SALINE WATER AND BOVINE BIOFERTILIZER CHEMICALLY ENRICHED ON JACKFRUIT SEEDLINGS var. SOFT

ÁGUA SALINA E BIOFERTILIZANTE ENRIQUECIDO EM MUDAS DE JAQUEIRA var. MOLE

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ABSTRACT: Water scarcity and water quality is a subject of constant debate around the world, with the accumulation of salts in water and on soils causing a negative impact on food production, man and herds, especially in the arid and semi-arid regions. The use of bovine manure biofertilizers that potentiate the use of brackish water, normally restricted in agriculture due to its salinity, has been suggested for seedling formation and crop production, including jackfruit plants. An experiment was carried out from October/2012 to February/2013, in a protected environment, at Agrarian Sciences Center, Federal University of Paraíba, Areia county, Paraíba State, Brazil, to evaluate the effects of saline water and bovine biofertilizer chemically enriched with gypsum, cow's milk and molasses. The experimental design was completely randomized, with five replications of a plant, in a factorial scheme 5×2, corresponding   at values of electrical conductivity of the water of 0.5, 1.0, 2.0, 3.0 and 4.0 dS m^{-1} substrate with and without bovine biofertilizer. Measurements were made of substrate salinity, height of growth, stem diameter, length mean root, leaf area, leaf area ratio, and total dry mass (root, shoots and leaves). The biofertilizer enriched with cow's milk, sugar cane molasses and agricultural gypsum increased the salinity of the soil; however, it attenuated the negative effects of the salts during establishment of jackfruit seedlings, to 95 days after emergence. All the growth variables studied were higher for seedlings developed in substrate with bovine biofertilizer chemically enriched.

KEYWORDS: *Artocarpus heterophyllus* Lam. Attenuating. Salinity. Organic input.

INTRODUCTION

The jackfruit plant is a fruit that grows well in tropical regions, and was introduced to Brazil in the middle of the 17th century (BERGALLO et al., 2016). The fruits of attractive shape and color, pleasant taste and aroma, are consumed directly from the plant or processed in the form of sweets, jellies and liqueur. They are rich in carbohydrates, vitamins and minerals, such as calcium and iron (MADRUGA et al., 2014). Despite these qualities and demand from consumers, production of jackfruit in Brazil is not well organized, either technically or logistically (BALIGA et al., 2011). Therefore, scientific reports on the production of seedlings, water requirements, nutritional requirements and salinity tolerance are still infrequent.

Under irrigation with salt water above 0.5 dS m^{-1}, jackfruit seedlings show a decline in growth, a reduction in dry biomass and a general loss of quality (OLIVEIRA et al., 2017; OLIVEIRA et al., 2018). Water with salt content above the limit tolerated by the vast majority of cultivated plants is very common in arid and semi-arid regions (ALLBED; KUMAR, 2013). In these situations, salts inhibit growth, biomass production and compromise the physiological processes of plants sensitive to salt stress (SÁ et al., 2013; HUSSAIN et al., 2018).

In addition to damage to biomass, growth and formation, salinity also compromises plant physiological processes by causing stomatal closure, with decreased transpiration, influx and assimilation of CO_2 (NEGRÃO; SCHMÖCKEL; TESTER, 2017). Damage also occurs by the indirect action of salts, through the loss of water extraction by plants and nutrient imbalance, in response to the low osmotic potential of the soil solution (PARIHAR et al., 2015; HUSSAIN et al., 2018). Since the twentieth century, these situations have demonstrated the need to use management and technical strategies to allow the use of water with high levels of salt in agriculture.

One approach is the adoption of technologies to allow the use of brackish water in agriculture, without great losses in the quality of seedlings and crop yield. In this context, the bovine biofertilizer Vairo promotes greater root and aerial tissue growth, and greater formation of biomass, in comparison to plants without this organic input, during the formation of seedlings of several non-fruit and fruit species (DINIZ NETO et al., 2014; OLIVEIRA et al., 2017; LIMA NETO et al., 2018).

The promising response of plants exposed to biofertilizer under irrigation with saline water is due to humic substances that promote improvements in the structure, porosity and hydraulic conductivity of the substrate (MELLEK et al., 2010; ALENCAR et al., 2018). This advantage contributes to greater root growth and biomass allocation in comparison to plants grown on soil without biofertilizer input, as reported for noni (*Morinda citrifolia*; SOUTO et al., 2013), oiticica (*Licania rigida*; DINIZ NETO et al., 2014) and papaya (*Carica Papaya*; LIMA NETO et al., 2016), respectively, for seedlings grown under non-salt and salt water irrigation.

There are few reports on the use of bovine biofertilizer, chemically enriched with cow's milk, molasses and agricultural gypsum, in plants irrigated with non-saline water and water with increasing salinity. Medeiros et al. (2013) showed chemically enriched biofertilizer increased biomass in tomato-cherry (*Licopersicon pimpinellifolium*), under irrigation with low and high salinity water. For the growth and quality of tamarind seedlings (*Tamarindus indica*) irrigated with salinity water ranging from 0.5 to 6.0 dS m^{-1}, Lima Neto et al. (2018) concluded that enriched biofertilizer, despite not exceeding common biofertilizer, exerted a significantly higher effect on the soil without any of the inputs.

Therefore, this study evaluated the effects of irrigation with water of increasing salinity and application of biofertilizer, chemically enriched with cow's milk, molasses and agricultural gypsum, on soil salinity, and growth and quality of jackfruit seedlings var. soft.

CONTENTS

The study was conducted in a shelter at the Center of Agricultural Sciences, Federal University of Paraíba, Areia county, Paraíba State, Brazil (06° 58' 00" S, 35° 41' 00" W and 575 m above sea level) between October/2012 and February/2013. It was designed to evaluate the effects of irrigation with saline water and bovine biofertilizer chemically enriched use on the formation of jackfruit seedlings (*Artocarpus heterophyllus* Lam.) var. Soft. The climate according to the Köppen classification was As type, with dry summers and hot rains in winter (ALVARES et al., 2013). The rainy season is from March to July, with historical annual average rainfall, temperature and relative humidity of 1,400 mm, 24 ºC and 70%, respectively.

The substrate, according to the criteria of the Brazilian System of Soil Classification (SiBCS; EMBRAPA, 2018), was a dystrophic Entisol. Material was collected from the 0.0─0.2 m layer, air dried in the shade and passed through a 2 mm sieve mesh. A volume of 3.5 dm^3 was then packed in black polyethylene bags with a capacity of 4.5 dm^3. Three samples of air dried earth were used for physical and chemical characterization of salinity (EMBRAPA, 2017) and saturation extract salinity (RICHARDS, 1954; Table 1).

Table 1. Physical and chemical characterization of soil fertility and salinity in the 0.0─0.2 m layer

Physical	Value	Fertility	Value	Salinity	Value
Sd (g cm^{-3})	1.51	pH em água (1: 2.5)	6.70	ECse (dS m^{-1})	0.55
Pd (g cm^{-3})	2.76	OM (g kg^{-1})	13.58	pH	6.25
Tp(m^3 m^{-3})	0.46	P (mg dm^{-3})	22.46	Ca^{2+} (mmol$_c$ L^{-1})	1.44
Sand (g kg^{-1})	869	K$^+$ (cmol$_c$ dm^{-3})	0.32	Mg^{2+} (mmol$_c$ L^{-1})	0.77
Silt(g kg^{-1})	69	Ca^{2+} (cmol$_c$ dm^{-3})	1.50	Na$^+$ (mmol$_c$ L^{-1})	2.76
Clay (g kg^{-1})	98	Mg^{2+} (cmol$_c$ dm^{-3})	1.48	K$^+$ (mmol$_c$ L^{-1})	0.53
CDW (g kg^{-1})	12	Na$^+$ (cmol$_c$ dm^{-3})	0.36	Cl$^-$ (mmol$_c$ L^{-1})	4.28
DF (%)	80.45	H$^+$ + Al^{3+}(cmol$_c$ dm^{-3})	2.65	CO$_3$$^{2-}$ (mmol$_c$ L^{-1})	-
DI (%)	19.55	Al^{3+} (cmol$_c$ dm^{-3})	0.00	HCO$_3^-$(mmol$_c$ L^{-1})	0.81
U$_{fc}$ (g kg^{-1})	12.43	SB (cmol$_c$ dm^{-3})	4.02	SO$_4$$^{2-}$(mmol$_c$ L^{-1})	0.21
U$_{pwp}$(g kg^{-1})	6.06	CEC (cmol$_c$ dm^{-3})	6.67	SAR (mmol L^{-1})$^{1/2}$	1.38
WA (g kg^{-1})	6.37	V (%)	60.26	PES (%)	5.39

Sd = Soil Density; Pd = Particle density; Tp = Total porosity; CDW = clay dispersed in water; DF = Degree of flocculation; DI = dispersion index; Ufc and Upwp = soil moisture at level of – 0.01 and -1.50 Mpa, respectively,; WA= Water available; OM = Organic matter; SB = Sum of bases (Ca^{2+} + Mg^{2+} + Na$^+$ + K$^+$); CEC = Cation exchange capacity = SB + (H$^+$ + Al^{3+}); V = saturation value per base (100 × SB/CEC); ECse = Electrical conductivity of the saturation extract; SAR = sodium adsorption ratio = Na$^+$ × [(Ca^{2+} + Mg^{2+})/2]^{½}; PES = Percentage of exchangeable sodium (100 × Na$^+$/CEC).

The design of the experiment was completely randomized, with five replications using the factorial scheme 5 × 2, corresponding to electrical conductivity values of the irrigation water (CEiw) of 0.5, 1.0, 2.0, 3.0 and 4.0 dS m^{-1} on a substrate with and without 350 mL of chemically enriched bovine biofertilizer applied only once, two days before sowing. Seeds of jackfruit var. Soft were obtained from fruits of free standing plants grown at the nursery of the Federal University of Paraíba, Areia, Paraíba, Brazil.

The values of electrical conductivity of water above 0.5 dS m^{-1} were obtained by diluting strongly saline dam water (15.12 dS m^{-1}) in non-saline water (0.5 dS m^{-1}). Equation (1) and portable conductivity meter Instrutherm (CD-860) were used to determine the electrical conductivity.

$$V_1C_1 = V_2C_2 \text{ (Eq. 1)}$$

where: V1 = constant volume of strongly saline water to obtain the volume of water with the pre-established electrical conductivity (dm^3); C_1 = electrical conductivity of strongly saline water (dS m^{-1}); V_2 = volume of non-saline water (0.5 dS m^{-1}) to obtain a mixture with the desired electrical conductivity (dm^3); and C_2 = electrical conductivity of the desired water (dS m^{-1}).

The bovine biofertilizer enriched was obtained by anaerobic fermentation in a biodigester containing equal parts of water and fresh bovine manure, chemically enriched with 4 dm^3 of molasses, 8 dm^3 of bovine milk and 4 kg of agricultural gypsum, giving a ratio of 1:2:1. To maintain the hermetically sealed system, one end of a 4 mm diameter plastic hose was connected to the upper base of the biodigester and its other end was immersed in a vessel with water, to allow pressure release without environmental contamination of the system. The biofertilizer was evaluated as water for irrigation (Table 2) using the methodologies recommended by Richards (1954).

Table 2. Chemical characterization of irrigation water and chemically enriched bovine biofertilizer

Compounds	Non - saline water	Saline water	Enriched bovine biofertilizer
EC (dS m^{-1})	0.51	15.12	6.28
SAR (mmol L^{-1})$^{1/2}$	2.44	20.80	2.29
Ca^{2+} (mmol$_c$ L^{-1})	1.37	10.83	20.48
Mg^{2+} (mmol$_c$ L^{-1})	0.83	37.53	13.82
Na$^+$ (mmol$_c$ L^{-1})	2.56	102.29	9.51
K$^+$ (mmol$_c$ L^{-1})	0.19	2.69	17.42
Cl$^-$ (mmol$_c$ L^{-1})	3.48	111.60	27.93
HCO$^-_3$ (mmol$_c$ L^{-1})	0.45	40.49	8.98
CO$^{2-}_3$ (mmol$_c$ L^{-1})	0.00	2.10	0.00
SO$^{2-}_4$ (mmol$_c$ L^{-1})	0.76	0.80	15.52
Classification	C_1S_1	C_4S_2	C_2S_1

EC = electrical conductivity; SAR = sodium adsorption ratio = Na$^+$× [(Ca^{2+}+ Mg^{2+})/2)]$^{1/2}$; C_1, C_2 and C_4 = low, medium and high risk to salinizing the soil, respectively; S_1 and S_2 = low and high risk of promoting soil sodicity, respectively.

Five jackfruit seeds with a viability of 92% were sown in each experimental unit. At 15 days after emergence (DAE), thinning was performed, maintaining the more vigorous seedlings. Irrigation with water of defined salinity was done by the weighing method. The evapotranspiration volume every 24 h was provided to maintain the soil moisture near 90% of the field capacity, to avoid leaching of the applied organic material.

At 95 DAE, at the end of the experiment, soil samples were collected for evaluation of their salinity by electrical conductivity of the saturation extract (ECse). At the same time, plant height (PH) and root length of the plants (RL) were measured with a millimeter ruler, stem diameter was

determined with a Digimess 300 digital caliper, and leaf area (LA) obtained with a LI-300C portable LA meter. Root and aerial tissue was collected separately, and dried in an oven with air circulation at a temperature of 65º C for a period of 72 hours, to constant mass. Dry mass of roots and aerial tissue were obtained on a semi-analytic balance, with their sum providing the total dry mass (TDM). The leaf area ratio (LAR) was determined by the ratio between LA and TDM for the seedlings (BENINCASA, 2003).

The Dickson quality index (DQI) was determined using the methodology contained in Dickson, Leaf and Hosner (1960), according to equation (2):

$$DQI=TDM\left[(PH/SD)+(DMAT/DMR)\right] \text{(Eq. 2)}$$

where: DQI = Dickson quality index; TDM = total dry matter (g); PH = plant height (cm); SD = stem diameter (mm); DMAT = dry mass of aerial tissue (g); and DMR = dry mass of roots (g).

The results were submitted to analysis of variance (ANOVA) by the F-test ($p < 0.05$). The biofertilizer averages were compared by F-test ($p < 0.05$), which was conclusive for two values from the same source of variation. The averages for the electrical conductivity of irrigation water were analyzed by regression at 5% of probability, using statistical software Sisvar 5.6 (FERREIRA, 2014).

The interaction between water salinity and the chemically enriched bovine biofertilizer had significant effects on soil salinity and on the growth and quality of jackfruit seedlings by the end of the experiment (Table 3). Similar soil and plant responses were recorded by Medeiros et al. (2013) and Lima Neto et al. (2018), when they concluded that the interaction of saline water and biofertilizer, enriched with cow's milk, molasses and agricultural gypsum, exerted significant effects on the growth and biomass of cherry tomato plants and the formation of tamarind seedlings.

Table 3. Summary of the analysis of variance for the electrical conductivity of soil saturation extract (ECse), plant height (PH), stem diameter (SD), root length (RL), leaf area (LA), leaf air ratio (LAR), total dry mass (TDM), and Dickson quality index (DQI) in leaves of jackfruit seedlings, as a function of water salinity and chemically enriched bovine biofertilizer

SV	DF	Square Mean							
		ECse	PH	SD	RL	LA	LAR	TDM	DQI
Sal (S)	4	16.68**	29.33 ns	1.13**	248.35**	4382.15**	1018.96**	7.03**	0.430**
Bio (B)	1	36.98**	369.92**	58.32**	5.78 ns	44045.12**	1478.04**	2.88**	0.310**
S × B	4	2.28**	97.970*	3.37**	124.13**	2187.47**	375.62**	1.83**	0.018*
Resíduo	40	0.14	18.02	0.19	12.32	414.36	42.11	0.41	0.006
CV (%)		10.81	11.16	8.79	9.72	10.60	13.49	15.39	15.79

SV = source of variation; DF = degrees of freedom; CV = coefficient of variation; ns = non-significant. * and **, significant at 5% and 1% of probability by the F-test, respectively.

Soil salinity increased linearly to levels of 0.3310 and 0.6406 per unit increase of the electrical conductivity of the irrigation water in treatments without and with enriched biofertilizer, respectively, with soil showing superiority with the organic input (Figure 1). The values increased from 1.09 to 3.34 dS m^{-1} and from 3.28 to 4.45 dS m^{-1} for plants irrigated with water of 0.5 and 4.0 dS m^{-1}, respectively, in soil without and with chemically enriched biofertilizer. The highest values for high electrical conductivity were the result of input of 6.28 dS m^{-1} water (Table 2), which contributed to the superiority of the saline character of the soil. For the waters of electrical conductivity 0.5, 1.0, 2.0, 3.0 and 4.0 dS m^{-1}, those treated with chemically enriched biofertilizer showed 201.8, 158.2, 92.7, 59.1 and 33.5% superiority in growth over plants without the biofertilizer. Despite the high values, compared to the initial level of 0.55 dS m^{-1} (Table 1), soil salinity at the end of the experiment, of 3.34 and 4.46 dS m^{-1}, did not reach the salinity reported by Richards (1954), with electrical conductivities > 8 dS m^{-1}.

For Richards (1954), the salinity of the water treatments increased the condition of non-saline soil (CEes <2 dS m^{-1}) to slightly saline (4> CEs>2 dS m^{-1}) and medium saline (4dS m^{-1}) soil, without and with bovine biofertilizer chemically enriched, respectively. However, even when not strongly saline, electrical conductivity values can inhibit the growth and quality of seedlings of susceptible and moderately salt-sensitive species (HOLANDA et al., 2016), including jackfruit (OLIVEIRA et al., 2017).
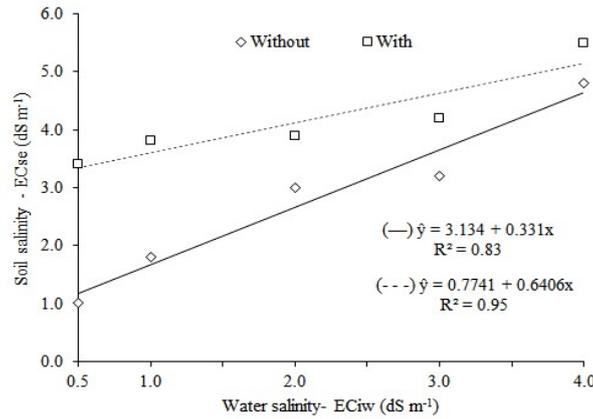
Figure 1. Electrical conductivity of soil saturation extract without (—) and with (---) chemically enriched bovine biofertilizer, as a function of salinity of irrigation water.

The enriched biofertilizer, despite raising the saline level of the soil, inhibited the adverse effects of irrigation water salinity. This conclusion was based on increased height, stem diameter and main root length in jackfruit, compared to plants grown in soil without enriched biofertilizer (Figure 2). These results were consistent with those obtained in noni (SOUTO et al., 2013) and papaya (LIMA NETO et al., 2016) seedlings, in soil with a similar biofertilizer.
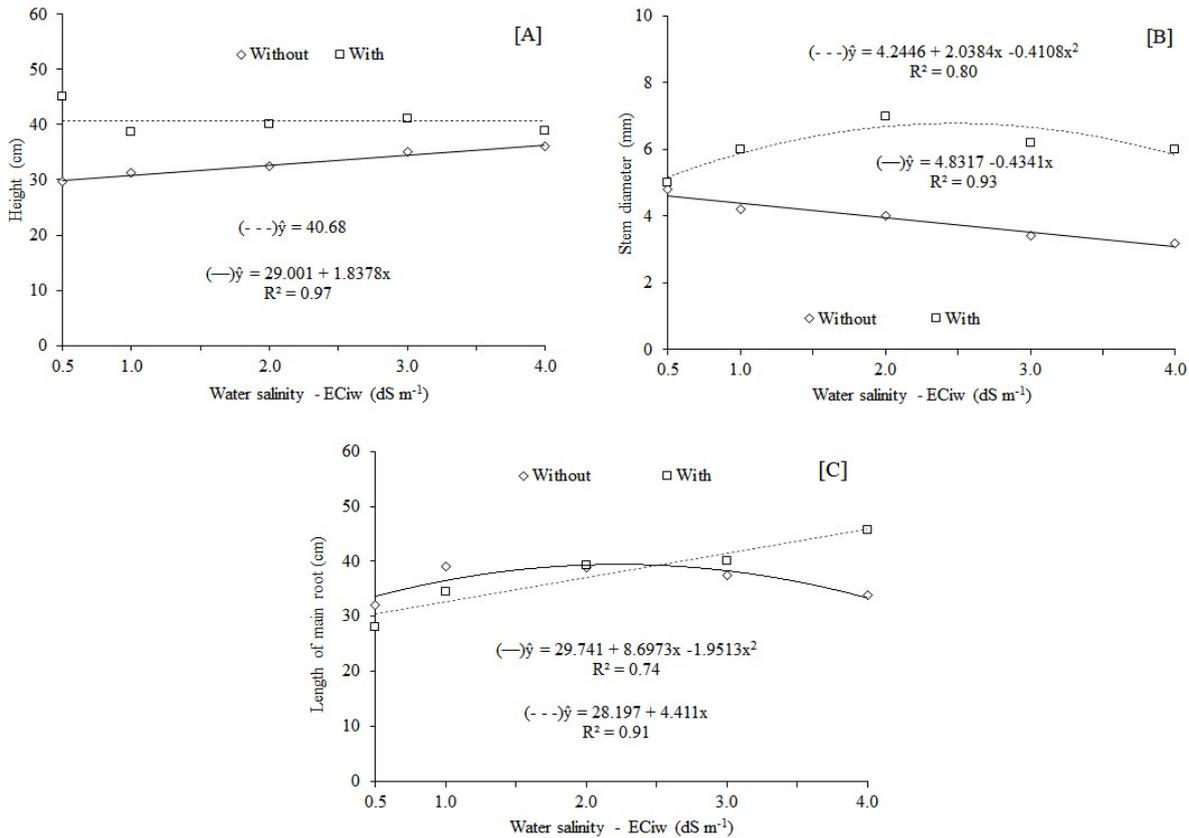
Figure 2. Growth in height (A), stem diameter (B) and length of main root (C) for seedlings of jackfruit irrigated with waters of increasing salinity, in soil without (—) and with (---) chemically enriched bovine biofertilizer.

The height of seedlings of jackfruit in soil without biofertilizer increased linearly with increasing water salinity from 29.54 to 36.35 cm, resulting in a 23.1% increase between water treatments of 0.5 and 4.0 dS m^{-1} (Figure 2A). This was in contrast to previous reports, where, in general, an increase in saline water concentration inhibited the growth of plants (SÁ et al., 2015), including jackfruit (OLIVEIRA et al., 2017; OLIVEIRA et al., 2018). In soil with the organic

input, the height data of the seedlings did not fit any regression model, due to the increase in the electrical conductivity of the waters, presenting an average value of 40.68 cm; however, they were higher than for plants in soil without biofertilizer (Figure 2A). The greater plant growth of seedlings that developed in soil with enriched biofertilizer was likely due to humic substances complexing salts (OUNI et al., 2014), improved hydraulic conductivity, structure and macro porosity of the soil (MELLEK et al. al., 2010), and increased availability of essential nutrients (ALVES et al., 2009).

Increase of salts in the irrigation water linearly inhibited stem diameter of jackfruit seedlings in soil without chemically enriched biofertilizer, in the proportion of 0.4108 mm per unit increase of the electrical conductivity of the water. By contrast, biofertilizer stimulated the growth of stem diameter in seedlings irrigated with water of maximum salinity estimated at 2.5 dS m^{-1} (Figure 2B). For plants in soils without and with enriched biofertilizer, stem diameter showed a loss of 18.4% and a gain of 31.2%, respectively, when comparing plants that were grown at 0.5 dS m^{-1} and 2.5 dS m^{-1}.

The salinity of the irrigation water reduced the ability of the roots to extract water from the substrate, which negatively interfered with photosynthetic processes and CO_2 assimilation, leading to a decrease in cell division and expansion (PARIHAR et al., 2015; NEGRÃO; SCHMÖCKEL; TESTER, 2017). However, because the enriched biofertilizer contained osmoregulatory substances such as potassium, its inclusion promoted greater absorption of water and nutrients by plants (ALENCAR et al., 2018).

Increase of irrigation water salinity in most treatments stimulated root growth of jackfruit seedlings, with the positive influence being most evident for soils containing enriched biofertilizer and irrigated with higher levels of water salinity (Figure 2C). The length of the main root of seedlings in soil without biofertilizer grew under irrigation with water of up to 2.2 dS m^{-1}, reaching the highest value of 39.43 cm. This increase in root growth in saline conditions might be a response of the seedlings to the adverse osmotic environment actively promoting greater growth (HUSSAIN et al., 2018).

In the soil with chemically enriched bovine biofertilizer, root growth increased linearly from 30.40 to 45.84 cm between plants irrigated with water of 0.5 and 4.0 dS m^{-1}, representing a gain of 50.8%. Similar behavior was observed for root growth in oiticica (Licania rigida Benth) seedlings irrigated with saline waters (DINIZ NETO et al., 2014). The biofertilizer, through its contribution of humic substances, promoted improvements in physical attributes of the soil, mainly in structure and porosity, which resulted in higher root growth under saline conditions (ALENCAR et al., 2018).

The chemically enriched biofertilizer also inhibited the negative effects of water salinity on LA and LAR of jackfruit seedlings in comparison to plants in soil without the biofertilizer (Figure 3). The change in electrical conductivities of the irrigating waters caused a loss of 23.2% and a gain of 5.6% in LA for soil with and without the biofertilizer, respectively. However, the absolute value ranges of $254.86 - 195.64$ cm^2 and $168.47 - 177.95$ cm^2, respectively, illustrated the positive effect of the chemically enriched biofertilizer in attenuating the adverse effects of all salinities (Figure 3A).
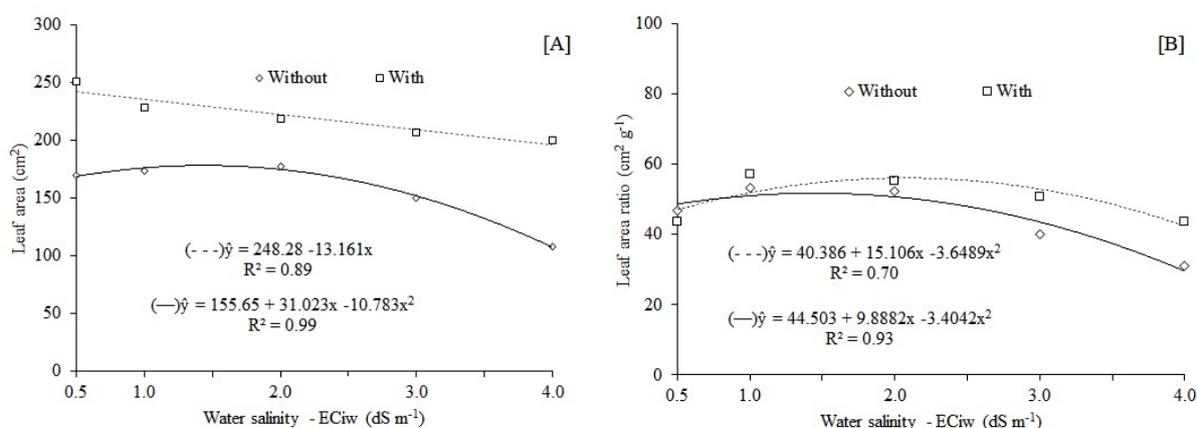
Figure 3. Leaf area (A) and leaf area ratio (B) of jackfruit seedlings irrigated with waters of increasing salinity, in soil without (—) and with (---) chemically enriched bovine biofertilizer.

In soil with similar biofertilizer or the biofertilizer Vairo, Diniz Neto et al. (2014) showed a similar trend for oiticica seedlings irrigated with saline water, with loss of LA on increasing electrical conductivity of water from 0.5 to 6.0 dS m^{-1}. It was also consistent with Souto et al. (2013), who observed a reduction of 35% in LA for noni plants irrigated with waters of the same electrical conductivity levels as the current study, but always with higher leaf areas in the seedlings treated with the organic input. The higher data values of plants in soil with enriched biofertilizer compared to those in soil without this input were consistent with findings for tamarind seedlings irrigated with water of increasing salinity (LIMA NETO et al., 2018).

For soil without and with chemically enriched biofertilizer, with increased water salinity irrigation from 0.5 to 1.5 dS m^{-1} and from 0.5 to 2.1 dS m^{-1}, an increased LAR was observed from 48.59 to 51.64 cm^2 g^{-1} and from 47.03 to 56.02 cm^2 g^{-1}, an increase of 6.3 and 19.1%, respectively (Figure 3B). When comparing the LAR of irrigated seedlings irrigated with water of 1.5 and 2.1 dS m^{-1}, in the absence and presence of enriched biofertilizer, there was a 6.2 and 11.5% increase, respectively.

This situation indicated a greater efficiency of leaves in transforming absorbed light per unit of biomass produced (DUNEA; NEAGU FRĂSIN; DINCĂ, 2015), and as for growth in height, stem diameter and main root length, indicated the effect of the biofertilizer in mitigating the adverse effects of increased salt concentrations for jackfruit with regard to their leaves. The biofertilizer, because it contains all the essential macronutrients, even if at low levels (ALVES et al., 2009), and provides organic solutes that regulate the osmotic environment (SOUSA et al., 2014), should contribute to a greater absorption of water and nutrients by plants under adverse conditions of salinity (SÁ et al., 2013).

Increases in saline water concentration linearly inhibited the formation of dry biomass for seedlings in the soil with biofertilizer. However, the inhibition was greater for plants grown without biofertilizer and irrigated with water of estimated maximum electrical conductivity of 2.0 dS m^{-1} (Figure 4). With the exceptions of water of 2.0 and 3.0 dS m^{-1}, seedlings in enriched biofertilizer had higher total dry biomasses than those grown without biofertilizer.

The increase in total dry biomass of seedlings in soil without organic input and irrigated with water of up to 2.0 dS m^{-1} indicated jackfruit, during this phase of development, were only moderately sensitive to water salinity, compared to other crops (DIAS et al., 2016). However, these results were in contrast to Oliveira et al. (2018) who found that total dry mass of jackfruit seedlings was linearly inhibited with increase in water salinity from 0.3 to 4.0 dS m^{-1}.
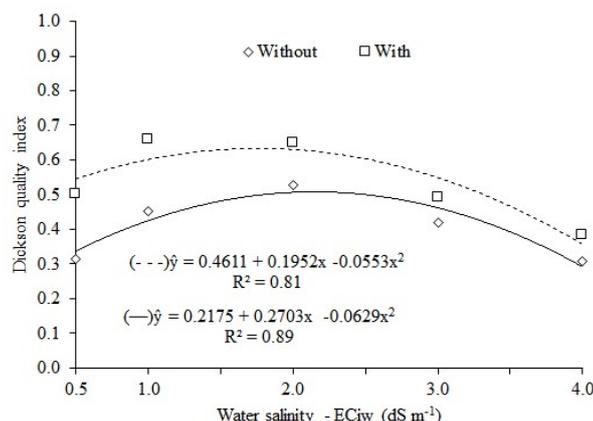
For plants in soil with enriched biofertilizer, total dry mass of plants decreased linearly from 5.30 to 3.53 g, a loss of 33.4%, for seedlings irrigated with water of 0.5 and 4.0 dS m^{-1}, respectively. This reduction, also observed in other variables, could be caused by a decrease in water absorption in response to the saline complex of osmotic effect and excess of specific ions. The toxic and nutritional imbalance might simultaneously affect photosynthetic processes, carbon assimilation, chlorophyll degradation and photo-assimilation, with resulting negative effects on plants (SHELDON et al., 2017). Similar behavior was observed by Sá et al. (2015), who found a decline in total dry mass for sugar-apples (*Annona squamosa*) of 0.0923 g per unit increase in the electrical conductivity of irrigation water.
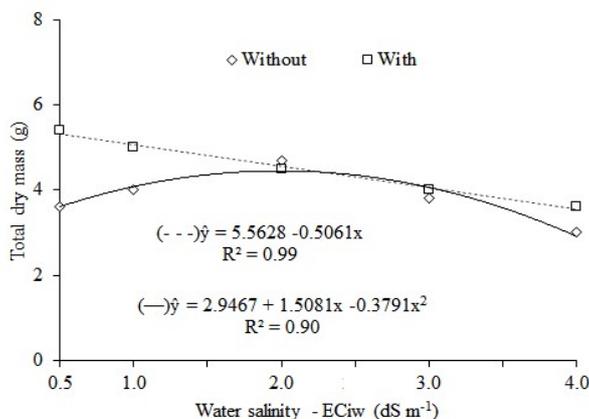
Figure 4. Total dry mass of jackfruit seedlings irrigated with water of increasing salinity, in soil (——) without and with (---) chemically enriched bovine biofertilizer.

Equations in figure:
$(- - -)\hat{y} = 5.5628 - 0.5061x$
$R^2 = 0.99$

$(——)\hat{y} = 2.9467 + 1.5081x - 0.3791x^2$
$R^2 = 0.90$

An increase in salt content of water from 0.5 to 2.1 and 0.5 to 1.8 dS m^{-1} resulted in improved quality of jackfruit seedlings, in soil without and with chemically enriched biofertilizer, with the highest values of 0.50 and 0.63 in the DQI, respectively (Figure 5). These results were consistent with 0.65 and >0.50, respectively, obtained by Oliveira et al. (2017) for jackfruit seedlings under irrigation with saline water in substrate without and with added nitrogen. When comparing the results at values of maximum salinity estimated at 1.8 and 2.1 dS m^{-1}, there was a 26.0 and 23.5% increase in DQI for jackfruit seedlings in soil with bovine biofertilizer, compared to those in soil without biofertilizer, once again indicating the positive effect of the chemically enriched biofertilizer in attenuating the harmful effects of salinity on the formation of jackfruit seedlings.

Figure 5. Dickson Quality Index in jackfruit seedlings irrigated with water of increasing salinity, in soil without (—) and with (---) chemically enriched bovine biofertilizer.

The bovine biofertilizer chemically enriched, in spite of increasing soil salinity, exerts an attenuating action on the salts, as observed during the formation of jackfruit seedlings irrigated with waters of increasing salinity. All growth variables were higher in soil with bovine biofertilizer enriched with milk, sugar cane molasses and agricultural gypsum. The best quality jackfruit seedlings were obtained in soil with enriched bovine biofertilizer, irrigated with water of up to 2.1 dS m^{-1}.

RESUMO: A escassez e a qualidade da água são assuntos de constante debate em todo o mundo, com o acúmulo de sais na água e nos solos, causando um impacto negativo na produção de alimentos, homem e rebanhos, especialmente nas regiões áridas e semiáridas. O uso de biofertilizante de esterco bovino que possibilita o uso de água salobra, normalmente restrita à agricultura devido à salinidade, tem sido sugerido para formação demudas e produção agrícola, inclusive de jaqueira. Um experimento foi desenvolvido entre outubro de 2012 e fevereiro de 2013, em ambiente protegido, no Centro de Ciências Agrárias, da Universidade Federal da Paraíba, Areia, Paraíba, Brasil, para avaliar os efeitos da água salina e biofertilizante bovino enriquecido quimicamente com calcário, leite de vaca e melaço. O delineamento experimental foi inteiramente casualizado, com cinco repetições e uma planta, em esquema fatorial 5 × 2. Água com condutividade elétrica de 0,5, 1,0, 2,0, 3,0 e 4,0 foram aplicadas no substrato com e sem biofertilizante bovino. Foi avaliada a salinidade do substrato, crescimento em altura, diâmetro caulinar, crescimento da raiz principal, área foliar, razão de área foliar e massa seca total (raiz, parte aérea e folhas). O biofertilizante enriquecido com leite de vaca, melaço de cana-de-açúcar e gesso agrícola aumentou a salinidade do solo, no entanto, atenuou os efeitos negativos da salinidade durante o estabelecimento das mudas de jaqueira, aos 95 dias após a emergência. Todas as variáveis estudadas foram maiores nas mudas que cresceram no substrato com biofertilizante enriquecido quimicamente.

PALAVRAS-CHAVE: *Artocarpus heterophyllus* Lam. Atenuante. Insumo orgânico. Salinidade

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