

## ORGANIC COMPOST AND SALINE WATER ON GROWTH AND CHLOROPHYLL INDEXES IN OITICICA SEEDLINGS

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**SUMMARY:** Oiticica is a native species of Brazilian semi-arid areas with a great potential for oil extraction. Thus, we aimed at evaluating both growth and chlorophyll indexes of oiticica seedlings in substrate, with different proportions of organic compost under saline water irrigation. Treatments were arranged in factorial 4 x 2, referred to four volumetric proportions of organic compost and soil (0:1; 1:1; 2:1 and 3:1 v/v) irrigated with non-saline and saline water (0.5 and 4.0 dS m<sup>-1</sup>) with five replicates. We evaluated the plant height, stem diameter, leaf area and leaf indexes of *a*, *b*, and *total* chlorophyll. The greatest growth values of 37.2 cm and 4.58 mm concerning height and seedlings stem diameter, respectively, were registered in plants irrigated with non-saline water. Leaf area enlarged by 25% on the substrate with the 1:1 proportion of the organic input on seedlings with 0.5 dS m<sup>-1</sup> water. Increased salinity inhibited the chlorophyll indexes *a*, *b* and *total*, evidenced by the low values on seedlings irrigated with saline water on proportions of 1:1 and 2:1. The addition of organic compost stimulates the growth of oiticica seedlings irrigated with saline and non-saline water, with a greater significance in proportions of 1:1 and 2:1 v/v.

**KEY WORDS:** Organic input, *Licania rigida*, salinity.

## COMPOSTO ORGÂNICO E ÁGUA SALINA NO CRESCIMENTO E ÍNDICES CLOROFILÁTICOS EM MUDAS DE OITICICA

**RESUMO:** A oiticica é uma espécie nativa de áreas semiáridas brasileiras com grande potencial para extração de óleo. Objetivou-se, avaliar o crescimento e índices clorofiláticos de mudas de oiticica em substrato com proporções de composto orgânico sob irrigação com

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águas salinas. Os tratamentos foram arrançados em fatorial  $4 \times 2$ , referente a quatro proporções volumétricas de composto orgânico e solo (0:1; 1:1; 2:1 e 3:1 v/v) irrigadas com água não salina e salina (0,5 e 4,0 dS m<sup>-1</sup>) em cinco repetições. Avaliou-se o crescimento em altura, diâmetro caulinar, área foliar e os índices foliares de clorofila *a*, *b* e *total*. Os maiores valores do crescimento de 37,2 cm e 4,58 mm, respectivamente para a altura e diâmetro caulinar das mudas, foram registrados nas plantas irrigadas com água não salina. A área foliar foi incrementada em 25% no substrato com proporção de 1:1 v/v do insumo orgânico nas mudas sob irrigação com água de 0,5 dS m<sup>-1</sup>. O aumento da salinidade da água de irrigação inibiu os índices de clorofila *a*, *b* e *total* evidenciados pelos mais baixos valores nas mudas irrigadas com água salina nos substratos de 1:1 e 2:1 v/v. A adição de composto orgânico estimula o crescimento de mudas de oiticica irrigadas com água salina e não salina com maior significância nas proporções do composto orgânico substratos 1:1 e 2:1 v/v.

**PALAVRAS-CHAVE:** Insumo orgânico, *Licania rígida*, salinidade.

## INTRODUCTION

The oiticica (*Licania rigida* Benth) is a forest species, which belongs to the Chrysobalanaceae family, being found in watercourses of Brazilian semi-arid regions. This species' greatest importance relates to environmental aspects and to the industrial productions of oil, biodiesel and derivatives (Macedo et al., 2011). Regarding the preservation of forest species, an adequate development of plants is the first step to guarantee a profitable production, which may be achieved through seedlings production with high-quality standards, being mostly related to physical and chemical characteristics of the substrate, allowing an adequate development of roots and nutrients supply (Santos et al., 2014).

Despite being an endemic species in semi-arid regions, the effects of salinization, whether in plants for food or non-food purposes, may inhibit its adequate growth, mainly by reducing water and nutrients absorption rates, thus resulting in a nutritional imbalance, toxicity, physiological and metabolic disturbances, by the excess of salts in the root development zone and foliar tissues (Aydin et al., 2012; Jibrán et al., 2013). These stresses are negatively reflected on plants growth and development, impairing growth, foliar expansion, photosynthetic rate and in the productive capacity of crops (Aydin et al., 2012; Diniz Neto et al., 2014).

The use of organic conditioners (e.g. bovine biofertilizer, bovine manure, stillage and composts containing humic substances) may minimize the effects of salts to plants, possibly by the liberation of carbon dioxide and organic acids during the organic matter decomposition, besides attenuating the sodium effects through calcium and magnesium liberation in the soil's exchange complex (Miranda et al., 2011; Calvo et al., 2014; Jardin, 2015). Promising results have been demonstrated in several plant species irrigated with saline water, as reported by Diniz et al. (2014), studying oiticica seedlings, Souto et al. (2013) with noni plants and Souza et al. (2012) when evaluating corn growth with the application of bovine biofertilizer.

Due to the scarcity of information concerning oiticica seedlings behavior in salinity conditions and the effects of the application of organic composts in the substrate produced by means of organic composting processes with castor bean and bovine manure, this study aimed at evaluating growth and chlorophyll indexes of oiticica seedlings in salinity conditions in substrate, with different proportions of an organic compost.

## **MATERIAL AND METHODS**

The experiment was conducted from February to May 2014, inside a greenhouse at the Center of Human, Social and Agrarian Sciences of the Federal University of Paraíba, Bananeiras-PB, Brazil.

Initially, a composting windrow was prepared with the vegetative parts of castor bean plants (stem, branches and leaves), which were milled and disposed in a height of 20 cm, interspersed with bovine manure in 5 cm layers. Windrows were made in the dimensions: 1 m wide, 1.5 m high and 5 m long. The materials were stirred every fifteen days and 80 days after the beginning of the composting process, it was observed that windrows were uniform in coloration and particles dimension, considered as adequate for the substrate preparation.

The experimental design was a randomized complete block design, with five replicates and two plants per plot, using the factorial scheme 4 x 4, referring to four volumetric proportions of organic compost + soil (0:1; 1:1; 2:1 and 3:1), irrigate with non-saline and saline (0.5 and 4.5 dS m<sup>-1</sup>) water. The soil used in the substrate was withdrawn from the layer 20-40 cm, with a lowest organic matter content, classified as the criteria defined by the Brazilian System of Soil Classification (EMBRAPA, 2013), as Yellow Dystrophic Latosol. Both the soil and the organic compost were chemically characterized, as the methodologies

suggested by the Brazilian Corporation of Agricultural Research - EMBRAPA (Donagema et al., 2011) and the results are presented in Table 1.

The experimental units were represented by black polyethylene bags (20 x 30 cm), with a capacity of 3 dm<sup>3</sup> of substrate, containing two seeds per treatment and the emergence occurred between 20 and 30 days of sowing. Ten days after emergence, thinning was performed, keeping the most vigorous plant by unit. Saline water preparation (4.5 dS m<sup>-1</sup>) was made by means of the addition of non-iodized sodium chloride with 92% purity, until the desired conductivity value, measured in a CD-860 portable digital conductivimeter.

Sixty days after seedlings emergence, we measured height growth (distance between plant's lap and the extremity of the main stem), stem diameter (measured at the lap's height with a pachymeter, 2 cm from soil), number of leaves, leaf area and the chlorophyll *a*, *b* and *total* indexes.

Data were submitted to a variance analysis by the F test and means related to soil with and without the organic compost were compared by the F test, which is conclusive for values between two factors, while the mean values of electrical conductivity of the irrigation water was analyzed by regression by the t-test, with the aid of the ASSISTAT software, version 7.7 beta (Silva & Azevedo, 2002).

## RESULTS AND DISCUSSION

The interaction between water salinity and organic compost proportions significantly interfered in growth and chlorophyll indexes, as showed in Table 2. A similar behavior was verified by Diniz Neto et al. (2014) by reporting that the application of bovine biofertilizer in oiticica seedlings irrigated with saline water exerted a significant influence on plant's growth and photosynthetic pigments.

The proportions of organic composts added to the substrate provided a better development of plants, considering its height, when comparing to plants exposed to the substrate containing only soil, and no difference was verified concerning irrigation water (Figure 1A). By relating the substrate results in the different proportions with the witness, it is verified that the organic input enabled increments of 50.0, 37.6 and 16.0% in non-saline water and 28.3, 36.5 and 47.9% in saline water, highlighting that in treatments with irrigation water with growth restrictions, increasing the proportion from 1:1 to 3:1 (organic compost: soil) has mitigated with greatest expressiveness the deleterious effects of salts to plants.

In high-salinity conditions, the application of organic inputs is important in mitigating salts for seedlings. Considering that the highest proportion (3:1) promotes greatest organic matter contents and, consequently, humic substances in the chemical composition of the substrate, it induces to a greater osmotic adjustment of plants in relation to the soil solution, facilitating water and nutrients absorption, thus stimulating seedlings growth in a saline environment (Aydin et al., 2012). A similar behavior was verified in oiticica seedlings by Diniz et al. (2014), observing that by using an organic compost (fermented bovine manure), the negative effects of salts were reduced when plants were irrigated with a saline water of  $6.0 \text{ dS m}^{-1}$  of electrical conductivity.

The oiticica seedlings stem diameter was always superior in the treatments of substrate with the addition of organic compost, in comparison to the witness, regardless of the water electrical conductivity (Figure 1B). Despite of the superiority of the substrate with the organic input, no significant difference was observed regarding the different tested proportions. By relating the values of stem diameter of plants irrigated with non-saline and saline water in the different substrates, it was observed that high salt contents in irrigation water promoted losses of 12.75, 11.50, 4.70 and 4.80%, respectively, in the proportions 0:1; 1:1; 2:1 and 3:1. The results demonstrate that the organic input increase on the substrate has a greater capacity of attenuating the deleterious effects of salts in oiticica seedlings.

This higher attenuation of salts promoted by the treatment with a greater quantity of organic compost (3:1) occurred to the improvement of physical characteristics, seen that adding organic matter increases particle aggregation, hydraulic conductivity and water infiltration, besides improving soil's structure for roots development (Miranda et al., 2011). In addition, it also enhances its chemical properties, by containing organic solutes and essential nutrients, which acts in the improvement of plants nutrition, by the capitation mechanisms of macro and micronutrients, as well as the osmotic regulation between plant and salinized soil solution (Jardin, 2015).

The highest values of leaf area were observed in plants cultivated in the substrate with the organic input (1:1), regardless of the water electrical conductivity (Figure 1C). When comparing the substrate only with soil and the proportion 1:1, the plants' leaf area increased from  $59.96$  to  $79.67 \text{ cm}^2$  in non-saline water and from  $47.38$  to  $60.20 \text{ cm}^2$  in plants irrigate with saline water, presenting respectively, an increment of 32.9 and 27.1% of this variable.

Increases in salt contents present in the soil solution causes specific ion toxicity in plants, due to the high concentration in leaf tissues, considering that one of the responses of plants to saline stress is foliar senescence controlled by specific genes, resulting in smaller

leaf area (Jibrán et al., 2013). A similar behavior was observed by Sousa et al. (2012) in corn plants (*Zea mays* L.) and Souto et al. (2013) in noni plants (*Morinda citrifolia* L.), irrigated with increasing salinity water. In order to minimize these effects, the application of an organic compost to the substrate acts by increasing osmoregulatory solutes, such as proteins, carbohydrates, lipids and humic substances, providing adequate conditions for the plant to absorb water and nutrients, even in conditions of high saline content (Calvo et al., 2014).

Although the salts content affected chlorophyll production in oiticica seedlings, the addition of an organic input minimized the deleterious effects of salinity (Figure 2). It was verified that the highest chlorophyll *a* indexes, regardless of water electrical conductivity, occurred in the substrate with organic input and soil in 1:1 and 2:1, presenting values of 32.16 and 30.68 in non-saline water, as well as 25.90 and 23.70 in saline water, respectively (Figure 2A). Although not statistically differing from the 2:1 ratio, the greatest chlorophyll *b* indexes were obtained in plants cultivated in 1:1 (Figure 2B), which overcame in 19.26 and 28.32% the substrate with only soil, when irrigated with water of 0.5 and 6.0 dS m<sup>-1</sup>, respectively.

Similar to chlorophyll *a*, the highest leaf indexes of *total* chlorophyll were verified in seedlings cultivated in substrate containing the organic input and soil at the proportions 1:1 and 2:1 (Figure 2C), where the application of the input promoted chlorophyll increases of 57 and 50.0% in plants irrigated with non-saline water and 57.2 and 43.0% with saline water. The reduction of leaf chlorophyll can be attributed to an enzyme's increasing activity that degrade chlorophyll pigments (chlorophyllase), as the toxic ions in high concentrations on leaf tissues, affecting the chlorophyll concentration (Aydın et al., 2012). However, by adding organic matter as the compost in substrate, humic substances increase was favored, which acts by minimizing physiological damage in plant species in saline environments (Calvo et al., 2014), as verified by Diniz Neto et al. (2014) in oiticica seedlings fertilized with bovine biofertilizer in the substrate and by Aydın et al. (2012) in beans (*Phaseolus vulgaris* L.) on the use of humic substances in soil.

## CONCLUSION

Using organic composts in the substrate attenuates the effects of salts to oiticica seedlings, allowing a greater development and chlorophyll indexes of plants.

For the production of oiticica seedlings irrigated with high salinity water, the use of substrate with an organic input in the proportion of 1:1 is indicated.

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**Table 1.** Chemical characterization of the soil at the layer 20-40 cm and of the castor bean compost used to prepare the substrate for oiticica seedlings.

Sources	Chemical attributes											
	*pH	P	K <sup>+</sup>	Na <sup>+</sup>	H <sup>+</sup> Al <sup>3+</sup>	Al <sup>3+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>	SB	CTC	V	OM
	mg dm <sup>-1</sup>				cmolc dm <sup>-3</sup>						%	g kg <sup>-1</sup>
Soil	5,7	19,1	0,23	0,1	0,2	0,0	4,4	0,4	5,1	5,3	96,9	10,4
COC	8,2	921,0	12,3	1,5	0,8	0,0	14,1	4,2	-	-	-	259

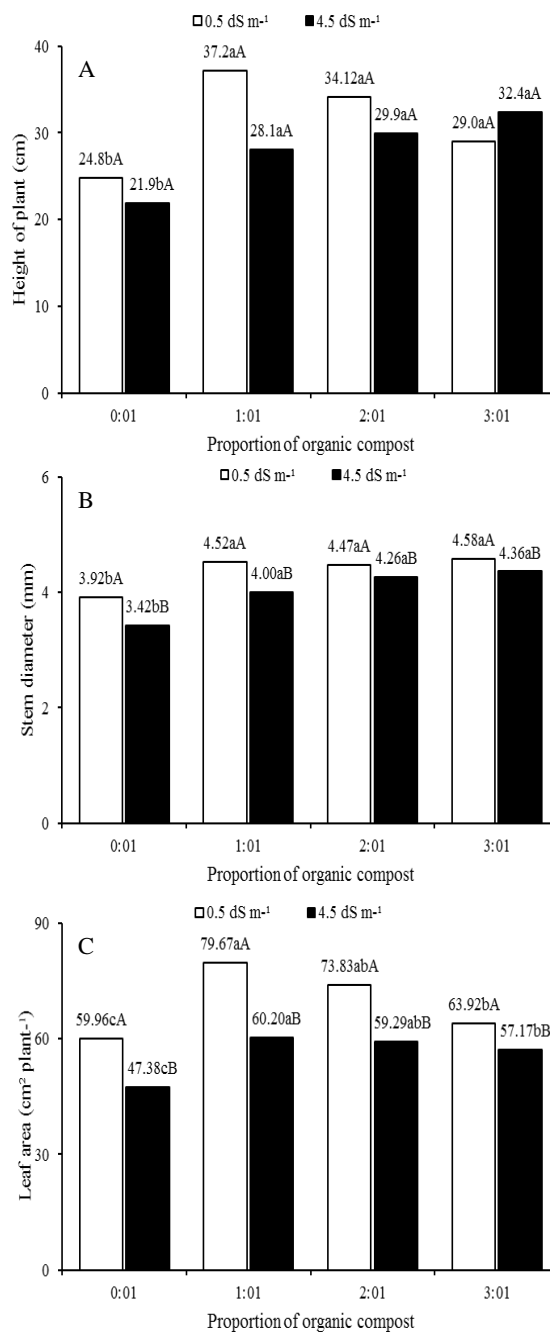
\*= pH in water; COC = castor bean organic compost; BS = base sum (Ca<sup>2+</sup> + Mg<sup>2+</sup> + K<sup>+</sup> + Na<sup>+</sup>); CTC = cation exchange capacity [BS + (H<sup>+</sup> + Al<sup>3+</sup>)]; V = saturation by exchangeable bases (BS/CTC)100; OM = Organic matter.

**Table 2.** Summary of the analysis of variance for plant growth in height (PHe), stem diameter (SD), leaf area (LA) chlorophyll *a* (Cla), chlorophyll *b* (Clb), total chlorophyll index (Clt) the effect of proportion of organic compost (P) on the substrate and the salinity of irrigation water under the initial development and chlorophyll of oiticica seedlings (*L. rigida*).

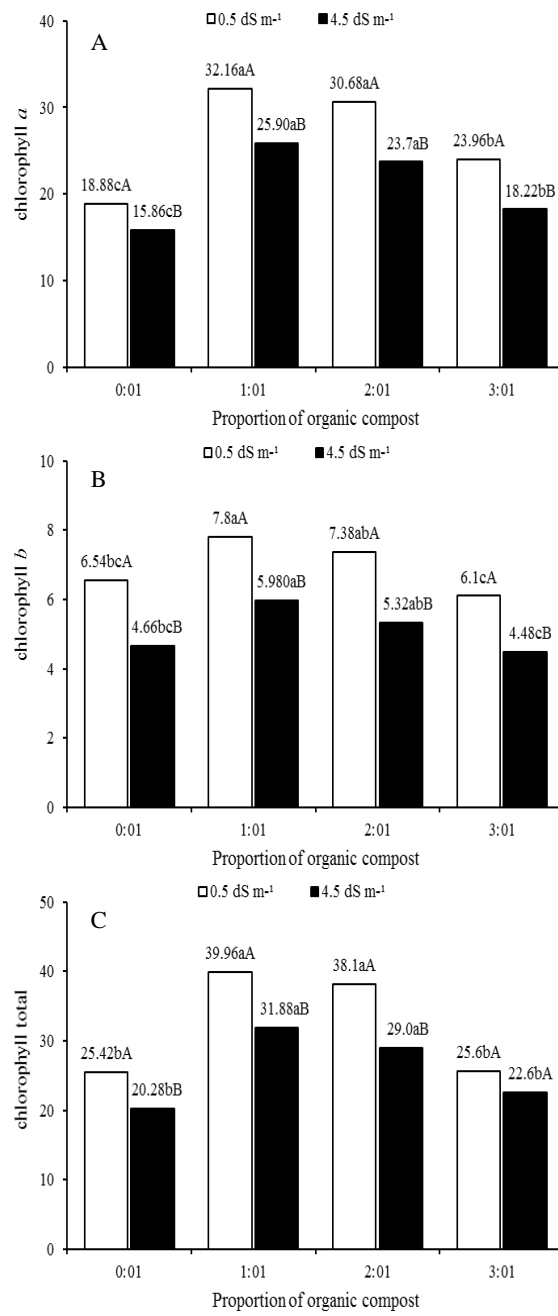
SOV	df	Mean square					
		pHe	SD	LA	Cla	Clb	Clt
Blocks	4	1.44*	0.11 <sup>ns</sup>	38.57 <sup>ns</sup>	1.31 <sup>ns</sup>	0.09 <sup>ns</sup>	1.49 <sup>ns</sup>
Salinity (S)	1	53.22*	0.48*	476.12**	302.50**	34.04**	398.16**
COC proportions (P)	4	435.13**	5.41**	2596.75**	291.55**	5.25**	433.29**
S × P	4	58.96 <sup>ns</sup>	0.21 <sup>ns</sup>	42.43 <sup>ns</sup>	7.48 <sup>ns</sup>	0.082 <sup>ns</sup>	19.20*
Error	36	23.95	0.22	45.21	5.30	0.39	47.72
Total	49	-	-	-	-	-	-
CV (%)	-	17.60	11.94	11.09	9.73	10.33	7.46

COC = castor bean organic compost; CV = Coefficient of variation; <sup>ns</sup> = not significant by Tukey test; \* and \*\* = significant at 5 and 1% probability, respectively.





**Figure 1.** Plants height (A), stem diameter (B) and leaf area (C) of oiticica seedlings in substrate with different proportions of organic input, irrigated with saline and non-saline water.



**Figure 2.** Chlorophyll *a* index (A), chlorophyll *b* index (B), total chlorophyll index (C), of oiticica seedlings in substrate with different proportions of organic input, irrigated with saline and non-saline water.