INTERACTION SALINITY, BIOFERTILIZER AND POTASSIUM FERTILIZATION IN YELLOW PASSION FRUIT SEEDLINGS FORMATION

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ABSTRACT: Aimed to evaluate the effect of the bovine biofertilizer on attenuating the effects of irrigation water salinity and potassium sources during the formation of yellow passion fruit seedlings known in the Western Curimataú of Paraiba State, Brazil, as Guinezinho.The study was conducted under greenhouse environment of the Agrarian Sciences Center, Federal University of Paraiba, in Areia City, Paraiba State, Brazil. with four replications and three plants per plot, using the factorial 5 x 3 x 2, corresponding to the values of electrical conductivity of irrigation water of 0.3; 1.0; 2.0; 3.0 and 4.0 dS m^{-1}, in the soil without potassium, with potassium chloride and potassium sulphate, without and with bovine biofertilizer (Bio), applied in the liquid form in the proportion 1:1 (Bio: Water) in volume of 10% of the substrate volume, 24 hours before to seedsowing.The increase in salinity of irrigation water impaired plant growth and biomass, but always to a lesser proportion in the treatments with the bovine biofertilizer.Potassium fertilization potentiated the soil salinity, mainly when associated with water of higher salt concentration.The biofertilizer attenuated the degenerative effects of salinity of the irrigation water, stimulating the leaf index of chlorophyll *a* and *b* of seedlings

KEYWORDS: Salinization, biofertilization, potassium fertilization

INTERAÇÃO SALINIDADE, BIOFERTILIZANTE E ADUBAÇÃO POTÁSSICA NA FORMAÇÃO DE MUDAS DE MARACUJAZEIRO AMARELO

RESUMO. Objetivou-se avaliar o efeito do biofertilizante bovino em atenuar os efeitos da salinidade da água de irrigação e fontes de potássio durante a formação de mudas de maracujazeiro amarelo. O trabalho foi desenvolvido em ambiente telado do Centro de

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Ciências Agrárias, Universidade Federal da Paraíba, no município de Areia, Estado da Paraíba, Brasil. Os tratamentos foram distribuídos em blocos casualizados, com quatro repetições e três plantas por parcela, usando o fatorial 5 x 3 x 2, correspondente aos valores de condutividade elétrica da água de irrigação de 0,3; 1,0; 2,0; 3,0 e 4,0 dS m^{-1}, no solo sem potássio, com cloreto de potássio e sulfato de potássio, sem e com biofertilizante bovino (Bio), aplicado na forma líquida na proporção 1:1 (Bio: Água) em volume de 10% do volume do substrato, 24 horas antes da semeadura. O aumento da salinidade da água de irrigação prejudicou o crescimento e a biomassa das plantas, mas sempre em menor intensidade nos tratamentos com o biofertilizante bovino. A adubação potássica potencializou a salinidade do solo, principalmente quando associada com a água de maior concentração de sais. O biofertilizante atenuou os efeitos degenerativos da salinidade da água de irrigação, estimulando os índices foliares de clorofila *a*e *b* das mudas.

PALAVRAS-CHAVE: Salinização, biofertilização, adubação potássica.

INTRODUCTION

The quality and quantity of agricultural crops are under continuous and severe threat of several abiotic stresses one of the most important being the salinity (Kumar et al., 2017).Salinity is more severe in the arid and semi-arid regions of the world, characterized by irregular and deficiency rainfall, high temperatures and evapotranspiration (Parihar et al., 2015).Saline stress exerts several effects on the plants ecophysiological process, among them growth inhibition, loss of protective enzyme activity, water and nutrient absorption, cell membrane permeability (Dogan et al., 2010); besides damaging the foliar content of chlorophyll and carotenoids, compromising the photosynthetic activity(Cavalcante et al., 2011; Taiz et al., 2017).

Salinity affects most glycophyte plants, with yellow passion fruit being one of them. According to Ayers & Westcot (1999), yellow passion fruit does not tolerate soil salinity with conductivity greater than 1.3 dS m^{-1}, because it causes potential loss of yield. The marginal effects of salinity act during all phases of the plants (Cavalcante et al., 2002). However, the first contact between the saline environment and the seedlings begins during the growth of the embryonic axis of the seed, and this can almost always compromise the germination process that constitutes the most important phase for the evaluation of the behavior of a given culture to the salinity (Nascimento et al., 2012).

The yellow passion fruit is very demanding in potassium, in general, it is the second nutrient, after the nitrogen, more demanded by the plants (Calvalcante et al., 2015). Potassium participates in several phases of metabolism, as in the reaction of phosphorylation, synthesis of carbohydrates, proteins, regulations, respiration and regulation of the opening and closing of stomata. It is also acts on root development, fruiting, maturation and fruit quality, as it is responsible for the conversion of starch to sugars (Taiz et al., 2017).

Some recent studies have shown that it is possible to produce in the saline environment using techniques that can alleviate the harmful effects of salinity on plants. According to Silva et al., (2011), conventional techniques of fertilization, based on the use of fertilizers favor the acquisition of the nutrients by plants in condition of salinity. Potassium play a vital role and stimulates various biological processes in plants such as enzymatic activities, photosynthesis, improvement in water balance and may be an alternative to increase plant tolerance to salinity (Prazeres et al., 2015); besides its management may results in a higher competition of this macroelement with the sodium ion (Heidari & Jamshid., 2010). In this context, Saida et al. (2014) observed that potassium fertilization attenuated the deleterious effects of salinity in the tomato crop stimulating the leaf area of the crop.

This study aimed to evaluate the effect of the bovine biofertilizer during the formation of yellow passion fruit seedlings irrigated with increasing salinity water in the soil without and with two potassium sources.

MATERIAL AND METHODS

The study was conducted from September to December 2015 under greenhouse environment of the Agrarian Sciences Center, Federal University of Paraiba, in Areia City, Paraiba State, Brazil, located in the geographical coordinates: latitude 6°58’12” S, longitude 35°42’15” W of the Greenwich Meridian and at an altitude of 619 meters. The climate of the municipality is AS’ type, with means hot and humid, with average values of temperature and relative air humidity of 25 °C and 75% in the warmer month, and 21.6 °C and 87% in the cooler month. The average historical precipitation of the region is of the order of 1200 mm per year, with rainfall concentrated in the period from March to August.

The substrate was obtained from Yellow Red Latosol, collected in the 0-20 cm depth layer. Before installing the experiment, substrate was characterized as to the saturation extract salinity (Richard, 1954); as regard physical and fertility aspects (Table 1), using the methodologies proposed by Donagema (2011).

Treatments were distributed in randomized blocks, with four replications and three units per plot, arranged in the factorial scheme 5 x 3 x 2, referring to the electrical conductivity levels of the irrigation water (0.3, 1.0, 2.0; 3.0, 4.0 dS m^{-1}), in the soil without potassium, with potassium chloride and potassium sulphate, without and with bovine biofertilizer.

The electrical conductivity levels of the irrigation water were obtained by the dilution of a strongly saline water of electrical conductivity - ECiw (15.7 dS m-1) coming from surface dam in non-saline water – ECwi = 0.3 dS m^{-1}.

The mineral fertilization consisted of 116.15 mg dm^{-3} of phosphorus, in the form of single superphosphate (18% P_2O_5; 11% Sand 19% Ca^{2+}) and 115.2 mg dm^{-3} of nitrogen, arising from urea (45% N). The potassium fertilization consisted of 140 mg dm^{-3} of K_2O in the form of KCl (60% K_2O) and 148.5 mg dm^{-3} of K_2O in the form of K_2SO_4 (48% K_2O, 16% S).

The biofertilizer was produced in a biodigester by mixing 60 L of fresh bovine manure together with 60 L of non-saline water (0.3 dS m^{-1}), the recipient being hermetically sealed for 30 days in a shaded place for fermentation anaerobic (Diniz et al., 2013). During this period, a homogenization was done every 24 hours for better fermentation efficiency. To release the methane gas produced by the fermentation, one end of a thin hose was connected to the top of the biodigester, keeping the other end submerged in a recipient with water to prevent air from entering.The biofertilizer was applied once in liquid form in a proportion of 1: 1 by volume of 10% of the substrate volume, equivalent to 250 mL, 24 hours before to seed sowing.

The water supply, from the Jacaré reservoir of the municipality of Remígio, PB and the liquid bovine biofertilizer were evaluated chemically as water for irrigation (Table 2) according to Richard (1954).

The seeds of yellow passion fruit, material known as Guinezinho by the producers of Nova Floresta, PB, were obtained from fruits harvested in a commercial orchard in the municipality of Nova Floresta-PB. The recipients used for conducting the experiment were 3.0 L polyethylene bags, filled with 2.5 L of substrate, since the remainder of the volume was used for the application of fermented bovine manure biofertilizer applied in liquid form. In each bagunit, ten (10) seeds were sown. Seedling emergence started nine days after sowing (DAS), at 15 days after emergence, a thinning was done, with only the most vigorous seedling being kept per recipient. Irrigations were done by the weighing process, providing daily volume of each type of evapotranspiration water the previous day.

At 60 DAS, measurements of the stem diameter were made at 5 cm from the soil with a digital caliper, the count of leaves and leaf area of all the seedlings was estimated by the product between length and greater width, then the correction was carried out by multiplying each value by factor 0.72 suggested by Cavalcante et al. (2002) for yellow passion fruit seedlings.The dry matter of the roots and shoot of the seedlings was obtained after drying the material in oven at 65 °C and weighing in a precision analytical balance. At the same age, the chlorophyll *a* and *b* indexes were measured directly on the top, middle and end of the third leaf of each seedling by the non-destructive method using the chlorophyll meter, ClorofiLOG® model CFL1030.

Data were submitted to analysis of variance by the F test ($p \leq 0.01$, $p \leq 0.05$); the measures related to the soil without and with biofertilizer were compared by the F test that is conclusive for the two factors, the corresponding to the soil without and with sources of potassium by the Tukey test and the ones referring to the electrical conductivity of the water by regression, using the software SAS/STAT® version 9.3 (SAS Institute, 2011).

RESULTS AND DISCUSSION

The increase in the salt concentration of the irrigation water affected the seedling diameter of the yellow passion fruit seedlings, but with less intensity in the treatments with the organic input (Figure 1).The reduction in the diameter of the seedlings by the salinity is due to the decrease of the osmotic pressure, preventing the expansion and the cellular division (Taiz et al., 2017) as for the biofertilizer keeps the substrate moisture close to the root zone, allowing the water absorption and nutrients by seedlings. Dias et al. (2013), evaluating the growth of passion fruit under irrigation with saline water and bovine biofertilizer, verified a negative effect on stem diameter only 59 days after planting for seedlings irrigated with waterof ECiw higher than 2.5 dSm^{-1}, with less harmful effect on the substrate with biofertilizer.On the other hand, Rodolfo Junior et al. (2009) observed increased diameter of the yellow passion fruit stem as a result of the increase of the biofertilizer concentration employed.

The stem diameter was also statistically influenced by potassium adduction, with the lowest values measured in the treatments with potassium chloride. It is believed that this fact occurred because this fertilizer contained chloride in its composition, being aggressive to the metabolism of the plants, when available in high concentration. These results are in conflict with Prado et al. (2004) where found an increase in leaf number in yellow passion fruit seedlings submitted to increasing doses of potassium.

The increasing concentrations of salts of irrigation water inhibited the growth of yellow passion fruit, expressed in leaf area (Figure 2A), root dry matter (Figure 2B) and shoot dry matter (Figure 2C and 2D).According to Silva et al. (2011), the inhibition of growth must have been due in large part to the toxic effects of the salts absorbed by the plants, the low capacity of the osmotic adjustment of the culture and the reduction of the total potential of the water caused by the increase of the saline concentration. These effects may also be associated to the maximum tolerance level of yellow passion fruit crop to soil salinity, which, according to Ayers & Westcot (1999), begins to grow inhibited from 1.3 dS m^{-1}. Similar behavior was observed by Mesquita et al. (2012), evaluating the leaf area of yellow passion fruit during initial growth.

On the other hand, it was observed that, in the treatments with the respective organic input, the plants presented greater leaf area, dry matter of root and shootin relation to the treatments without the input. This fact occurred due to the positive action of the biofertilizer in the attenuation of the deleterious effects of the salinity to the seedlings.Similar behavior was recorded by Nunes et al. (2009), when evaluating the initial growth of *Morinda citrifolia* and yellow passion fruit, and also by Silva et al. (2011) in cowpea plants under irrigation with saline water in soil without and with bovine biofertilizer.

The biofertilizer had a significant effect on the foliar indexes of chlorophyll *a* and *b* (Figure 3A and 3B). It was observed that the highest chlorophyll *a* and *b* values were obtained in the soil with the organic input, with losses of 16.98 and 34.4% in the respective variables among the seedlings of the treatments without the biofertilizer.This increase in chlorophyll indexes may be related to the attenuating action of the biofertilizer in releasing and producing humic substances that elevate the osmotic potential between the interior of the plants and the saline environment, reflecting on the absorption of mineral nutrients and the survival of the crops that, over time, they can grow in salinized adversely means(Larcher, 2006; Taiz et al., 2017).

CONCLUSION

The increase in the electrical conductivity of irrigation water impaired the formation of yellow passion fruit seedlings, but with less loss in the treatments with the bovine biofertilizer.

The bovine biofertilizer does not eliminate but attenuates the effects of irrigation water salinity on growth and chlorophyll accumulation in yellow passion fruit seedlings.

The addition of potassium chloride inhibited the stem diameter of the seedlings.

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Table 1. Chemical (fertility and salinity) and physical attributes of the substrate used for the production of yellow passion fruit seedlings, collected in the 0-20 cm layer

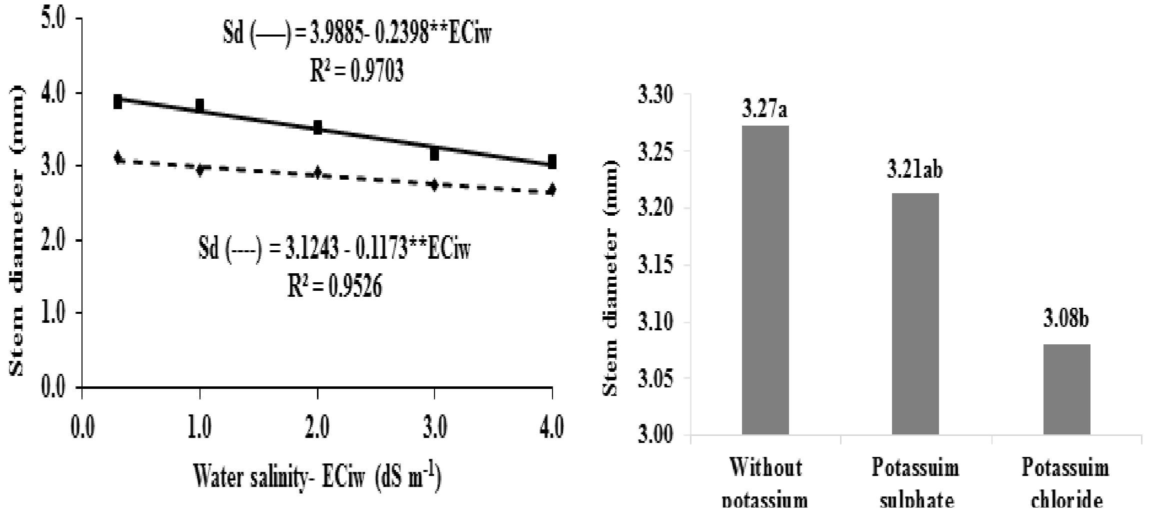
Fertility Attributes	Values	Salinity Attributes	Values	Physical Attributes	Values
pH (1:2,5)	6,53	ECse (dS m^{-1})	1,12	Soil density (g cm^{-3})	1,60
P (mg dm^{-3})	38,15	pH (1:2,5)	5,89	Particles density (g cm^{-3})	2, 69
K^+ (mg dm^{-3})	91,60	Ca^{2+} ($mmol_c$ L^{-1})	0,31	Total porosity (m^3 m^{-3})	0,37
Ca^{2+} (cmolc dm^{-3})	2,40	Mg^{2+} ($mmol_c$ L^{-1})	0,87	Sand (g kg^{-1})	863
Mg^{2+} ($cmol_c$ dm^{-3})	1,70	Na^+ ($mmol_c$ L^{-1})	6,13	Silt (g kg^{-1})	82
Na^+($cmol_c$ dm^{-3})	0,12	K^+ ($mmol_c$ L^{-1})	0,37	Clay (g kg^{-1})	55
Al^{3+}($cmol_c$ dm^{-3})	0,00	Cl^- ($mmol_c$ L^{-1})	0,40	Ada(g kg^{-1})	0,00
H^++Al^{3+}($cmol_c$ dm^{-3})	1,65	CO_3^{2-} ($mmol_c$ L^{-1})	0,00	GF (%)	100,00
SB ($cmol_c$ dm^{-3})	4,45	HCO^-_3 ($mmol_c$ L^{-1})	0,70	Adi (g kg^{-1})	47,02
CEC ($cmol_c$ dm^{-3})	6,10	SO^{2-}_4 ($mmol_c$ L^{-1})	1,15		--
V%	72,96	SAR (mmolL^{-1})	7,98		--
m%	0,00	ESP(%)	1,97		--
SOM (g kg^{-1})	14,80	Classification	NS	Textural classification	SF

SB = Exchangeable base sum - SB = Ca^{2+} + Mg^{2+} + K^+ + Na^+; CEC = Cation exchange capacity - CEC = SB+ (H^+ + Al^{3+}); V = Exchangeable basis saturation = (SB/CTC)*100; SOM = Soil organic matter;ECse = Eelctrical conductivity of soil saturation extract; RAS = Sodium adsorption ratio - SAR = $Na^+/[(Ca^{2+}+Mg^{2+})/2]^{1/2}$; ESP = Exchangeable sodium percentage - ESP = (Na+ /CTC)*100; NS = Non saline; Ada = Clay dispersed in water; DF = Degree of flocculation; Adi = Water available; SF = Sand franca.

Table 2. Chemical characterization of non-saline water (NSW), dam saline water (DSW) and biofertilizer (BIO).

Água	pH	ECse	Ca^{2+}	Mg^{2+}	Na^+	K^+	SC	Cl^-	CO_3^-	HCO_3^-	SO_4^{2-}	SA	SAR	CL
	H_20	dS m^{-1}	------------------------------------				mmol$_c$ L^{-1}		------------------------------------				(mmol $L^{-1})^{0,5}$	
NSW	6,15	0,48	1,08	0,66	2,03	1,12	4,89	3,78	0,00	0,32	0,76	4,86	2,18	C_1S_1
DSW	8,52	15,70	10,83	37,53	102,2	2,69	153,3	111,6	2,10	40,49	0,80	154,9	20,80	C_4S_4
BIO	6,74	3,67	11,09	8,11	5,12	13,17	37,49	25,91	0,00	5,47	5,35	36,73	1,65	C_4S_1

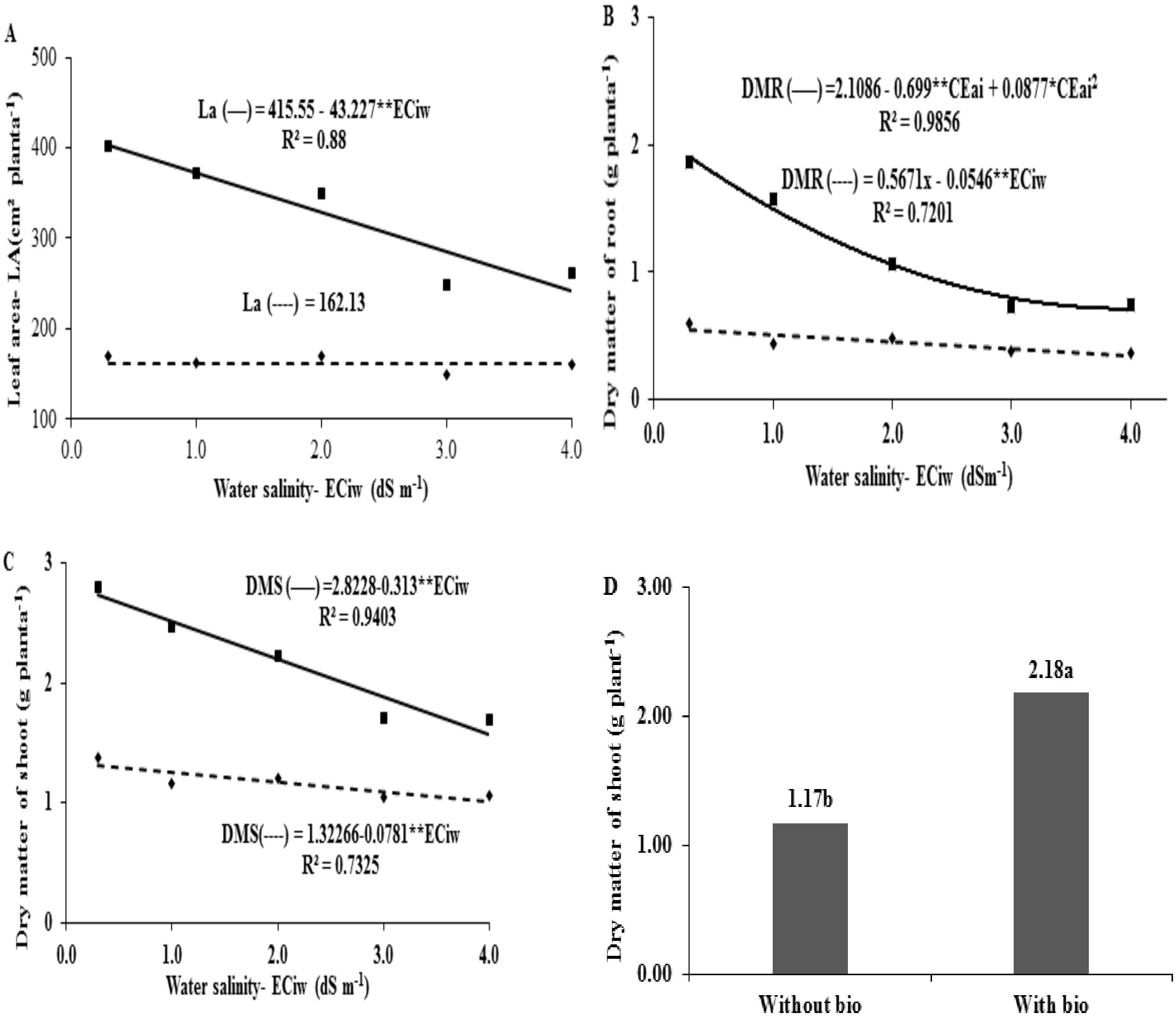
ECse = Electrical conductivity of saturation extract; SAR = Sodium adsorption ratio - SAR = Na + / [(Ca2 ++ Mg2 +) / 2] 1/2; CL = classification; SA = Sum of anions.



**: significant at 1% probability by test F

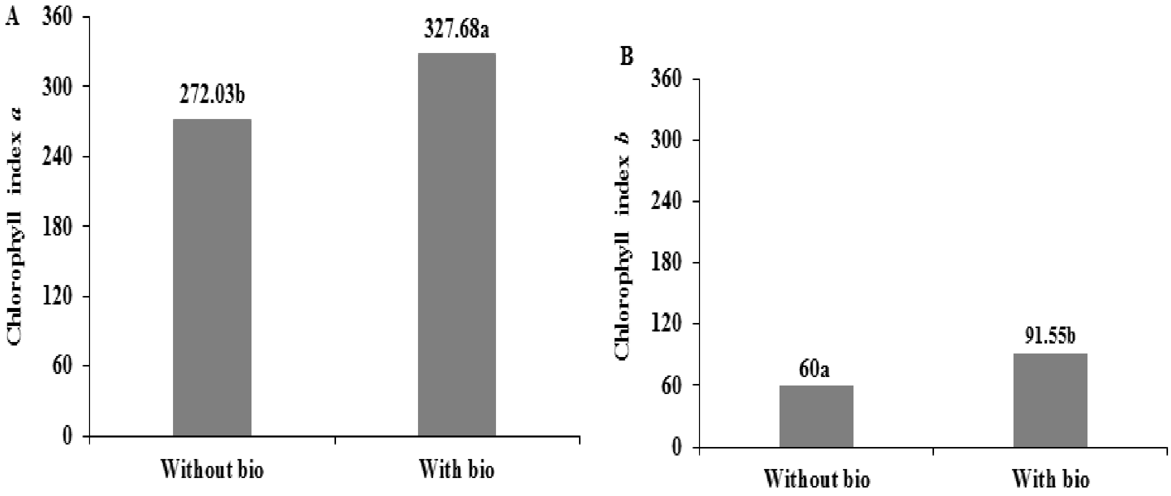
Means followed by the same letter do not differ by Tukey's test (p ≤0.05).

Figure 1. Stem diameter (Sd), as a function of the salinity of the irrigation water in the soil without (----) and with (—) bovine biofertilizer, and as a function of the potassium sources in the substrate.



** and *: significant at 1% and 5% of probability by the F test.

Figure 2. Leaf area (A), dry matter of root (B), dry matter of shoot (C and D) of yellow passion fruit, as a function of salinity of irrigation water in the substrate without (----) and with (—) bovine biofertilizer.



Means followed by the same letter do not differ by Tukey's test ($p \leq 0.05$).

Figure 3. Leaf indices of chlorophyll a (A) and b (B) on leaves of yellow passion fruit on the substrate without and with bovine biofertilizer at 60 days after sowing.