Brackish water and organic matter in the substrate for the growth and quality of oiticica seedlings

Água salobra e matéria orgânica no substrato para o crescimento e qualidade de mudas de oiticica

Agua salobre y materia orgánica en el sustrato para el crecimiento y la calidad de las plántulas de oiticica

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Alian Cássio Pereira Cavalcante
PhD in Plant Science
Institution: Centro de Ensino Superior de São Gotardo (CESG)
Address: São Gotardo – Minas Gerais, Brasil
E-mail: cassio.alian216@gmail.com

Manoel Alexandre Diniz Neto
PhD in Agronomy
Institution: Universidade Federal da Paraíba (UFPB) - campus Universitário III
Address: Bananeiras - Paraíba, Brasil
E-mail: manoel.alexandre@academico.ufpb.br

Lourival Ferreira Cavalcante
PhD in Soils and Plant Nutrition
Institution: Universidade Federal da Paraíba (UFPB) - campus II
Address: Areia – Paraíba, Brasil
E-mail: lofeca1946@yahoo.com.br

Antônio Gustavo de Luna Souto
PhD in Plant Science
Institution: Universidade Federal Rural do Semiárido (UFERSA)
Address: Mossoró - Rio Grande do Norte, Brasil
E-mail: gustavo.luna@ufersa.edu.br

Adailza Guilherme Cavalcante
PhD in Agronomy - Plant Production
Institution: Universidade Estadual Paulista “Júlio de Mesquita Filho”
Address: Jaboticabal – São Paulo, Brasil
E-mail: adailzacavalcante@gmail.com
ABSTRACT
Oiticica is a forest species endemic to the semi-arid regions of Brazil, where the salinity water has caused reductions in the quality of seedlings, including oiticica. The objective of this study was to evaluate the effects of the proportion of organic matter in the substrate on the growth and quality of oiticica seedlings irrigated with brackish water. The experiment was conducted in a randomized complete block design, in a 4 × 2 factorial, with four proportions: organic matter to mineral soil ratios of 0:1, 1:1, 2:1 and 3:1 and two irrigation treatments. non-saline (0.5 dS m$^{-1}$) and brackish water (4.5 dS m$^{-1}$) water. Biomass characteristics and Dickson Quality Index were evaluated. Elevated irrigation water salinity compromised the biometric growth, dry mass accumulation, and the quality of oiticica seedlings. The addition of organic compound to the substrate is limited to the formation of oiticica seedlings.

Keywords: Licania rígida B., organic input, composting, saline stress.

RESUMO
Oiticica é uma espécie florestal endêmica das regiões semi-áridas do Brasil, cuja salinidade da água tem provocado reduções na qualidade das mudas, incluindo a oiticica. O objetivo deste trabalho foi avaliar os efeitos da proporção de matéria orgânica do substrato sobre o crescimento e a qualidade de mudas oiticica irrigadas com água salobra. O experimento foi conduzido em delineamento de blocos ao acaso, no fatorial 4 × 2, com quatro proporções: matéria orgânica para solo mineral de 0:1, 1:1, 2:1 e 3:1 e dois tratamentos de irrigação. água salobra (0,5 dS m$^{-1}$) e salina (4,5 dS m$^{-1}$). Foram avaliadas características de biomassa e índice de Qualidade de Dickson. A elevada salinidade da água de irrigação comprometeu o crescimento biométrico, o acúmulo de massa seca e a qualidade das mudas de oiticica. A adição de matéria orgânica ao substrato é limitante à formação de mudas de oiticica.

Palavras-chave: Licania rígida B., insumo orgânico, compostagem, estresse salino.
RESUMEN
La oiticica es una especie forestal endémica de las regiones semiáridas de Brasil. La salinidad del agua ha causado reducciones en la calidad de las plántulas, incluyendo la oiticica. El objetivo de este estudio fue evaluar los efectos de la proporción de materia orgánica en el sustrato sobre el crecimiento y la calidad de las plántulas de oiticica regadas con agua salobre. El experimento se realizó en un diseño de bloques al azar 4 × 2, con cuatro proporciones: materia orgánica a suelo mineral de 0:1, 1:1, 2:1 y 3:1 y dos tratamientos de riego: agua salobre (0,5 dS m⁻¹) y agua salina (4,5 dS m⁻¹). Se evaluaron las características de la biomasa y el índice de calidad de Dickson. La elevada salinidad del agua de riego comprometió el crecimiento biométrico, la acumulación de masa seca y la calidad de las plántulas de oiticica. La adición de materia orgánica al sustrato es limitante para la formación de plántulas de oiticica.

Palabras clave: Licania rigida B., aporte orgánico, compostaje, estrés salino.

1 INTRODUCTION

The oiticica (Licania rigida Benth) is a forest tree endemic to the riparian forest regions of the Northeast Brazilian States (Roque; Loiola, 2013). Plants are found on the banks of river courses, streams, and water sources where they provide major environmental and economic value for the rural population, primarily resulting from the production of oil (Macedo et al., 2011). The oil content in the oiticica seeds can reach 60 % and the oil is widely used, for example in automotive paint, printing, varnish, and biodiesel manufacturing industries (Queiroga et al., 2016).

Despite the importance of the species in the semi-arid region, oiticica is threatened with extinction because of increased deforestation in the Caatinga, mainly for the extraction of wood used in bread making, ceramics, and charcoal. Additionally, the climatic conditions of the semiarid area, including rainfall irregularities, low humidity, and high air temperature, as well as soil source material complexes (Ribeiro et al., 2016) that are rich in soluble salts (Oliveira et al., 2017) restrict the use of water and limit agricultural production (Dias et al., 2016).

The use of water with high salt content in silvicultural systems has increased since it is often the only available source of water for propagating forest and native species in semi-arid areas (Lima et al., 2015; Souza et al., 2015), including the production of oiticica seedlings (Diniz Neto et al., 2014; Cavalcante et al., 2016; Cavalcante et al., 2020). Increasing the concentration of salts in the soil solution inhibits the plant's ability to absorb water is reduced and the excess of
specific ions, mainly Na\(^+\) and Cl\(^-\) cause nutritional imbalances and visual lesions on leaf tissues (Parihar et al., 2015; Machado; Serralheiro, 2017).

Organic matter from plant and animal origin is applied as a potential mitigator of soil salts’ effects on plants. The application of organic inputs aims to increase the content of humic substances in the soil that promote a favorable osmotic gradient, allowing greater absorption of water and nutrients in salinized media (Khaled; Fawy, 2011) and interfering in the formation of seedlings of forest species, raising the quality standard (Caldeira et al., 2008; Maranho; Paiva, 2012; Lustosa Filho et al., 2015).

The formulation of a suitable substrate for plant growth is contingent upon balanced proportions of organic matter and soil that allow for water retention and nutrient absorption, appropriate substrate pore space for contact with roots, and microbiological activity (Morais et al., 2012; Silva et al., 2012; Trazzi et al., 2013). Despite the benefits of organic matter in substrates for initial growth of several crops when irrigated with saline water, there is limited information pertaining to the amount or proportion of organic matter to apply to substrates to mitigate the effects of salts on plants.

The objective of this work was to evaluate the effects of variable organic matter proportions from the remains of castor bean (**Ricinus communis**) on oiticica seedling growth, dry biomass accumulation, and quality when irrigated with brackish water.

### 2 MATERIAL AND METHODS

The experiment was carried out from February to May 2020 at the Seedlings Production Sector, located in the Agriculture Sector in the Center of Human Sciences, Social and Agrarian of the Federal University of Paraíba, located in the city of Bananeiras, Paraíba. The municipality is located at latitude 6° 46 '00'' S and longitude 35° 38' 0' W and is at 552 m altitude. The climate of the region, according to the classification of Koppen, is type ‘As’ (tropical rainy), hot and humid (Alvares et al., 2013). The benches used for the experiment were protected with shading screens, which blocked 50% of solar radiation. The rainy season is concentrated between April and August and the dry season between September and December, with annual average temperature and humidity of 25 °C and 65%, respectively.
The experiment was conducted in randomized blocks, in the factorial scheme $4 \times 2$, with five replications and two plants per useful plot. The factorial consisted of four proportions of organic matter based on composted remains of castor bean plants and two irrigation salinity levels. Growth substrate consisted of composted organic matter (OM) and soil (S) mixed in the ratios: 0OM:1S, 1OM:1S, 2OM:1S, and 3OM:1S. Treatments were irrigated with non-saline (0.5 dS m$^{-1}$) and brackish water (4.5 dS m$^{-1}$) water. The oiticica seeds were obtained from parent plants located in the city of Catolé do Rocha, Paraíba, Brazil. After collection, the seed bark was revolved with a sharp instrument and then placed in labeled paper bags.

The soil used as substrate was collected from the 0.20-0.40 m layer of a natural soil classified according to the criteria of the Brazilian Soil Classification System (SiBCS) (Embrapa, 2018) as a Yellow Dystrophic Latosol. The organic matter was obtained through composting the aerial remains of crushed castor bean plants (i.e., stems, branches, and leaves) mixed with tanned bovine manure in a 4:1 ratio, that is a 0.2 m thick layer of plant material mixed with a 0.05 m bovine manure layer.

The material stack was constructed in 1.0 m wide $\times$ 1.5 m tall $\times$ 5.0 m long stacks and rotated every 15 days for a period of 90 days, at which time the compost was uniformly stained and appropriately decomposed for use as a substrate. Soil and organic matter samples were collected and chemically characterization (Table 1) according to the methodologies contained in Embrapa (2017).
Table 1. Chemical characterization of soil and organic matter derived from castor bean compost that was used as substrate.

<table>
<thead>
<tr>
<th>Chemical characterization</th>
<th>Soil</th>
<th>Organic matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (H₂O)</td>
<td>5.7</td>
<td>8.2</td>
</tr>
<tr>
<td>Phosphorus (mg dm⁻³)</td>
<td>19.1</td>
<td>921.0</td>
</tr>
<tr>
<td>Potassium (cmol c dm⁻³)</td>
<td>0.23</td>
<td>12.3</td>
</tr>
<tr>
<td>Calcium (cmol c dm⁻³)</td>
<td>4.4</td>
<td>14.1</td>
</tr>
<tr>
<td>Magnesium (cmol c dm⁻³)</td>
<td>0.4</td>
<td>4.2</td>
</tr>
<tr>
<td>Sodium (cmol c dm⁻³)</td>
<td>0.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Potential Acidity (cmol c dm⁻³)</td>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td>Exchangeable aluminum (cmol c dm⁻³)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>SB (cmol, dm⁻³)</td>
<td>5.1</td>
<td>--</td>
</tr>
<tr>
<td>CEC (cmol, dm⁻³)</td>
<td>5.3</td>
<td>--</td>
</tr>
<tr>
<td>V (%)</td>
<td>96.9</td>
<td>--</td>
</tr>
<tr>
<td>Organic matter (g kg⁻¹)</td>
<td>10.4</td>
<td>259.0</td>
</tr>
<tr>
<td>Relationship C:N</td>
<td>--</td>
<td>18:1</td>
</tr>
</tbody>
</table>

pH = hydrogen ion potential; phosphorus (P) = extractor - Melich-1; potassium (K⁺) = extractor - Melich-1; calcium (Ca²⁺) = extractor - KCI 1 mol L⁻¹; magnesium (Mg²⁺) = extractor - KCI 1 mol L⁻¹; sodium (Na⁺) = extractor - KCI 1 mol L⁻¹; hydrogen + aluminum (Al³⁺ + H⁺) = extractor - 0.5 mol L⁻¹ calcium acetate; exchangeable aluminum (Al³⁺) = extractor - 0.5 mol L⁻¹ calcium acetate; sum of bases (SB) = (Ca²⁺ + Mg²⁺ + K⁺ + Na⁺); cation exchange capacity (CEC) = (SB + [Al³⁺+ H⁺]); base saturation (V) = ([SB / CEC] × 100); organic matter (OM) = Walkley-Black method (Embrapa, 2017).

Source: Cavalcante, A. C. P. (2020).

Each experimental unit was composed of a 0.2 × 0.3 m black polyethylene bag with a 3.5 dm³ capacity and filled with 3 dm³ of substrate. Two oiticica seeds were sown in each bag. Emergence began 20 days after sowing (DAS) and stabilized at 30 DAS. Thinning was done 10 days after emergence (DAE), maintaining the most vigorous seedling per experimental unit.

Non-saline irrigation water (0.5 dS m⁻¹) came from the municipal water supply and brackish water (4.5 dS m⁻¹) was prepared by diluting a 92% pure sodium chloride (NaCl) solution in non-saline water until the desired electrical conductivity was measured with portable digital (CD-860) conductivity meter. Irrigations were performed manually every 24 h with the weighing method to replace water lost to evapotranspiration and raise substrate moisture to field capacity.

At 60 DAE, plant height (PH) and root length (RL) were evaluated to the nearest millimeter in cm; stem diameter (SD), in mm, was measured 2 cm above the surface of the substrate with a Digimess digital caliper (Digimess, Buenos Aires, Argentina); the number of fully expanded leaves (NL) was counted and leaf area (LA) was measured, in cm², as the product of the greatest width, leaf length (i.e., estimated leaf area – LAe), and the correction factor 0.79 that was determined from the relation between actual and estimated leaf area for leaves of oiticica (LA = LAe × 0.79). After biometric measurements, plants were separated into root and aerial fractions and the materials were placed to dry in a circulating oven at 65 °C for 72 h to reach
constant mass and by adding the dry mass of the root and leaf, the total dry mass (TDM) of the seedlings was obtained in g plant$^{-1}$.

The Dickson Quality Index (DQI), which measures the quality of seedlings species, was obtained using the method of Dickson et al. (1960):

$$DQI = \frac{TDM}{\frac{PH}{SD} + (SDM + RDM)}$$

Eq. 1

Analysis of variance was used to compare variable means among the different substrate and irrigation treatments using a statistical threshold of $p<0.05$. 'F' tests ($p<0.05$) were used to compare mean values between irrigation treatments. Tukey’s post-hoc tests were used to compare individual substrate treatment groups, also with 5% probability thresholds. The standard deviation of each variable was calculated in Excel 2010 (Microsoft Corp., Redmond, WA, USA) and the statistical software SISVAR version 5.6 (Ferreira, 2019) was used for data analysis.

3 RESULTS AND DISCUSSIONS

Except for seedling total dry mass (TDM), the interaction between irrigation salinity and substrate organic matter content did not influence the other studied variables (Table 2). Plant height (PH) and main root length (RL) were influenced independently by substrate organic matter content and Dickson quality index (DQI) was influenced by irrigation salinity. Stem diameter (SD), the number of leaves per plant (NL), and leaf area (LA) responded independently to both the irrigation salinity and substrate organic matter content.

Table 2. Summary and analysis of variance for the effects of irrigation water salinity (S) and substrate organic matter content on plant height (PH), stem diameter (SD), leaf number (LN), leaf area (LA), root length (RL), total dry mass (TDM), and Dickson quality index (DQI) of oiticica seedlings.

<table>
<thead>
<tr>
<th>FV</th>
<th>GL</th>
<th>Mean square</th>
<th>PH</th>
<th>SD</th>
<th>LN</th>
<th>LA</th>
<th>RL</th>
<th>TDM</th>
<th>DQI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blocks</td>
<td>4</td>
<td></td>
<td>15.46$^{**}$</td>
<td>0.22$^{**}$</td>
<td>0.22$^{**}$</td>
<td>28.97$^{**}$</td>
<td>4.96$^{**}$</td>
<td>9.41$^{**}$</td>
<td>0.35$^{**}$</td>
</tr>
<tr>
<td>Salinity (S)</td>
<td>1</td>
<td></td>
<td>105.62$^{**}$</td>
<td>2.02$^{**}$</td>
<td>7.22$^{**}$</td>
<td>1798.90$^{**}$</td>
<td>8.10$^{**}$</td>
<td>27.22$^{**}$</td>
<td>5.62$^{**}$</td>
</tr>
<tr>
<td>organic matter (OM)</td>
<td>3</td>
<td></td>
<td>188.42$^{**}$</td>
<td>0.69$^{*}$</td>
<td>4.09$^{*}$</td>
<td>510.46$^{**}$</td>
<td>29.66$^{**}$</td>
<td>17.49$^{**}$</td>
<td>0.49$^{ns}$</td>
</tr>
<tr>
<td>S x OM</td>
<td>3</td>
<td></td>
<td>67.62$^{**}$</td>
<td>0.15$^{**}$</td>
<td>0.82$^{**}$</td>
<td>66.03$^{**}$</td>
<td>1.90$^{**}$</td>
<td>11.42$^{**}$</td>
<td>0.49$^{ns}$</td>
</tr>
<tr>
<td>Error</td>
<td>28</td>
<td></td>
<td>28.26</td>
<td>0.22</td>
<td>0.92</td>
<td>31.07</td>
<td>2.03</td>
<td>3.82</td>
<td>0.53</td>
</tr>
<tr>
<td>Total</td>
<td>39</td>
<td></td>
<td>29.7</td>
<td>4.17</td>
<td>5.67</td>
<td>62.70</td>
<td>21.60</td>
<td>10.67</td>
<td>4.17</td>
</tr>
<tr>
<td>Means</td>
<td></td>
<td></td>
<td>3.44</td>
<td>0.30</td>
<td>0.62</td>
<td>3.61</td>
<td>0.92</td>
<td>1.26</td>
<td>0.47</td>
</tr>
<tr>
<td>dms (S)</td>
<td></td>
<td></td>
<td>6.49</td>
<td>0.57</td>
<td>1.17</td>
<td>6.80</td>
<td>1.74</td>
<td>2.38</td>
<td>0.89</td>
</tr>
<tr>
<td>dms (OM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
This behavior of oiticica seedlings irrigated with brackish water in substrate supplemented with composted bovine manure and castor bean and potassium differs from that presented by Diniz Neto et al. (2014) who found that all biometric growth and quality variables were significantly influenced by the interaction between sources of variation. In contrast, our results are in agreement with Cavalcante et al. (2016) who concluded that oiticica seedlings did not respond to the interactive effects of water-salinity × organic matter, but were rather influenced the independent effects of each source of variation.

Despite the additions of the organic matter to the substrate in ratios of 1:1, 2:1, and 3:1, no significant differences in plant height were observed among these groups of seedlings (Figure 1) exceeded 40.2, 37.6 and 31.2 %, respectively, growth of seedlings oiticica the substrate without organic compound (0OM:3S). These results highlight the importance of organic matter presence, and not of quantity, in the substrate for seedling development.

Figure 1. Oiticica seedlings heights in substrates with different proportions of organic matter and soil. Mean followed by the same lower-case letters in the same conditions of proportions of organic matter and soil in the substrate do not differ, statistically, from each other by the Tukey test (p <0.05). Vertical bars refer to standard error deviation from the mean (n = 5).

Source: Cavalcante, A. C. P. (2020).
Similar behavior was observed by Caldeira et al. (2008) who evaluated the growth of mastic-red (*Schinus terebinthifolius*) seedling substrates and found that a substrate with 50% organic matter and 50% subsoil promoted height growth relative to treatments with greater proportions of organic matter. Successive applications and large dosages of organic matter to soil or substrate require systematic monitoring of moisture, porosity, pH, nutrient availability, root growth impairment, and seedling development in general (Galbiatti et al., 2007).

The irrigation with brackish water reduced oiticica seedling stem diameter by 8.5% (Figure 2A). Similarly, Diniz Neto et al. (2014) found that increasing the salinity of irrigation water from 0.5 to 6.0 dS m\(^{-1}\) reduced oiticica seedling stem diameter. Consistent responses are reported in the literature for most plants irrigated with high salinity water (Dias et al., 2016; Sheldon et al., 2017).

Figure 2. Oiticica seedlings stem diameters (SD) irrigated with non-saline (0.5 dS m\(^{-1}\)) and brackish water (4.5 dS m\(^{-1}\)) (A) and in substrates with different proportions of organic matter and soil (B). Mean followed by the same lower-case letters in the same conditions of water salinity (A) and proportions of organic matter and soil in the substrate (B) do not differ, statistically, from each other by the Tukey test (p <0.05). Vertical bars refer to standard error deviation from the mean (n = 5).

The application of the organic matter stimulated stem diameter growth in oiticica seedlings (Figure 2B). Increasing the ratio of the organic matter in the substrate from 1:1 to 3:1 increased SD from 4.26 to 4.46 mm, representing a gain of 4.7%. Compared to the treatment with no organic matter, SD were 16.1, 18.8, and 21.5% greater in seedlings with substrates containing 1:1, 2:1, and 3:1, respectively, organic matter to mineral soil ratios.
Organic matter from composted castor bean and bovine manure was a source of nutrients (Table 1) that stimulated the growth in stem diameter of oiticica seedlings. Trazzi et al. (2013) suggested that organic inputs have attributes that contribute to the proliferation of beneficial microorganisms, which increase the availability of water and nutrients to plants, resulting in improved plant growth and development.

Maranho e Paiva (2012) investigated Itaúba-de-capoeira (*Physocalymma scaberrimum* Pohl) seedlings grown in substrate containing organic crop residues from açaizeiro (*Euterpe oleracea*), and Lustosa Filho et al. (2015) investigated substrate with carnauba bagasse (*Copernicia prunifera*) cattle manure organic matter on the growth of jatobá (*Hymenaea stigonocarpa*) seedlings. Both groups found that seedlings grown in substrates with greater proportions of organic matter had greater stem diameters.

Irrigation with brackish water reduced the number of leaves and leaf area of oiticica seedling, but organic matter promoted the growth of both leaves and leaf area (Figure 3). Seedlings irrigated with brackish water had 14.7 % fewer leaves (Figure 3A) and 19.2 % less leaf area (Figure 3B) than seedlings irrigated with non-saline water (0.5 vs. 4.5 dS m⁻¹).
Leaf reductions may provide evidence of morphological acclimation during the initial growth of oiticica seedlings to the saline environment. The reduced leaf area results in less absolute transpiration volume, thus reducing water loss and decelerating plant dehydration in response to low osmotic potential (Souza et al., 2015; Sheldon et al., 2017).

As with height and stem diameter, substrate organic matter content also exerted positive effects on the number of leaves and leaf area of the seedlings (Figure 3). The highest number of leaves was found in the treatment with proportions of organic matter:soil of 1OM:1S and 3OM:1S, followed by the proportion 2OM:1S. The plants grown in the 1OM:1S ratio had 29.2% more leaves than those without organic matter in their substrate (Figure 3C).
Similar trends were observed for leaf area (Figure 3D), in which seedlings grown in substrate composed of equal parts organic matter and soil had 30.3 % greater leaf area than those grown in substrate without organic matter. According to Almeida et al. (2012) and Silva et al. (2012), greater leaf number and leaf area results from organic matter improving the physical (i.e., structure and aggregation) and chemical (i.e., nutrient and water availability to plants) qualities of soil that attenuates the negative effects of salinity on seedling growth and development.

Oiticica seedling primary root length increased with organic matter in the substrate (Figure 4). Increasing the proportion of organic matter in the growth substrate from 0OM:1S to 1OM:1S and 2OM:1S increased root length from 21.3 to 22.2 (4.2 %) and 23.5 (10.3 %) cm, respectively. When organic matter constituted 75 % of the substrate (3OM:1S) root length was compromised, seedlings in this treatment had the shortest roots at 19.4 cm, that is, 8.9 % shorter than seedlings grown in substrate without organic matter.

Caldeira et al. (2008) observed a similar trend in aroeira-vermelha seedlings production (*Schinus terebinthifolius* Raddi), concluding that high doses of organic matter in the substrate exerted negative effects on root length and dry biomass of red-root roots. Evaluating different
proportions of biosolids in the substrate composition, Caldeira et al. (2012) concluded that a high proportion of organic input impairs the quality of timbó seedlings (*Ateleia glazioveana* Baill). Cavalcante et al. (2007) also observed that high proportions of organic matter increased saline soil level and hampered the growth and production of yellow passion fruit (*Passiflora edulis*), irrespective of the irrigation water salinity.

In seedlings irrigated with non-saline water, total dry mass accumulation did not differ with the proportion of organic matter (OM) in the substrate (1OM:1S, 2OM:1S, and 3OM:1S), but total dry mass was, respectively, 30.5, 34.7, and 10.5% greater than in the treatment without OM (0OM:1S) in the substrate (Figure 5).

![Figure 5](image-url)

**Figure 5.** Total dry mass of oiticica seedlings irrigated with non-saline (0.5 dS m\(^{-1}\)) and brackish water (4.5 dS m\(^{-1}\)) and in substrate with different proportions of organic matter and soil. Mean followed by the same lower-case letters in the same conditions of water salinity and capital letters in the same conditions of proportions of organic matter and soil in the substrate, do not differ, statistically, from each other by the Tukey test (p <0.05). Vertical bars refer to standard error deviation from the mean (n = 5).

Organic matter content in the substrate above the 2OM:1S proportion inhibited biomass production in oiticica seedlings obeying. Overall total dry mass of the treatments followed the sequence 0OM:1S < 1OM:1S < 2OM:1S > 3OM:1S. The decrease in total dry mass in the 2OM:1S and 3OM:1S treatments was because organic matter at high concentrations increased soil salinity and compromised the production of dry matter in seedlings as was found by Cavalcante et al. (2007) for yellow passion fruit (*Passiflora edulis*) in the field and by Silva et
al. (2008) for guava plants \((Psidium guajava)\) in a greenhouse that were irrigated with increasingly saline water.

Similar to seedlings irrigated with non-saline water \((0.5 \text{ dS m}^{-1})\), increasing substrate organic matter stimulated seedling dry mass production in seedlings irrigated with brackish water \((4.5 \text{ dS m}^{-1})\). Seedling total dry mass in the 1OM:1S, 2OM:1S, and 3OM:1S substrates was, respectively, 29.7, 28.4, and 63.5% greater than seedlings grown in a substrate free of organic matter (Figure 5). When considering the supremacy of the seedlings, of the respective treatments, in relation to the substrate without organic compound, the positive action of this input in the reduction of the harmful effects of water salinity on the formation of oiticica seedlings, as recorded per Cavalcante et al. (2016) and Cavalcante et al. (2020) in seedlings of the same species.

The low total dry mass of seedlings grown in substrate without organic matter may result from the osmotic potential reductions in the soil solution caused by high salt concentrations, especially of \(\text{NaCl}\), that promote toxicity and nutritional imbalances in plants generally (Parihar et al., 2015; Machado; Serralheiro, 2017), and in oiticica seedlings specifically (Diniz Neto et al., 2014).

Despite the absence of statistical differences in the total dry biomass of seedlings between non-saline and brackish water irrigated treatments (between the substrates 1OM:1S, 2OM:1S, and 3OM:1S and the organic matter free substrate) in the substrate of the plants irrigated with brackish water, probably contribute to the increase of humic substances, which improve water storage and availability and increases plant osmotic adjustment to salinity that improves membrane permeability, cellular enzymatic activity, and the availability of essential nutrients to plants under salt stress (Khaled; Fawy, 2011).

Irrigation with brackish water \((4.5 \text{ dS m}^{-1})\) impairs the quality of oiticica seedlings, with reductions of 14.44% compared to seedlings irrigated with non-saline water \((0.5 \text{ dS m}^{-1})\), as seen in Figure 6. Diniz Neto et al. (2014) observed similar results in a study that also investigated oiticica seedlings irrigated with 0.5 to 6.0 \text{ dS m}^{-1} \text{ irrigation water.}
Figure 6. Dickson quality index of oiticica seedlings irrigated with non-saline (0.5 dS m⁻¹) and brackish (4.5 dS m⁻¹) water. Mean followed by the same lower-case letters in the same conditions of water salinity do not differ statistically, from each other by the Tukey test (p <0.05). Vertical bars refer to standard error deviation from the mean (n = 5).

Mean followed by the same lower-case letters in the same conditions of water salinity do not differ statistically, from each other by the Tukey test (p <0.05). Vertical bars refer to standard error deviation from the mean (n = 5).

Elevated water salinity reduces seedling quality because of induced water deficits. Salinity also reduces the soil solution osmotic potential, promoting specific toxicity, especially with Na⁺ and Cl⁻, and nutritional imbalances that impair morphological (height, diameter, leaf area, and biomass growth) and physiological (decrease in outflow and carbon assimilation and photosynthetic electron transport) processes. Collectively, soil salinity results in biometric growth and dry matter accumulation inhibition, and overall seedling quality loss (Diniz et al., 2014; Parihar et al., 2015; Machado; Serralheiro, 2017).

4 CONCLUSIONS

Increasing irrigation water salinity from 0.5 to 4.5 dS m⁻¹ compromised biometric growth, biomass accumulation, and quality of oiticica seedlings.

The addition of organic matter to the soil substrate enhanced the growth of oiticica seedlings when organic matter was balanced with mineral soil content, thus the proportion of organic matter in the substrate should be 50 – 66 %.
Organic matter mitigated the detrimental effects of irrigation water salinity on oiticica seedlings, though did not eliminate them.

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REFERENCES


KHALED, H.; FAWY, H. A. **Effect of different levels of humic acids on the nutrient content, plant growth, and soil properties under conditions of salinity.** Soil and Water Research, v. 6, n° 1, p. 21 - 29, 2011.


