

Biometric variables and photosynthetic pigments in tamarind seedlings irrigated with saline water and biofertilizers

Variáveis biométricas e pigmentos fotossintéticos em mudas de tamarindeiro irrigadas com água salina e biofertilizantes

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Abstract

Saline level of water or soil beyond the limit tolerated by crops may impair morphological, physiological, and biochemical processes of plants in general, including tamarind. This problem requires the adoption of management and input techniques to reduce the degenerative effects of salts on plant species. In this sense, the aim of this study was to assess the effect of bovine biofertilizers on biometric variables and chlorophyll contents in tamarind seedlings irrigated with saline water. The experiment was conducted from October 2012 to January 2013, in Areia, PB, Brazil, in a randomized block design with four replications and five plants per plot in a 5×3 factorial scheme, consisting of electrical conductivity of water of 0.5, 1.5, 3.0, 4.5, and 6.0 dS m^{-1} and soil without and with common and chemically enriched biofertilizers. Leaf area, shoot dry matter, and contents of chlorophyll *a*, *b*, total, and carotenoids were assessed at 100 days after sowing. The increased water salinity reduced leaf area and seedling biomass formation, with a higher intensity in the soil without biofertilizer. The addition of biofertilizers allows the formation of tamarind seedlings irrigated with water of a salinity not tolerated by them when cultivated in the soil without the tested inputs.

Key words: Organic inputs. Water salinity. *Tamarindus indica*.

Resumo

O nível salino da água ou do solo além do limite tolerado pelas culturas, pode prejudicar os processos morfológicos, fisiológicos e bioquímicos das plantas em geral, inclusive do tamarindeiro. Esse problema exige a adoção de técnicas de manejo e de insumos com a finalidade de reduzir os efeitos degenerativos dos sais às espécies vegetais. Nessa direção, o trabalho teve como objetivo avaliar o efeito de biofertilizantes bovinos sobre variáveis biométricas e teores de clorofila em mudas de tamarindeiro irrigadas com água salina. O experimento foi conduzido no período de outubro de 2012 a janeiro de

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2013, Areia, PB, Brasil, em blocos casualizados com quatro repetições e cinco plantas por parcela, usando o esquema fatorial 5×3 , referente à condutividade elétrica das águas de 0,5; 1,5; 3,0; 4,5 e 6,0 dS m^{-1} , em solo sem e com biofertilizante comum e enriquecido quimicamente. Aos 100 dias após a semeadura, foram avaliados a área foliar, massa de matéria seca da parte aérea e os teores de clorofila *a*, *b*, total e carotenoides. O aumento da salinidade das águas reduziu a área foliar e a formação de biomassa pelas mudas, com maior intensidade no solo sem biofertilizante. A adição dos biofertilizantes permite a formação de mudas de tamarindeiro irrigadas com águas de salinidade não tolerada por estas plantas quando cultivadas no solo sem os insumos testados.

Palavras-chave: Insumos orgânicos. Salinidade da água. *Tamarindus indica*.

Introduction

Tamarind (*Tamarindus indica* L.) is a perennial fruit tree of slow growth and natural occurrence more frequent in semiarid regions of Africa and Asia, but also it is disseminated in several regions of Brazil (GÓES et al., 2016). In these regions, this species may grow in physically and chemically degraded areas, including salt-affected soils (HARDIKAR; PANDEY, 2011; HUNSCHE et al., 2010).

Tamarind is considered a moderately salinity-tolerant plant at the initial stage of growth, according to results obtained in the assessments of growth and physiological and nutritional responses (GEBAUER et al., 2004; HARDIKAR; PANDEY, 2011). This indicates that this crop can be used in studies to assess the influence of management techniques aiming at reducing the negative effects of salinity during the initial growth of plants grown in semiarid regions.

Salinity promotes changes in different morphological, physiological, and biochemical processes of plants, such as seed germination, growth, chlorophyll production, stomatal conductance, and the net photosynthesis rate, in addition to affecting root growth and water and nutrient uptake by plant species (BARBOSA et al., 2017; FERNÁNDEZ-GARCÍA et al., 2014; HUNSCHE et al., 2010; OLIVA et al., 2008).

Irrigation water quality for seedling production is closely related to a satisfactory plant growth. In semiarid regions, in addition to water scarcity, salt concentrations often higher than the tolerable by crops compromise the initial growth of species,

requiring the use of management practices that alleviate their deleterious effects on plants. In this sense, the application of organic inputs, such as manure and bovine biofertilizer, has been used as a mitigator or attenuator of saline stress to plants (GOMES et al., 2015; YARAMI; SEPASKHAH, 2015).

The benefits of applying organic inputs as saline stress attenuators can be attributed to humic substances such as humins, fulvic acids, and humic acids, which provide a higher osmotic regulation between root and soil solution (ASIK et al., 2009; CANELLAS et al., 2015). Under these conditions, humic substances stimulate root growth and nutrient uptake even in environments under saline stress, as observed by Silva et al. (2008) and Sönmez and Gülser (2016) when assessing the action of organic matter and humic substances on the formation of guava (*Psidium guajava*) and bell pepper (*Capsicum annuum*) seedlings under salinity conditions.

Considering the evidence of the attenuating effect of organic inputs on plants under saline stress, this study aimed to assess the application of bovine biofertilizers on the initial growth and photosynthetic pigment content in tamarind seedlings irrigated with saline water.

Material and Methods

The experiment was carried out in a screened environment of the Center of Agricultural Sciences of the Federal University of Paraíba, Areia city, Paraíba State, Brazil, from October 2012 to January 2013. The substrate was collected in the soil layer

of 0–20 cm depth and was classified as an Ultisol (Argissolo Vermelho-Amarelo, Brazilian System of Soil Classification, SiBCS) (EMBRAPA, 2013). Soil physical and chemical characterization was performed according to Donagema et al. (2011)

and soil and water salinity according to Richards (1954), as shown in Table 1. The experimental units were composed of plastic containers with a capacity of 7 L filled with 5 L of soil (Table 1).

Table 1. Chemical and physical characterization of soil fertility and salinity before substrate preparation.

Fertility		Salinity		Physical attributes	
pH in water (1:2.5)	6.4	pH	6.6	Soil bulk density (g cm ⁻³)	1.14
P (mg dm ⁻³)	5.41	Ca ²⁺ (mmol _c L ⁻¹)	0.81	Soil particle density (g cm ⁻³)	2.71
K ⁺ (cmol _c dm ⁻³)	0.51	Mg ²⁺ (mmol _c L ⁻¹)	0.34	Total porosity (m ³ m ⁻³)	0.58
Ca ²⁺ (cmol _c dm ⁻³)	1.71	K ⁺ (mmol _c L ⁻¹)	0.16	Sand (g kg ⁻¹)	557
Mg ²⁺ (cmol _c dm ⁻³)	0.58	Na ⁺ (mmol _c L ⁻¹)	1.16	Silt (g kg ⁻¹)	63
Na ⁺ (cmol _c dm ⁻³)	0.11	Cl ⁻ (mmol _c L ⁻¹)	1.57	Clay (g kg ⁻¹)	380
SB (cmol _c dm ⁻³)	2.92	CO ₃ ²⁻ (mmol _c L ⁻¹)		Clay dispersed in water (g kg ⁻¹)	26
Al ³⁺ (cmol _c dm ⁻³)	0.12	HCO ₃ ⁻ (mmol _c L ⁻¹)	0.22	Degree of flocculation (%)	93.2
H ⁺ + Al ³⁺ (cmol _c dm ⁻³)	1.08	SO ₄ ²⁻ (mmol _c L ⁻¹)	0.74	Dispersion index (%)	7.8
CEC (cmol _c dm ⁻³)	3.40	ECse (dS m ⁻¹)	0.25	Mfc (g kg ⁻¹)	103.4
V (%)	85.8	SAR (mmol L ⁻¹) ^{0.5}	1.53	Mpwp (g kg ⁻¹)	48.2
SOM (g dm ⁻³)	1.12	ESP (%)	2.68	Water available (g kg ⁻¹)	55.2
Classification	Eut.	Classification	NSS	Textural classification	SL

P, K⁺, and Na⁺ = Melihch-1 extractor; Al³⁺, Ca²⁺, and Mg²⁺ = 1 M KCl extractor; SB = Sum of exchangeable bases (Ca²⁺ + Mg²⁺ + K⁺ + Na⁺); CEC = Cation exchange capacity (SB + H⁺ + Al³⁺); V = Base saturation percentage ([SB/CEC] × 100); SOM = Soil organic matter by oxidation with potassium permanganate; Eut = Eutrophic; ECse = Electrical conductivity of soil saturation extract; SAR = Sodium adsorption ratio = Na⁺ [(Ca²⁺ + Mg²⁺)/2]^{1/2}; ESP = Exchangeable sodium percentage = 100 × (Na⁺/CEC); NSS = Non-saline soil; DF = Degree of flocculation = [(total clay – clay dispersed in water)/total clay] × 100; DI = dispersion index = 100 – DF; Wa = Water available = Mfc – Mpwp; Mfc = Soil moisture at the field capacity (–0.033 MPa); Mpwp = Soil moisture at the permanent wilting point (–1.5 MPa); SL = sandy loam.

The experimental design was a randomized block design in a 5 × 3 factorial design, with treatments consisting of five salinity levels of irrigation water (0.5, 1.5, 3.0, 4.5, and 6.0 dS m⁻¹) without biofertilizer and with common and chemically enriched biofertilizers. Each treatment consisted of four replications with five plants per replication, totaling 60 experimental units and 300 plants. At 40 days after sowing (DAS), thinning was conducted and only the most vigorous plant was left per experimental unit.

Both biofertilizers were produced via anaerobic fermentation. The common biofertilizer (CB) was obtained from a mixture of equal parts of fresh bovine manure and non-saline and non-chlorinated water (SILVA et al., 2007). The chemically enriched

biofertilizer (EB) was prepared with the same proportions of fresh manure and water from the common biofertilizer, adding 2 kg agricultural gypsum (28% CaO and 17% S), 2 kg MB-4 rock powder (5.9% CaO, 17.8% MgO, 1.4% Na₂O, and 0.84% K₂O), 4 L cow milk, and 4 L sugarcane molasses (MEDEIROS et al., 2011).

For releasing the methane gas produced during the methanogenic fermentation, a thin hose was connected to the top of the biodigester and the other end of the hose was submerged in a vessel with water to prevent the entry of other gases into the system. Biofertilizers were applied to the soil in the liquid form, being chemically analyzed (RICHARDS, 1954) as water for irrigation (Table 2).

Biofertilizers were applied once after dilution in non-saline and non-chlorinated water at a proportion of 1:1 24 h before sowing. Due to the different values of electrical conductivity (Table 2), the application of both biofertilizers was carried out in order to provide different input volumes, but with the same electrical conductivity value. In this sense, the common biofertilizer applied in a volume

corresponding to 10% of the substrate volume was used as a reference, as in Cavalcante et al. (2011). Thus, 500 mL common biofertilizer and 300 mL enriched biofertilizer was supplied. This volume of 300 mL was calculated by multiplying the 500 mL of common biofertilizer by the value of a coefficient obtained between the electrical conductivity values of the common and enriched biofertilizers.

Table 2. Chemical characterization of irrigation water and biofertilizers applied to soil in a liquid form.

Variables	Water	Biofertilizer	
		Common	Enriched
pH	6.64	6.82	6.44
EC at 25°C (dS m ⁻¹)	0.45	3.48	5.81
Ca ²⁺ (mmol _c L ⁻¹)	1.21	6.64	18.24
Mg ²⁺ (mmol _c L ⁻¹)	0.78	8.35	14.51
Na ⁺ (mmol _c L ⁻¹)	2.38	10.05	12.36
K ⁺ (mmol _c L ⁻¹)	0.12	9.53	13.21
SAR (mmol L ⁻¹) ^{1/2}	2.39	3.67	3.05
Classification	C ₁ S ₁	C ₄ S ₁	C ₄ S ₁

EC = Electrical conductivity; SAR = Sodium adsorption ratio = $\text{Na}^+ [(\text{Ca}^{2+} + \text{Mg}^{2+})/2]^{1/2}$.

Sowing was carried out with five tamarind seeds at a depth of 1 cm in each experimental unit. Irrigation with each type of water was performed from sowing until the end of the experiment by the weighing method, providing a volume of water equivalent to the evapotranspiration every 24 h for the maintenance of substrate with a moisture corresponding to 90% of the field capacity. For preparing the water with different electrical conductivity, a strongly saline water (EC_w = 7.36 dS m⁻¹) collected in the Jacaré reservoir, municipality of Remígio, Paraíba State, Brazil, was diluted in a non-saline water (0.5 dS m⁻¹).

At 100 DAS, leaf area values were obtained and the chloroplastidic pigment contents (chlorophyll *a*, *b*, total, and carotenoids) were determined. Subsequently, the shoot of plants was collected and taken to an air circulation oven at 65 °C for 72 h until constant weight in order to determine shoot dry matter.

Plant leaves were detached and scanned for leaf area determination using the software Determiner Digital of Area (DDA) (FERREIRA et al., 2008). The determination of contents of chlorophyll *a*, *b*, total, and carotenoids was performed in the third pair of leaves from the plant apex (GEBAUER et al., 2004). After collected, the leaves were immediately conditioned in aluminum foil envelopes, placed in thermal containers with ice, and taken to the laboratory.

In the laboratory, samples of vegetal tissue were taken from the middle third of each leaf by using a hollow punch and the mass was measured on a precision scale. Subsequently, the material was macerated and placed in aluminum-lined containers with 25 mL 80% acetone. These containers were refrigerated at 8 °C for 24 h and the extracts (acetone + foliar tissue) were filtered on filter paper for 5 min (ARNON, 1949).

The absorbances of extracts were read in a spectrophotometer at wavelengths of 470 (A₄₇₀), 647

(A_{647}), and 663 nm (A_{663}) by using 80% acetone as white. Chlorophyll *a*, *b*, total, and carotenoids were calculated by equations described by Lichtenthaler (1987):

$$\text{Chlorophyll } a \text{ (Cl } a) = 12.25 A_{663} - 2.79 A_{647}$$

$$\text{Chlorophyll } b \text{ (Cl } b) = 21.50 A_{647} - 5.10 A_{663}$$

$$\text{Total chlorophyll (Cl } t) = 7.15 A_{663} + 18.71 A_{647}$$

$$\text{Total carotenoids (Cr } t) = (1,000 \times A_{470} - 1.82 \text{ Cl } a - 85.02 \text{ Cl } b) / 198$$

The contents of chlorophyll *a*, *b*, and total in leaves were expressed in milligrams per gram of fresh matter (mg g^{-1} FM).

The data were submitted to analysis of variance by the F-test at 5% probability. The mean values of biofertilizers were compared by the Tukey's test ($p < 0.05$) and irrigation water salinity by regression by using the statistical program Sisvar (FERREIRA, 2014).

Results and Discussion

Tamarind seedling growth was linearly reduced as irrigation water salinity increased, regardless of the application or not of biofertilizers. However, a reduction was observed in the shoot dry matter of the substrate without biofertilizer, but the data did not fit any mathematical model. Although the biofertilizers did not differ from each other, there was a superiority of them in relation to the plots without biofertilizer, especially in the low and moderate salinity levels (Figure 1). The increased salt concentration of water from 0.5 to 6.0 dS m^{-1} led to a reduction in leaf area from 330.39 to 79.53 cm^2 in plants without biofertilizer, 913.92 to 213.95 cm^2 in plants with common biofertilizer, and 853.93 to 135.81 cm^2 in plants with chemically enriched biofertilizer, with losses of 75.9, 76.6, and 84.1%, respectively (Figure 1A).

Even considering the highest percentage losses attributed to biofertilizers, the absolute values exceed those without biofertilizer, following the order common biofertilizer > enriched biofertilizer > without biofertilizer. Gomes et al. (2015) observed the same behavior, in which biofertilizer reduced the deleterious effects of salts in sunflower plants. Saline stress impairs plant growth due to a reduction of the net photosynthesis rate and stomatal conductance, leading to a lower CO_2 assimilation by plants (BARBOSA et al., 2017; FERNÁNDEZ-GARCÍA et al., 2014; YARAMI; SEPASKHAH, 2015).

Plants grown on substrate without biofertilizer and irrigated with water of 3.0 dS m^{-1} presented a leaf area of 216.4 cm^2 , which is the same value of those treated with common and enriched biofertilizer and irrigated with higher salinity waters (5.98 and 5.38 dS m^{-1} , respectively). These results indicate that under biofertilizer application, seedlings tolerated water with a higher saline level. Gomes et al. (2015) observed similar behavior when assessing the initial growth of sunflower irrigated with water from 0.8 to 6.0 dS m^{-1} .

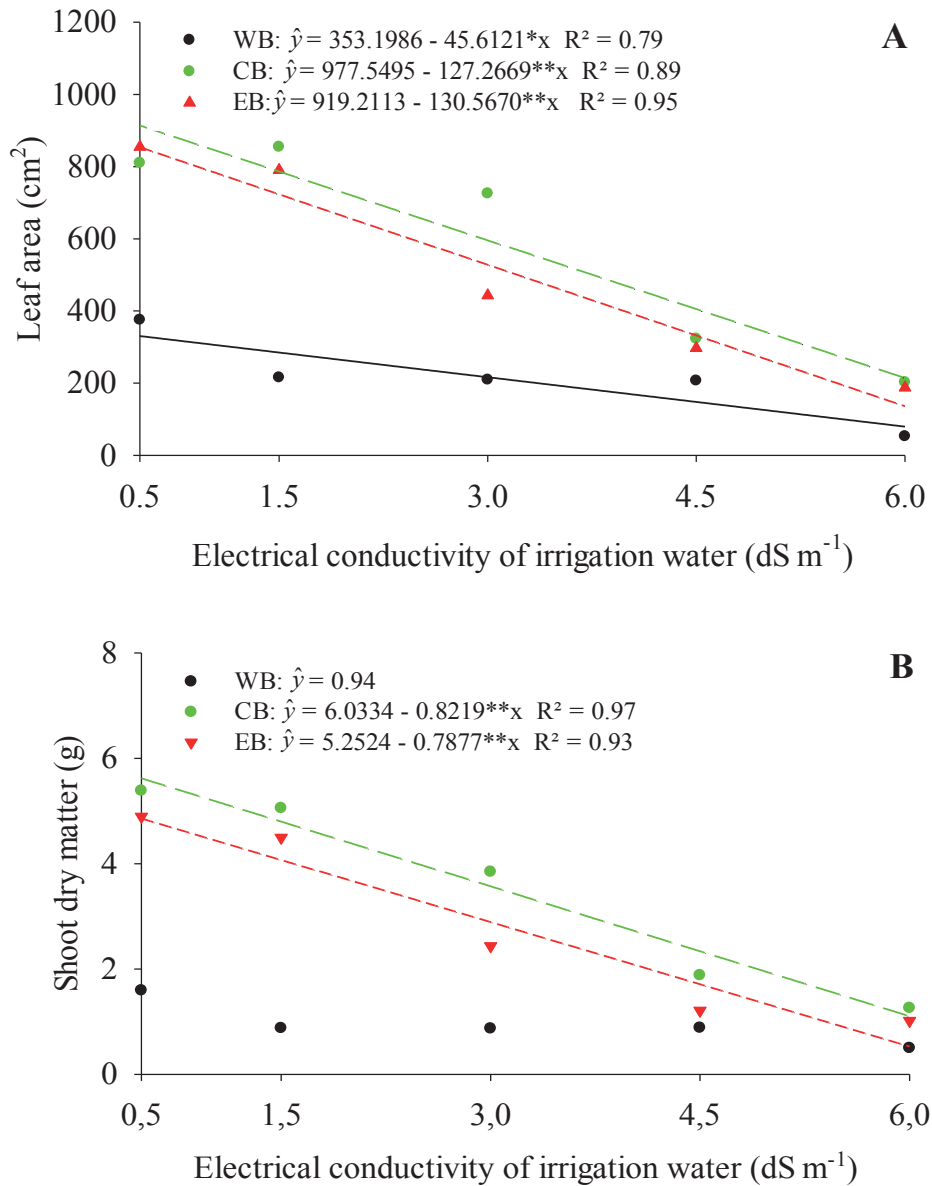
The promising effects of biofertilizer on plant growth under saline stress conditions occur due to the presence of humic substances in its composition, which are associated with improvements in soil physical, chemical, and microbiological properties, in addition to stimulating root system growth and enabling a higher uptake of water and nutrients (CANELLAS et al., 2015), inducing an osmotic adjustment of plants to the adversely saline environment (SILVA et al., 2011).

Shoot dry matter production presented the same behavior observed for leaf area, with reductions of 0.82 and 0.78 g per linear increase of water salinity in plots that received common and enriched biofertilizer. In the soil without biofertilizer, shoot dry matter did not fit any mathematical model, being represented by an average value of 0.94 g (Figure 1B). Negative effects of saline stress on leaf area and dry matter production of tamarind were also

observed by Gebauer et al. (2004) and Hardikar and Pandey (2011) when working with seedlings grown in nutrient solution with up to 10.3 dS m^{-1} and in soil with an electrical conductivity of up to 13.9 dS m^{-1} . Kchaou et al. (2013) worked with olive trees (*Olea europaea* L.) and found that the saline stress compromised dry matter production in different

organs. In general, the degenerative effects of salinity affect plant growth by reducing the osmotic potential, which results in water deficit, and by the ionic effect resulting from the accumulation of toxic ions such as Na^+ and Cl^- , which cause an imbalance in nutrient uptake, such as N, P, K^+ , and Ca^{2+} (TAIZ et al., 2017).

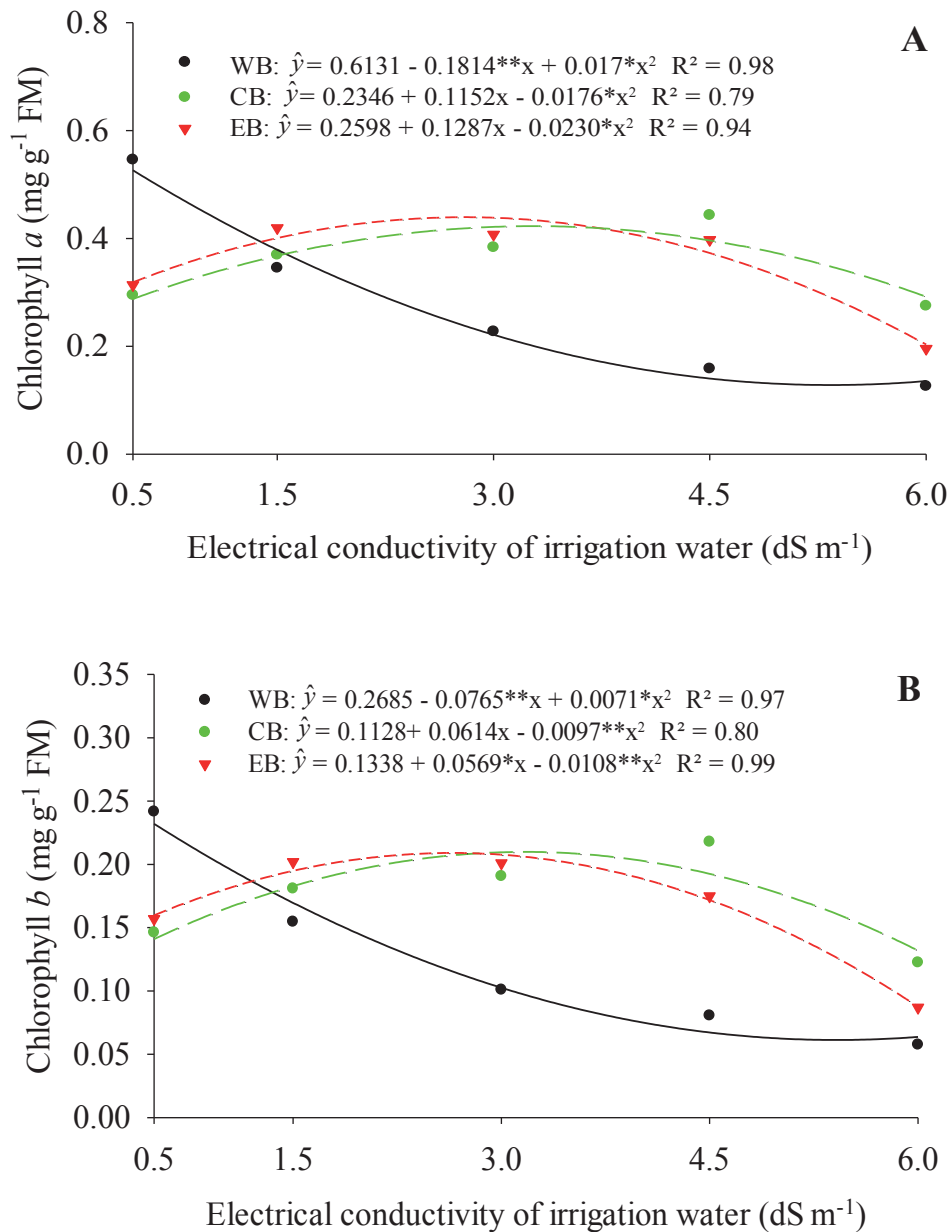
Figure 1. Leaf area (A) and shoot dry matter (B) of tamarind seedlings as a function of the electrical conductivity of irrigation water (EC_w) in the soil without biofertilizer (—) and with common (- - -) and chemically enriched (- · - ·) biofertilizers.



Leaf contents of chlorophyll *a* and *b* were also influenced by water salinity and biofertilizer application to the soil (Figure 2). In treatments without the organic input, the increase in water salinity in the range of 0.5 to 6.0 dS m⁻¹ drastically reduced Cl *a* contents by 74% (Figure 2A) and inhibited Cl *b* production in 72% (Figure 2B). These

losses, although high, are lower than those found by Gebauer et al. (2004), who observed reductions of 81.5 and 83.7% in Cl *a* and Cl *b* contents, respectively, in tamarind seedlings when salinity of irrigation water was increased from 0.54 to 10.3 dS m⁻¹, respectively (GEBAUER et al., 2004).

Figure 2. Leaf contents of chlorophyll *a* (A) and chlorophyll *b* (B) of tamarind seedlings as a function of the electrical conductivity of irrigation water (ECw) in the soil without biofertilizer (—) and with common (- - -) and chemically enriched (----) biofertilizers.



The reduction in *Cl a* and *Cl b* contents occurs due to the excess of salts in the foliar tissue above that tolerated stimulate the activity of the chlorophyllase enzyme, responsible for degrading chlorophyll and chloroplasts, leading to losses of photosynthetic activity of pigmentation proteins (MUNNS; TESTER, 2008).

Although saline stress compromise the chlorophyll contents of tamarind seedlings, the application of organic inputs to the substrate resulted in an increase in the leaf content of *Cl a*, reaching maximum values of 0.423 and 0.439 mg g⁻¹ FM at the estimated salinity levels of 3.27 and 2.80 dS m⁻¹ for plants that received common and enriched biofertilizers, respectively. These increases correspond to increments of 47.0 and 38.1% for plants treated with common and chemically enriched biofertilizers, respectively (Figure 2A). Oliva et al. (2008) observed a similar trend after applying a vermicompost to the soil, which reduced the deleterious effects of salts on the chlorophyll content in tamarind seedlings irrigated with saline water varying from 0.54 to 10.3 dS m⁻¹.

Organic compounds such as manure, vermicompost, and biofertilizers have humic substances in their composition and, when supplied to the soil, increase *Cl a*, *Cl b*, and *Cr t* contents (ERTANI et al., 2013) of plants, promoting higher photosynthetic and respiratory rates and increased stomatal conductance, resulting in a higher osmotic adjustment to salts and plant growth (YARAMI; SEPASKHAH, 2015).

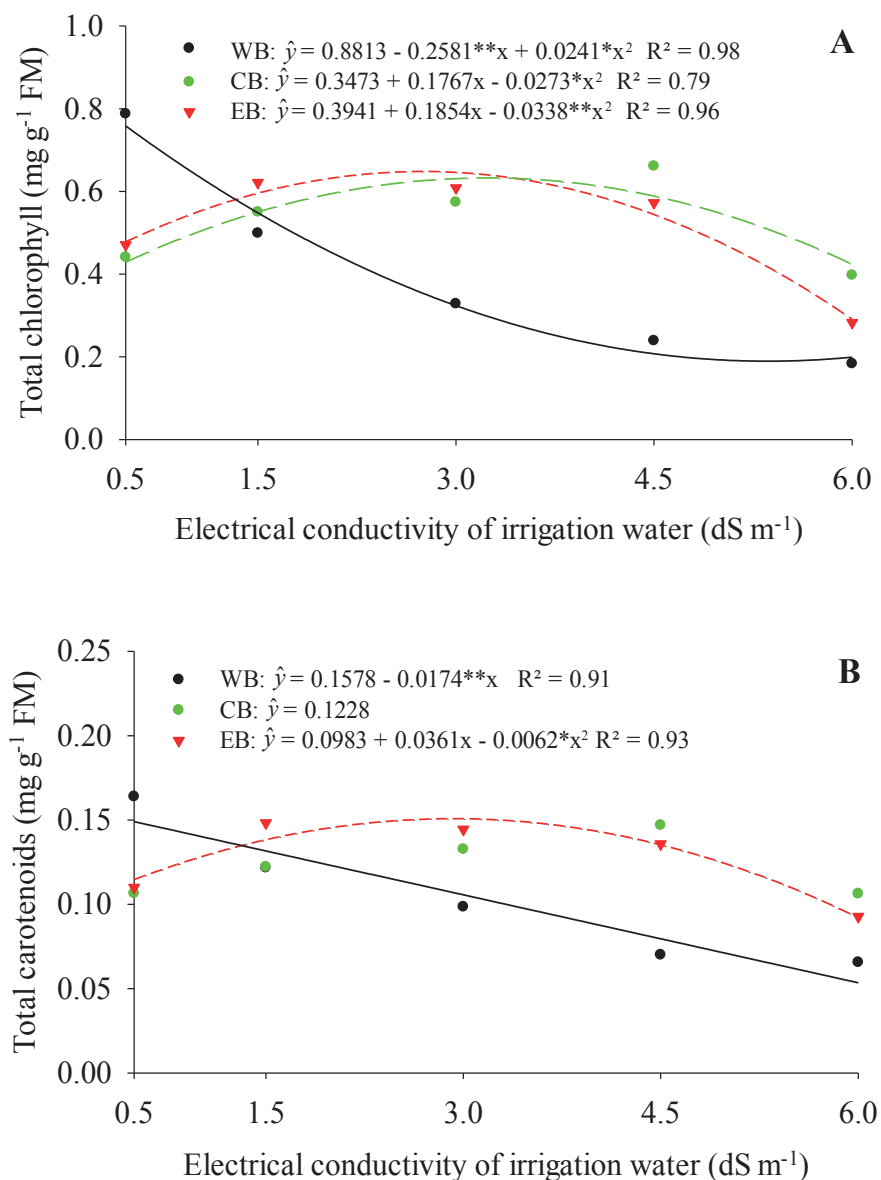
Leaf contents of *Cl b* in tamarind seedlings also increased with organic input application, reaching maximum values of 0.21 and 0.138 mg g⁻¹ FM at the estimated salinity levels of 3.16 and 2.63 dS m⁻¹ for plants under application of common and enriched biofertilizers, respectively (Figure 2B). These results

are different from those obtained by Cavalcante et al. (2011), who found that the application of common bovine biofertilizer (fermented manure and water) had no effect on chlorophyll contents in yellow passion fruit plants irrigated with water of 0.5 to 4.5 dS m⁻¹.

The increased salinity of irrigation water had different effects on the formation of total chlorophyll and carotenoids in tamarind seedlings according to the treatments with and without biofertilizers (Figure 3). In the substrate without bovine biofertilizer, *Cl t* and *Cr t* contents were drastically reduced from 0.758 to 0.200 and 0.149 to 0.053 mg g⁻¹ FM, respectively, with reductions of 73.6 and 64.4% in plants irrigated with water of 0.5 and 6.0 dS m⁻¹, respectively. Similar behavior was also observed by Hunsche et al. (2010) when irrigating tamarind seedlings with water of up to 15.2 dS m⁻¹, but with losses of 10% in *Cl t* contents.

The contents of *Cl t* reached maximum values of 0.632 and 0.648 mg g⁻¹ FM at estimated levels of irrigation water salinity of 3.24 and 2.74 dS m⁻¹, respectively, for plants under application of common and chemically enriched liquid biofertilizer applied to soil (Figure 3A). Under the same conditions, *Cr t* contents of seedlings treated with common biofertilizer did not fit any mathematical model, with an average value of 0.1228 mg g⁻¹ FM. Regarding the chemically enriched biofertilizer, *Cr t* contents increased from 0.1148 to 0.2034 mg g⁻¹ FM in plants irrigated with water at a lower salinity level (0.5 dS m⁻¹), with an estimated value of 2.91 dS m⁻¹ (Figure 3B). These results are different from those obtained by Cavalcante et al. (2011), who found that bovine biofertilizer had no influence on *Cl t* and *Cr t* contents of yellow passion fruit plants irrigated with saline water of 0.5 to 4.5 dS m⁻¹.

Figure 3. Leaf contents of total chlorophyll (A) and total carotenoids (B) of tamarind seedlings as a function of the electrical conductivity of irrigation water (EC_w) in the soil without biofertilizer (—) and with common (- - -) and chemically enriched (- · - ·) biofertilizers.



Although organic fertilizers (CB and EB) have exerted a positive action on leaf area (Figure 1A) and shoot dry matter formation (Figure 1B) of plants irrigated with water of lower saline level (0.5 dS m⁻¹), the effects promoted by organic inputs practically disappeared at the highest studied salinity levels (6.0 dS m⁻¹). However, no effect was observed at the lowest salinity level on

the total carotenoid contents (Figure 3B), which presented values of 0.149, 0.123, and 0.115 mg g⁻¹ FM in plants without the organic input and under application of common and enriched biofertilizers, respectively. In general, a lower deleterious effect was observed for water salinity on seedling growth, following the order CB > EB > WB.

The highest chlorophyll contents (Cl *a*, Cl *b*, and Cl *t*) were obtained in plants of treatments without biofertilizer irrigated with lower saline water. In plants irrigated with saline water varying from 1.5 to 5.0 dS m⁻¹, biofertilizers exerted superiority on Cl *a*, Cl *b*, and Cl *t* contents. However, in salinity levels higher than 5.0 dS m⁻¹, the superiority of biofertilizers was reduced when compared to the soil without biofertilizer, tending to disappear at higher salinity levels, with higher drops in treatments with enriched biofertilizer. For these variables, an alteration was observed in the order of values in plants irrigated with water of saline concentration below 1.5 dS m⁻¹ (WB > EB > CB), between 1.5 and 3.0 dS m⁻¹ (EB > CB > WB), and above 3.0 dS m⁻¹ (CB > EB > WB).

Although biofertilizers have been applied to different volumes based on electrical conductivity, the inversion of the order between the enriched (EB) and common biofertilizer (CB) is due to the higher electrical conductivity of input, which is related to the solubilization of its components during fermentation, as well as the higher sodium content in the enriched biofertilizer, which was 22% higher than that found in the common biofertilizer (Table 2). This situation contributed to increasing the electrical conductivity of soil saturation extract (EC_{se}) at all electrical conductivity levels of the irrigation water in treatments with EB at the end of the experiment. Lima Neto et al. (2015) found that EC_{se} at the end of the experiment was, on average, 10.7% higher in plots with EB, which reflected more sharply in plants irrigated with water of higher salinity when compared to common biofertilizer. These results are in accordance with Medeiros et al. (2011), who found that soil salinity in treatments irrigated with water of salinity higher than 3.0 dS m⁻¹ was higher in treatments with biofertilizer chemically enriched with milk, molasses, and gypsum.

Conclusions

The increase in saline concentration of irrigation water compromised growth and the production of chlorophyll and total carotenoids in tamarind seedlings.

Biofertilizers attenuated the negative effects of salinity on growth variables of tamarind seedlings, especially at low and moderate salinity levels. For photosynthetic pigments, gains obtained by biofertilizers are more evident at salinity levels between 1.5 and 5.0 dS m⁻¹.

The use of biofertilizers allows the irrigation with water of a saline level not tolerated by tamarind trees in the soil without any of the inputs, but the common biofertilizer surpasses that chemically enriched.

Tamarind seedling growth (leaf area and dry matter) followed the order common biofertilizer (CB) > enriched biofertilizer (EB) > without biofertilizer (WB). For chlorophyll contents, this order varied according to the saline level, as follows: WB > EB > CB for saline levels below 1.5 dS m⁻¹, EB > CB > WB for saline levels between 1.5 and 3.0 dS m⁻¹, and CB > EB > WB for saline levels above 3.0 dS m⁻¹.

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