compound is important for obtaining positive results in the seedlings production (RAMIRES et al., 2021).

Analysis of Maximum Technical Efficiency (DMET) doses of different fertilization technologies for the production of seedlings of *E. edulis*

Controlled-Release Fertilizer (CRF)

The Maximum Technical Efficiency (DMET) dose for the CRF was calculated for all seedling quality parameters and indices, except for H/DC (Figure 1). DMET determined for parameter H was 26.61 kg.m^{-3} and 38.05 kg.m^{-3} for DC, both much higher than the maximum dose tested (Figure 2) and the average results found for native forest species (ROSSA et al., 2011, 2015; CUNHA et al., 2022). The appropriate dosage for the development of *Euterpe oleracea* and *Euterpe precatoria* is similar, 8 kg.m^{-3} (ARAÚJO et al., 2019; ALMEIDA et al., 2018), valor much lower than those found for *E. edulis*.

The trend lines obtained with $R^2 \geq 0.70$ show growth projection within and above the doses tested, without reaching a maximum point (Figure 1), therefore, the seedlings would probably still present positive responses if fertilized with higher doses of CRF. Thus, it was not possible to infer a DMET value for this fertilizer. However, based on the biometric parameters and quality indices found, a dose of at least 12 kg.m^{-3} of CRF is adequate for the production of *E. edulis* seedlings.

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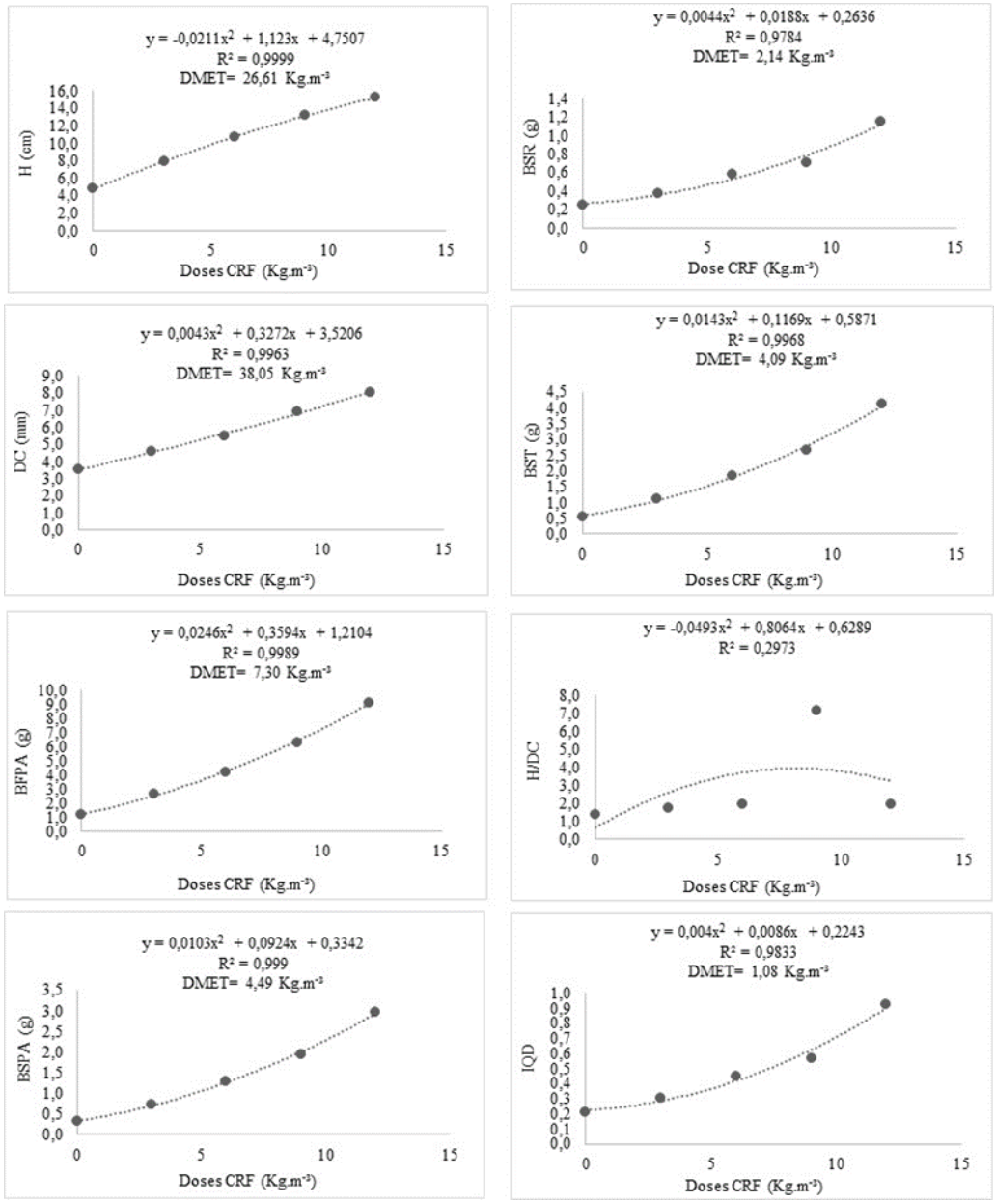

Source: The Author (2022)

Figure 2. Regression curves for aboveground height (H), stem diameter (DC), aboveground fresh mass (BFPA), aboveground dry mass (BSPA), root dry mass (BSR), total dry mass (BST), height and stem diameter ratio (H/DC) and Dickson quality index (DQI) of *E. edulis* seedlings with different doses of Controlled-Release Fertilizer (CRF).

Figura 2. Curvas de regressão para altura (H), diâmetro do colo (DC), massa fresca da parte aérea (BFPA), massa seca da parte aérea (BSPA), massa seca da raiz (BSR), massa seca total (BST), relação altura e diâmetro do colo (H/DC) e índice de qualidade de Dickson (DQI) de mudas de *E. edulis* com diferentes doses de fertilizante de liberação controlada (CRF).

Organic Compound Fertilizer

The Maximum Technical Efficiency (DMET) dose for the FCO was calculated for all parameters and for the seedling quality indices (Figure 3). DMET found for H was 151 kg.m^{-3}, lower than the highest fertilization dose tested. For DC, the result was 167 kg.m^{-3}. DMET

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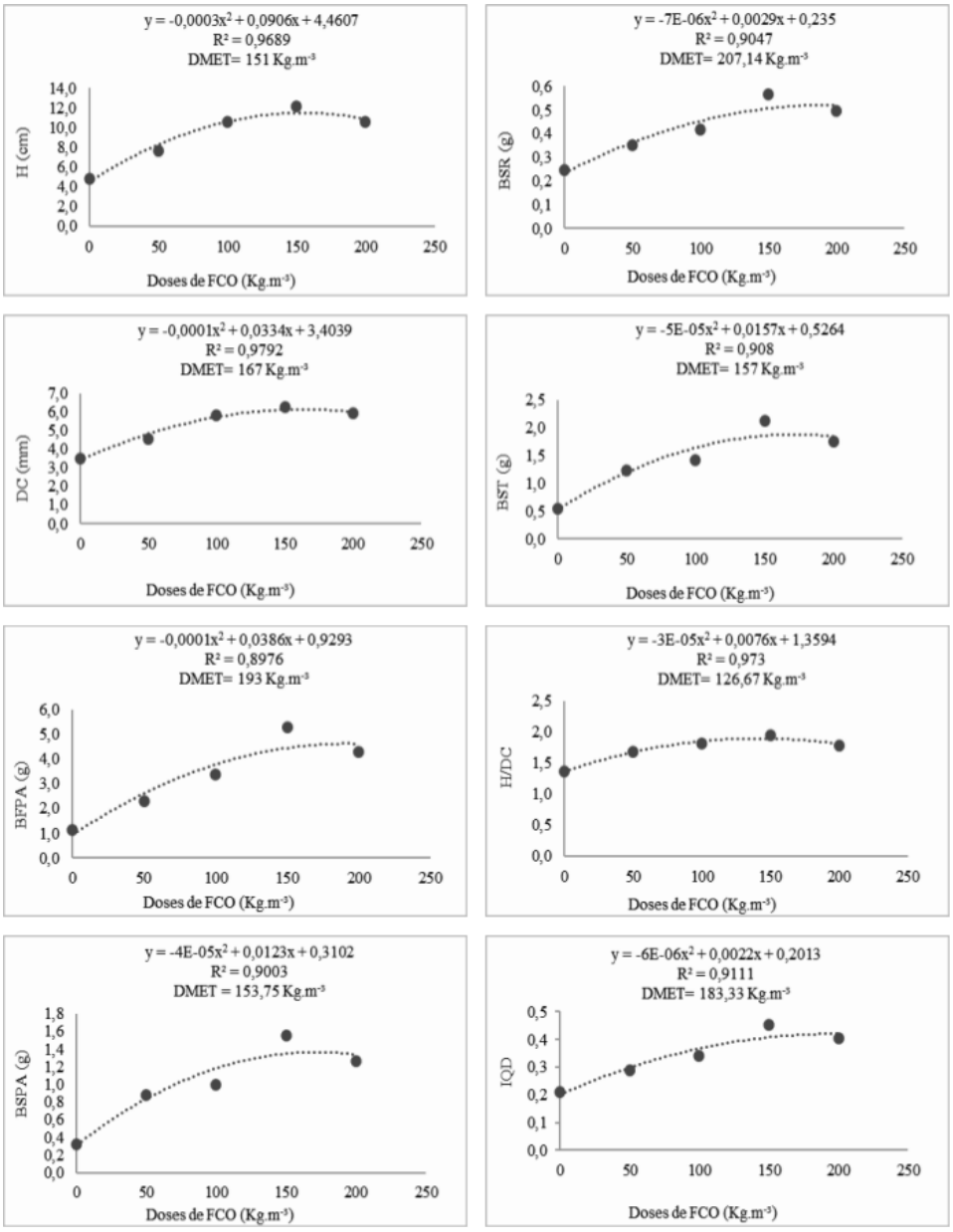
calculated for the IQD was 183.33 kg.m^{-3}, close to the maximum dosage tested (Figure 2). The highest DMET observed for the BSR parameter was calculated as 207 kg.m^{-3}.



Source: The Author (2022)

Figure 3. Regression data from aerial part height (H), stem diameter (DC), fresh aerial part matter (BFPA), dry aerial part matter (BSPA), dry root matter (BSR), total dry matter (BST), ratio of stem height and diameter (H/DC) and Dickson quality index (IQD) of the seedlings of *E. edulis* fertilized with different doses of organic compound (FCO).

Figure 3. Dados de regressão da altura da parte aérea (H), diâmetro do colo (DC), matéria fresca da parte aérea (BFPA), matéria seca da parte aérea (BSPA), matéria seca da raiz (BSR), matéria seca total (BST), relação entre altura e diâmetro do caule (H/DC) e índice de qualidade de Dickson (IQD) das mudas de *E. edulis* fertilizadas com diferentes doses de composto orgânico (FCO).

The average DMET estimated for the FCO, considering all biometric parameters and seedling quality indices, was 167.36 kg.m^{-3}. This value is recommended to produce quality seedlings of *E. edulis* and corroborates the data reported by Oliveira and Viani (2020) who obtained positive responses for doses of 120 and 250 kg.m^{-3} of composted sewage sludge on the substrate.

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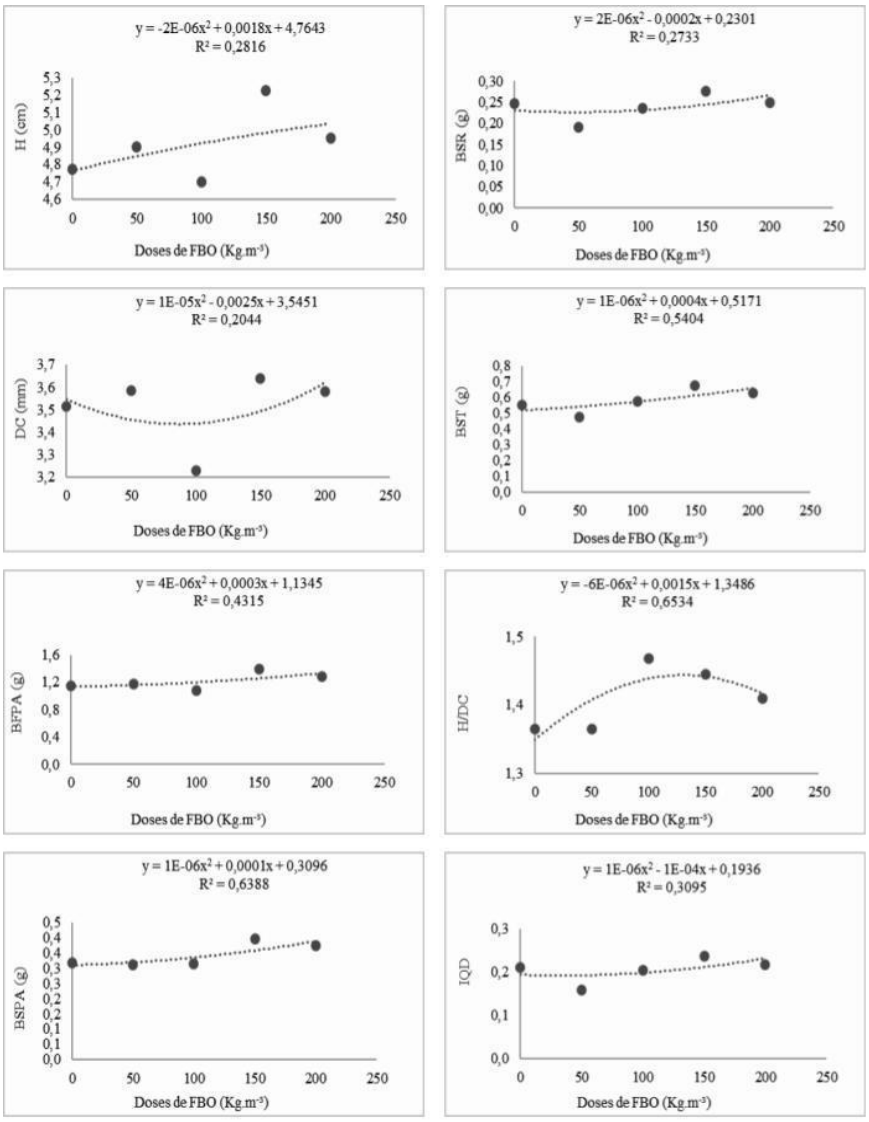
Bokashi Fertilizer

It was not possible to estimate the *Maximum Technical Efficiency (*DMET) dose for the FBO, since in all biometric parameters and seedling quality indices the coefficients of determination R^2 were lower than 0.70 (Figure 4). It should be observed that the seedlings produced with FBO did not reach minimum quality parameters and indices to be considered suitable for field implantation. Although *bokashi* can replace traditional fertilizers (VICENTE et al., 2020), and may be suitable for the seedlings production, its quality and composition must be observed (RAMIRES et al., 2021). It should be noted that, in the present study, the macronutrient values obtained for the FBO (Table 1) were far below those obtained in the other fertilizers tested.



Source: The Author (2022)

Figure 4. Regression data of height (H), stem diameter (DC), fresh aerial part matter (BFPA), dry aerial part matter (BSPA), dry root matter (BSR), total dry matter (BST), ratio of stem height and diameter (H/DC) and Dickson quality index (IQD) of the seedlings of *E. edulis* fertilized with different doses of bokashi (FBO).

Figure 4. Dados de regressão de altura (H), diâmetro do colo (DC), matéria fresca da parte aérea (BFPA), matéria seca da parte aérea (BSPA), matéria seca da raiz (BSR), matéria seca total (BST), relação entre altura e diâmetro do colo (H/DC) e índice de qualidade de Dickson (IQD) das mudas de *E. edulis* fertilizadas com diferentes doses de bokashi (FBO).

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CONCLUSION

E. edulis seedlings responded positively to the use of CRF and FCO technologies, with adequate results to produce of high-quality seedlings.

CRF presented the best responses for both the quality indices of seedlings and biometric parameters. The seedlings produced with bokashi did not respond satisfactorily in the experimental conditions tested.

Considering the different potential uses and fertilization technologies, to produce *E. edulis* seedlings in 280 cm^3 pots, it is recommended to use doses of 167.36 $kg.m^{-3}$ in case of FCO and at least 12 $kg.m^{-3}$ when appliyng CRF.

The recommendations of this work can assist forest nurseries in decision-making regarding fertilization technologies, suggesting their limits and potentials in the production of *E. edulis* seedlings with desirable characteristics for landscaping and ornamental projects.

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