ISSN: 1984-5529

Científica

Jaboticabal

v.44, n.1, p.91–101, 2016

http://dx.doi.org/10.15361/1984-5529.2016v44n1p91-101

Seedlings of yellow passion fruit in soils degraded by salts treated with bovine biofertilizer

Mudas de maracujazeiro amarelo em solos degradados por sais e tratados com biofertilizante

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Recebido em: 08-02-2015; Aceito em: 24-08-2015

Abstract

Salinity and soil sodicity promote high losses in the quality of seedlings of most commercially important plants, including yellow passion fruit. An experiment was conducted in a greenhouse environment to evaluate the effects of bovine biofertilizer in the emergence and morphological and physiological variables of yellow passion fruit seedlings in an extremely sodic soil and in an extremely saline soil. The treatments were arranged in a randomized block design with three replications and six plants per plot, using a 2 × 2 factorial design referring to a saline-sodic soil and a saline soil with and without bovine biofertilizer for an evaluation in three periods: 40, 60 and 80 days after sowing. The biofertilizer was diluted in a non-saline water (ECw dS = 0.31 m^{-1}) in a 1:1 ratio and applied to the soil surface only once, 24 hours before sowing, with a volume corresponding to 10% of the substrate volume. The seedlings were irrigated with non-saline water, providing an evapotranspirated volume every 24 hours based on the average value obtained by the process of weighing the units of each treatment. From the results, the biofertilizer more efficiently mitigated the salinity of the soil sodicity. In the treatments without organic inputs, seedlings did not emerge in the saline-sodic soil. In the saline soil, seedlings that emerged did not survive the damaging effects of salinity. Despite attenuating the degenerative effects of salinity on plants, the bovine biofertilizer contributes to the increase of saline content in the soil.

Additional keywords: organic input; *Passiflora edulis;* sodicity and salinity of the soil

Resumo

A salinidade e a sodicidade do solo promovem elevadas perdas na qualidade de mudas da grande maioria das plantas de importância comercial, inclusive do maracujazeiro-amarelo. Nesse sentido, um experimento foi conduzido em ambiente telado para avaliar os efeitos do biofertilizante bovino na emergência e nas variáveis morfofisiológicas de mudas de maracujazeiro-amarelo, em um solo extremamente sódico e noutro extremamente salino. Os tratamentos foram arranjados em blocos ao acaso, com três repetições e seis plantas por parcela, usando o esquema fatorial 2 × 2, referente a um solo salino-sódico e um solo salino, sem e com biofertilizante bovino, em amostras divididas no tempo para avaliação em três épocas, aos 40; 60 e 80 dias após a semeadura. O biofertilizante foi diluído em água não salina (CEa = 0,31 dS m^{-1}) na proporção de 1:1 e aplicado na superfície dos solos uma única vez, 24 h antes da semeadura, em volume correspondente a 10 % do volume do substrato. As mudas foram irrigadas com água não salina, fornecendo o volume evapotranspirado a cada 24 h, com base no valor médio obtido pelo processo de pesagem das unidades de cada tratamento. Pelos resultados, o biofertilizante atenua mais eficientemente a salinidade do que a sodicidade dos solos. Nos tratamentos sem o insumo orgânico, as plântulas não emergiram no solo salino--sódico, e as que emergiram no solo salino, não sobreviveram aos efeitos danosos da salinidade. O biofertilizante bovino, apesar de atenuar os efeitos degenerativos da salinidade às plantas, contribui para o aumento do caráter salino dos solos.

Palavras-chave adicionais: insumo orgânico; *Passiflora edulis;* salinidade e sodicidade do solo.

Introduction

The culture of passion fruit has a great production potential and is economically important to Brazil. The yellow passion fruit (*Passiflora edulis* f. *flavicarpa* Deg) is the most cultivated species. Despite the expansion of the cultivated area in recent years, the national productivity is still low and less than 15.0 t ha^{-1}. In the semiarid region, this occurs due to low investment in the sector, the lack of new production technologies and mainly high temperatures, high evapotranspiration rates and low quality of irrigation water of the Brazilian northeast, limiting the growth and development of cultures with a commercial importance (Lopes et al., 2008; Freire et al., 2012.).

Despite the importance of this culture for the Brazilian northeast, production areas are generally characterized by high evaporation, use of water from springs that have an electrical conductivity higher than 1.5 dS m^{-1} and inappropriate use of drainage (Lopes et al., 2008). These factors may cause morphological, physiological and biochemical modifications in seedlings and in plants, affecting the development of crops and the quality of fruits. It also causes a reduced yield (Silva et al., 2008b; Neves et al., 2009).

The salt content of soils in semi-arid areas is a major obstacle to the crop production system in regions subjected to water stress. Its effects are manifested through changes in physical and chemical properties, which reduce the osmotic potential of the soil solution, and by a direct action of specific ions in the mineral nutrition of plants (Mesquita et al., 2012; Dias et al., 2013). This means that the germination and growth of seedlings, including yellow passion fruit seedlings, can be inhibited by the harmful effects of soil salinity during the formation of seedlings or after transplanting (Cavalcante et al., 2009).

In the case of saline-sodic or sodic soils, it is essential to the use of correctives to neutralize the effect of dispersing cation (Na^+) in the soil. Some products such as gypsum, sulfuric acid and vinasse are chemical correctives used with an adequate efficiency. However, some alternatives have been investigated to mitigate the effects of salts in the soil, such as the use of organic matter (Gheyi et al., 1995; Cavalcante et al., 2002). Another alternative which has also been extensively studied to form seedlings and grow in areas affected by salts, or to irrigate them with water that exerts limitations to the majority of cultivated plants, is the use of bovine biofertilizer mainly because it affects the conditioning of the soil, acts as a fertilizer and a microbial inoculant to the soil, contributing positively in the osmotic adjustment between the plant and the environment, enabling a further development of the culture of neem (Nunes et al., 2012; Diniz et al., 2013) and yellow passion fruit (Campos et al., 2011a,b; Mesquita et al., 2012; Dias et al., 2013).

When considering the positive action of humic substances on the physical properties of the soil and on reducing depressive effects of water salinity to plants (Baalousha et al., 2006; Mellek et al., 2010), the use of bovine biofertilizer applied to soils that have restrictions regarding salinity may possibly inhibit the deleterious effects of salts on yellow passion fruit plants, stimulating growth during the formation of seedlings.

In this sense, the objective of this study was to evaluate the formation of seedlings of yellow passion fruit irrigated with water without a salt restriction and grown in strongly saline soils without drainage using liquid bovine biofertilizer.

Material and methods

The study was conducted from May to July 2013 in a laterally shaded greenhouse environment with a white mesh and covered with white plastic film, both without interference to sunlight, at the Department of Soil Sciences and Agricultural Engineering of the Federal University of Paraíba, Areia, Paraíba. The climate of the municipality is As', according to the Köppen classification, which means hot and humid, with temperature averages and relative humidity of 25 °C and 75% in warmer months and 21.6 °C and 87% in colder months, respectively. Inside the greenhouse, the temperature and the relative humidity varied from 26 to 40 °C and from 70 to 85%, respectively.

As a substrate, materials from two soils were used: one extremely salinated and one extremely solodized. Materials were collected in the downstream of the Jacaré reservoir in the municipality of Remígio, PB, and in the sector 9 of the Irrigated Perimeter of São Gonçalo in the municipality of Sousa, PB, belonging to the Federal Institute of Paraíba (IFPB), respectively, at a depth of 0-20 cm. The soils were chemically characterized regarding fertility and physical attributes (Donagema et al., 2011) using the values shown in Table 1 and regarding salinity (Table 2), electrical conductivity, pH and Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-, CO_3^{2-}, HCO_3^- and SO_4^{2-} contents of the saturation extract (Richards, 1954).

The treatments were arranged in a randomized block design with three replications and six plants per plot in a 2 × 2 factorial design. The plots were divided, referring to two soils (Table 1) with and without bovine biofertilizer (Table 2), in three evaluation periods at 40, 60 and 80 days after sowing (DAS). The substrate consisted of 2.5 dm^3 of each soil conditioned in black polyethylene pots with a capacity of 3.0 dm^3. Due to the low organic matter, phosphorus and potassium contents of the respective soils (Table 1) and the biofertilizer, which, because it is fermented and diluted with water, had a low organic matter, nitrogen, phosphorus and potassium contents (2.14, 1.48, 2.13 and 0.32%, respectively), a fertilization was made to raise the levels of N, P and K to 100, 200 and 150 mg dm^{-3} as recommended by Novais et al. (1991) for experiments in greenhouses with non-saline soils. When considering the high salinity and the sodicity of the soils, fertilizers with low saline levels were used for N (urea = 75%), P (simple superphosphate = 8%) and K (potassium sulfate = 46%), using as a reference sodium nitrate with a 100% saline index (Murray & Clapp, 2004).

The bovine biofertilizer was produced anaerobically by fermenting equal parts of fresh manure from dairy cows and non-saline water, according to Diniz et al. (2013). The organic input (bovine biofertilizer) was applied only once over the soil surface in a liquid form, with a 1:1 ratio in relation to non-saline water (EC = 0.31 dS m^{-1}), 24 hours before the sowing with a volume corresponding to 10% of the substrate volume (250 mL of bovine biofertilizer).

Prior to the application of biofertilizer in liquid form in each soil, three 1 L samples were collected at the top, middle and bottom of a biodigester. They were diluted in the same water and the same ratio used for the chemical characterization regarding salinity (Table 2), in the form of analysis of water for irrigation purposes, adopting the methodologies proposed by Richards (1954).

Table 1 - Chemical attributes regarding fertility and physical soil attributes used as substrates.

Fertility	Saline-sodic	Saline	Physical attributes	Saline-sodic	Saline
pH in water (1.0:2.5)	10.52	5.91	Ds (g cm^{-3})	1.76	1.30
OM (g dm^{-3})	8.41	9.32	Dp (g cm^{-3})	2.65	2.77
P (mg dm^{-3})	4.00	6.00	Pt (m^3 m^{-3})	0.33	0.53
K^+ ($cmol_c$ dm^{-3})	0.11	0.12	Sand (g kg^{-1})	656.00	800.00
Ca^{2+} ($cmol_c$ dm^{-3})	2.16	17.71	Silt (g kg^{-1})	288.00	197.00
Mg^{2+} ($cmol_c$ dm^{-3})	0.34	27.22	Clay (g kg^{-1})	56.00	13.00
Na^+ ($cmol_c$ dm^{-3})	3.36	1.12	Cdw (g kg^{-1})	51.00	10.00
BS ($cmol_c$ dm^{-3})	5.97	46.17	DF (%)	8.90	23.00
H^++Al^{3+} (($cmol_c$ dm^{-3})	0.00	0.88	DI (%)	91.10	77.00
Al^{3+} ($cmol_c$ dm^{-3})	0.00	0.31	Mfc (g kg^{-1})	113.90	61.20
CEC ($cmol_c$ dm^{3-})	5.97	47.05	Mpwp (g kg^{-1})	31.60	30.40
V (%)	100.00	98.13	AW (g kg^{-1})	82.30	30.80
ESP (%)	56.22	2.38	------	------	------

OM = soil organic matter; BS = base sum (K^+ + Ca^{2+} + Mg^{2+} +Na^+); CEC = cation exchange capacity [BS + (H^+ + Al^{3+})]; V = base saturation [100 (BS/CEC)]; ESP = exchangeable sodium percentage = 100 (Na^+/CEC); Ds = soil density; Dp = particle density; Pt = total porosity; Cdw = clay dispersed in water; DF = degree of flocculence; DI = dispersion index = 100 - DF; Mfc = soil moisture at field capacity; Mpwp = soil moisture at permanent wilting point; AW = available water.

Table 2 - Results of chemical analyses of the soil, bovine biofertilizer in liquid form and the water used in irrigation regarding its salinity.

Variables	Saline-sodic	Saline	Biofertilizer	Water
pH	10.41	5.83	6.77	7.16
EC at 25°C (dS m^{-1})	23.91	47.17	3.11	0.31
Ca^{2+} ($mmol_c$ L^{-1})	3.12	142.50	7.02	1.25
Mg^{2+} ($mmol_c$ L^{-1})	1.88	307.50	9.21	1.25
Na^+ ($mmol_c$ L^{-1})	242.35	29.08	5.12	0.78
K^+ ($mmol_c$ L^{-1})	0.46	1.76	9.56	0.16
Cl^- ($mmol_c$ L^{-1})	172.90	436.40	10.50	2.25
CO_3^{2-} ($mmol_c$ L^{-1})	13.06	a	a	a
HCO^-_3 ($mmol_c$ L^{-1})	9.17	5.00	8.80	0.51
SO_4^{2-} ($mmol_c$ L^{-1})	a	39.43	nd	nd
SAR ($mmol_c$ L^{-1})	153.27	1.94	1.89	0.70
Classification	*	**	C_4S_1	C_1S_1

EC = electrical conductivity; SAR = sodium adsorption ratio = Na^+ $[(Ca^{2+} + Mg^{2+})/2]^{1/2}$; a = absent; nd = not determined; * = Extremely sodic, ** = Extremely saline; C_1 = low risk of salinity; C_4 = high risk of salinity; S_1 = Low risk of sodicity.

The seeds of yellow passion fruit were obtained from fruits harvested from selected plants based on the mass selection of the local genotype known as "Guinezinho" from a commercial orchard in the city of Remígio, Paraíba. This genotype is traditionally grown under irrigation with water that has an electrical conductivity of 3.2 to 3.6 dS m^{-1} (Cavalcante et al., 2005; Diniz et al., 2012) in the municipalities of Cuité and Nova Floresta in Paraíba and Jaçanã and Coronel Ezequiel in Rio Grande do Norte. This type of water exerts a high salt restriction to agriculture in general, including yellow passion fruit. Then, 100 seeds were sown in each quadrant of a plastic tray with washed sand and irrigated with the same water used for the preparation of the biofertilizer and the irrigation of the experiment. An emergence percentage of 92% was obtained.

One day after the application of the bovine biofertilizer, the irrigation of each soil and the sowing of five seeds per experimental unit were made. The beginning of the emergence occurred at 10 DAS. Irrigation was performed every day in the evening using the mass measurement method in an electronic scale with a capacity of 5 kg with 20 g divisions to raise the moisture of both soils to the field capacity level. In the treatments without biofertilizer, all 2.5 kg of each soil were irrigated until draining and another 10% of the water blade were applied until the start of drainage. After cessation of drainage, the mass of the soil-water system was measured and each value was adopted as the field capacity standard. In the irrigation of these treatments, the volumes were applied to increase the mass of each experimental unit in 24 hours up to the standard value. In the treatments with biofertilizer, the organic liquid input was firstly applied to the surface of each experimental unit. A complete infiltration was expected and water was supplied until the drainage began. From the beginning of the drainage, the procedure was the same for the treatments without biofertilizer.

The emergence of normal seedlings of yellow passion fruit was evaluated at 40, 60 and 80 DAS. The multiplication of the relation between emerged seedlings was made, divided by the number of seeds sown, and multiplied by the 92% viability. At 40, 60 and 80 DAS, the height from the base of the plant and the end of the apical bud was also obtained with a millimeter ruler. The stem diameter was obtained using a digital caliper with 6" (150 mm), DC-60 Western, measured in millimeters, at the base of the plant. The leaf area was quantified through photographic images taken with digital camera and processed by the software Sigma Scan Pro 5.0 Demo. The length and the diameter of the main root was measured with a millimeter ruler and a digital caliper. Then, the green biomass of the seedlings was washed and put to dry in an oven with ventilation at 65 °C to obtain the mass of the total dry matter of seedlings in a semi-analytical balance with 0.01 g accuracy. At each evaluation date, the samples of the initial, middle and end parts of each experimental unit were collected and transformed into a composite sample for the evaluation of the electrical conductivity of the saturation extract and the pH of the saturated extract (Richards, 1954).

The results were submitted to an analysis of variance by F test, evaluated by comparison of means by Tukey test at 5% probability, using the SAS® software version 9.3 (SAS®, 2011).

Results and discussions

According to the summaries of analyses of variance, it is verified that, except for the pH of the saturated extract, which responded to the effects of the interaction between the soil and the age of the seedlings, the other variables were influenced by the interaction soil x biofertilizer x age of plants after seeding (Table 3).

Table 3 - Summary of analyses of variance by the mean square for the electrical conductivity of the soil saturation extract (ECse), pH of the saturated extract, emergence of normal seedlings (EMER), plant height (PH), stem diameter (SD), leaf area (LA), length of the main root (LROOT), diameter of the main root (DROOT) and total dry matter (TDM) of yellow passion fruit seedlings.

F. V.	DF	ECse	pH	EMER	PH	SD	LA	CROOT	DROOT	TDM
Block	2	0.7^{ns}	0.094^{ns}	40.1^{ns}	0.009^{ns}	0.008^{ns}	2.9^{ns}	0.02^{ns}	0.001^{ns}	0.0003^{ns}
Soil (S)	1	13671.0**	136.072**	9074.3**	38.327**	2.814**	727.4**	21.84**	2.224**	0.1296**
Bio. (B)	1	95.6**	0.028^{ns}	10265.0**	41.969**	3.287**	1248.5**	61.24**	3.362**	0.1503**
S×B	1	3.5^{ns}	0.003^{ns}	8485.6**	35.294**	2.478**	623.9**	7.24**	1.928**	0.0788**
Error A	6	5.2	0.077	44.5	0.011	0.009	6.5	0.31	0.005	0.0001
Age (A)	2	219.3**	0.425*	171.5**	0.375**	0.047**	158.9**	10.03**	0.087**	0.0083**
S×A	2	34.2**	1.309**	73.5^{ns}	0.181**	0.020*	254.5**	3.87**	0.022^{ns}	0.0073**
BxA	2	18.6^{ns}	0.063^{ns}	119.0*	0.213**	0.021**	160.6**	1.41**	0.036*	0.0054**
S×B×A	2	31.0*	0.176^{ns}	78.8**	0.288**	0.043**	297.5**	15.59**	0.064**	0.0213**
Error B	16	5.1	0.076	21.4	0.008	0.003	1.5	0.13	0.006	0.0002
Total	35	-	-	-	-	-	-	-	-	-
CVa (%)		4.30	3.45	38.30	9.69	30.83	41.11	34.44	22.12	12.85
CVb (%)		4.20	3.43	26.50	8.22	17.98	19.82	22.67	24.78	18.17

^{ns} = not significant; * and ** = significant levels at 5 and 1% probability for the F test, respectively; DF = degrees of freedom; CV = Coefficient of variation; Bio. = Biofertilizer.

The electrical conductivity of the saturation extract, which expresses the total concentration of salts dissolved in the solution in both soils (Richards, 1954; Ayers & Westcot, 1999), with a superiority of the treatments with bovine biofertilizer and saline soil in relation to saline-sodic soils, was too high (Table 4). This supremacy, although consistent with the initial saline conditions of the respective soils before applying the treatments, with values of 23.91 dS m^{-1} for the saline-sodic soil and 47.17 dS m^{-1} for the saline soil (Table 2), is a response to a leaching water depth of at least 10% not being adopted (Ayers & Westcot, 1999; Cavalcante et al., 2010) for the washing of the soils to promote the leaching of salts.

The increase in the concentration of salts in the treatments without biofertilizer was caused by the high evaporation rates caused by the high temperatures inside the protected environment, reaching 40 °C and resulting in high accumulations of salts. In the treatments with the mentioned organic input, in addition to the remaining salts of the soils from accumulations resulting from evaporation, the biofertilizer also has a high electrical conductivity (3.11 dS m^{-1}) and stimulates the increase of the soil salinity. This was also verified by Diniz et al. (2013) studying the effects of salinity of irrigation water and bovine biofertilizer on the growth and water consumption of neem (*Azadirachta indica)*. They verified a greater increase in the levels of soluble cations and anions and consequently in a higher electric conductivity of the soil saturation extract.

Table 4 - Values of the electrical conductivity of the saturation extract (ECse) and the pH of the saline-sodic and saline soils, with and without bovine biofertilizer, during the formation of yellow passion fruit seedlings at 40, 60 and 80 days after sowing (DAS).

Soil type	[(1)]Bovine Biofertilizer					
	Days after sowing - DAS					
	40	60	80	40	60	80
	Without			With		
	Electrical conductivity of the soil saturation extract (dS m^{-1})					
Saline-sodic	29.38 bAβ	37.53 aAβ	29.81 bBβ	26.36 bAβ	40.03 aAβ	38.21 aAβ
Saline	66.16 bBα	72.05 aAα	73.53 aAα	70.92 bAα	75.67 abAα	76.83 aAα

[(1)] Means followed by the same lowercase letters in lines between the different ages, in the same use conditions of bovine biofertilizer, uppercase letters in lines between the different conditions of use of bovine biofertilizer in the same age, and the same Greek letters in columns do not differ statistically from each other by Tukey test (P < 0.05).

In the saline-sodic soil without bovine biofertilizer (Table 4), there was no significant difference between the values of the electrical conductivity of the saturation extract (ECse) of the first (29.38 dS m^{-1}) and last evaluation (29.81 dS m^{-1}), at 40 and 80 DAS, respectively. However, they were significantly lower in 27.7 and 25.9% at 37.53 dS m^{-1} referring to 60 DAS. In treatments with the organic input, the electrical conductivity increased by 51.85% from the first (26.36 dS m^{-1} at 40 DAS) to the second reading (40.03 dS m^{-1} at 60 DAS), without differing from the average value of the third evaluation (38.21 dS m^{-1} at 80 DAS) (Table 4). In both situations, the order of ECse values was 60>80>40 DAS. It may have been due to a reduction of temperature and an increase of relative air humidity inside the shaded greenhouse, keeping the soil less heated and wetter and resulting in less evaporation and in a lesser accumulation of salts (Richards, 1954; Cavalcante et al., 2005).

Comparing the average values among treatments with and without bovine biofertilizer at the same period after seedlings emergence, it is clear that in the first and the second evaluation (40 and 60 DAS, respectively), the application of organic input did not interfere with the electrical conductivity of the soil. On the other hand, at the last reading (80 DAS), the biofertilizer provided an increase of 28.17% in the ECse of the soil in relation to the first reading (Table 4). These higher values can be attributed to a high electrical conductivity of the organic input (3.11 dS m^{-1}) before its application to the soil (Table 2) and to the absence of soil's salt leaching.

As to the saline soil, its superiority over the saline-sodic soil is due to its higher salt content, as indicated in Table 2. The saline condition, expressed by ECse, increased over the evaluation period after the emergence of normal seedlings, mainly from the first to the second sampling, regardless of soil (with or without bovine biofertilizer) (Table 4). In the treatments without organic inputs, the values from the first evaluation differed significantly from the second (72.05 dS m^{-1}) and third (73.53 dS m^{-1}) evaluations, respectively. These values express a superiority of 9.0% when compared to the first evaluation (66.16 dS m^{-1}). The values of the second evaluation (75.67 dS m^{-1}) did not differ from the third evaluation (76.83 dS m^{-1}) and the first reading (70.92 dS m^{-1}) in treatments with bovine biofertilizer. These figures show an 8.3% increase in the electrical conductivity of the soil saturation extract from the first to the third evaluation period.

By the comparison of electrical conductivity values of the saturation extract of the saline soil, between treatments with and without the natural input, in the same period of evaluation, it appears that there was a statistical difference with the application of the organic input only in the first evaluation period (Table 4). The tendency of data to be superior in treatments with the natural input in both soils is in accordance with Mesquita et al. (2012) for yellow passion fruit crops and with Diniz et al. (2013) for neem crops.

The respective increases in salinity in both soils, independently of the absence or presence of biofertilizer, the high temperatures in the environment where the experiment was developed, the action of the input in promoting the release of some complex elements from the exchange of each soil to the solution, and the high electrical conductivity of the biofertilizer are mostly responses to the absence of draining and to the washing of salts of the respective soils for the leaching of the root zone of the plants (Cavalcante et al., 2010). This indicates the need to use drainage and apply a water blade at least 10% greater than the irrigation water blade (Ayers & Westcot, 1999; Cavalcante et al., 2010), as done by Mesquita et al. (2012) and Diniz et al. (2013) for the leaching of salts, contributing to the correction of soils degraded by salts.

Regardless of saline or saline-sodic soil, the high electrical conductivity values establish the saline character of both soils as extremely saline, wherein ECse exceeds 18.0 dS m^{-1} (Richards, 1954). This situation undermines, for agriculture in general, the process of seed germination, seedling emergence, initial growth and the quality of seedlings for growing almost all economically interesting plants, even yellow passion fruit (Ayers & Westcot, 1999; Cavalcante et al., 2007).

The pH of the soil saturated extract was not influenced by the interaction soil x biofertilizer x age of the seedlings. However, these effects responded to the interaction between the different soils at post-emergence evaluation periods of normal seedlings (Table 5). In all evaluation periods, the pH of the saline-sodic soil was higher than values for the saline soil. This superiority is a response from the initial values of pH of the soils at the beginning of the experiment implementation (Table 2), which were 10.41 and 5.83 for saline-sodic and saline soils, respectively. As mentioned for ECse, the need of using a leaching fraction for soil washing and drainage for the leaching of the salts of the respective soils is thus evidenced. This practice reduces the salt content of soils originally high in salt content (Barros et al., 2005), as is the case, or caused by irrigation with saline water for an electrical conductivity levels that allow germination and formation of seedling with an apt quality for planting (Mesquita et al., 2012; Diniz et al., 2013).

Table 5 - pH values of saline-sodic and saline soils during the formation of yellow passion fruit seedlings at 40, 60 and 80 days after sowing (DAS).

Soil type	[(1)]pH		
	Days after emergence - DAE		
	40	60	80
Saline-sodic	9.85 aA	10.01 aA	10.14 aA
Saline	6.59 aB	6.19 abB	5.56 bB

[(1)] Means followed by the same lowercase letters in rows and uppercase in columns do not differ statistically by Tukey test (P < 0.05).

In the saline-sodic soil, pH values of 9.85, 10.01 and 10.14 of the saturated extract did not differ at 40, 60 and 80 DAS. This statistical similarity and a high pH conservation is due to the absence of drainage to bicarbonates and carbonates leaching (Richards, 1954; Leite et al., 2010), thus keeping the value high. In saline soil, there are pH reductions along the evaluation periods of 15.5% between the values determined at 40 and 80 DAS. This reduction is in accordance with Sousa et al. (2008). They established that the increase in the salinity of irrigation water in the soil with bovine biofertilizer reduced the soil pH during the formation of yellow passion fruit seedlings.

When considering that the viability of seeds was 92%, it is possible to verify that the saline-sodic and the saline character of the soil significantly inhibited the germination process of yellow passion fruit evaluated at 40 DAS (Table 6), in general more drastically in the saline-sodic soil and in the treatments without bovine biofertilizer (Table 6).

In saline-sodic soil, in the treatments without bovine biofertilizer, the emergence inhibition was 100%. Thus, the null value (0.00) expressed in Table 6 for emergence and other variables indicates that there was no seedling emergence or that after emergence, the seedlings did not survive. The seedlings did not emerge because the excessive salinity stress reduces water absorption and increases the concentration of salts absorbed by the seeds. This is caused by the negative effects of salinity and sodicity on the survival and quality of seedlings (Munns et al., 2006; Silva et al., 2008a). In this case, there is a reduction of the seed imbibition speed, decreasing the potential for germination, delaying or preventing the division and cell expansion, and undermining the production and the mobilization of reserves vital to the germination process (Taiz & Zeiger, 2013). In the same soil with the organic input, seedlings, despite a low percentage, emerged as the data at 40 DAS indicate (Table 6).

In saline soil without biofertilizer, even with a low value, the seedlings emerged as the data in Table 6 indicate. The significant superiority of 53.16%

compared to 3.14% at 40 DAS indicates the positive action of the liquid organic input in alleviating the depressive action of salts on plants during the process of seed germination. Positive results, but in much lower proportions, were presented by Cavalcante et al. (2007) during the formation of yellow passion fruit seedlings in a saline soil with a 5.0 dS m^{-1} ECse, combined with bovine biofertilizer before sowing and 30 days after emergence (DAE). Despite the high saline level of the soil, it appears that a bovine biofertilizer content less than 50% reduced the degenerative effects of salinity on seedling emergence, even if inefficiently (Table 6). This situation is evident when comparing the values of 3.14 and 53.16% at 40 DAS with the initial value of 92%. It is possible to verify that the emergence losses were 96.6% and 42.2%, respectively, in the soil without and with bovine biofertilizer. The 96.6% loss at 40 DAS shows the degenerative action of salts (Mesquita et al., 2012) and the 42.2% loss indicates a positive action of bovine biofertilizer on the germination process of passion fruit seeds in a soil with a high degree of salinity (Cavalcante et al., 2009; Campos et al., 2011a).

Table 6 - Mean values of seedling emergence, stem height and stem diameter of yellow passion fruit seedlings grown in saline-sodic and saline soils with and without bovine biofertilizer at three evaluation periods (40, 60 and 80 days after sowing - DAS).

Soil type	[1]Bovine Biofertilizer					
	Days after sowing - DAS					
	40	60	80	40	60	80
	Without			With		
	Seedling emergence (%)					
Saline-sodic	0.00 aAβ	0.00 aAα	0.00 aAα	9.20 aAβ	0.00 aAβ	0.00 aAβ
Saline	3.14 aBα	0.00 aBα	0.00 aBα	53.16 bAα	70.53 aAα	72.88 aAα
	Plant height (cm)					
Saline-sodic	0.00 aBβ	0.00 aAα	0.00 aAα	0.54 aAβ	0.00 bAβ	0.00 bAβ
Saline	0.25 aBα	0.00 bBα	0.00 bBα	4.30 bAα	3.71 cAα	4.67 aAα
	Stem diameter (mm)					
Saline-sodic	0.00 aBα	0.00 aAα	0.00 aAα	0.24 aAβ	0.00 bAβ	0.00 bAβ
Saline	0.11 aBα	0.00 aBα	0.00 aBα	1.01 cAα	1.17 bAα	1.31 aAα

[1] Means followed by the same lowercase letters in lines between the different periods, in the same use conditions of bovine biofertilizer, uppercase letters in lines between the different conditions of use of bovine biofertilizer, and the same Greek letters in columns do not differ statistically from each other by Tukey test ($P < 0.05$).

By comparing the results, it is clear that the organic input was more effective in reducing the negative effects of salinity than sodicity during the process of seed germination, as assessed by the emergence of normal seedlings. When chemically considering that the reduction of sodicity of saline-sodic soil (Richards, 1954; Barros et al., 2005; Leite et al., 2010) is made by replacing the sodium of the soil exchange complex by the calcium from the chemical corrective applied, or by an organic compound rich in calcium (Cavalcante et al., 2002), and that the biofertilizer was applied in a liquid form and has a low calcium concentration (7.02 $mmol_c$ L^{-1}) (Table 2), the sodium character was not reduced. Due to the supremacy of the variables evaluated in saline soil, it is clear that during the emergency process, the yellow passion fruit is more sensitive to sodicity than salinity. A similar tendency of the effects of bovine biofertilizer on reducing the harmful action of salts on the seedling emergence and seed germination, in soils seriously compromised by salts, was presented by Campos et al. (2011a), after studying the same culture in a sodic Luvisol with liquid bovine manure or bovine biofertilizer.

The action of the biofertilizer during the early seedling growth was similar to that observed for the process of seedling emergence. It was more effective in attenuating the marginal effects of salinity on the saline soil when compared to the saline-sodic soil. Normal seedlings that emerged until 40 DAS in the saline soil without biofertilizer and in the saline-sodic soil with biofertilizer did not survive the salt stress. By the results of growth in height of the saline soil seedlings with biofertilizer at 40, 60 and 80 DAS, it is verified that the yellow passion fruit, however sensitive to salinity (Ayres & Westcot, 1999), is more sensitive to the saline adversity of the soil in the growth phase than during the seedling emergence. This behavior of the data is also similar to that reported by Sousa et al. (2008) after evaluating the effects of salinity during the emergence and the formation of yellow passion fruit seedlings irrigated with saline water.

In saline soil with biofertilizer, plant height at 80 DAS overcame that recorded at 40 and 60 DAS in the following order: 4.67 > 4.30 > 3.71 cm. These values are low, considering that the growth of seedlings, in their respective ages, is significantly lower than that obtained in environments without salt stress (Sousa et al., 2008). However, on the other hand, they express the stimulus of the input in the growth of seedlings under salt stress in relation to the same soil without the input, which could not tolerate the aggressiveness of the salts and died after 40 DAS.

These results indicate, especially in the saline soil, the more effective action of the bovine biofertilizer in stimulating the production of vital substances such as organic solutes, nucleic acids, enzymes, proteins and the supply of humic substances, which contribute to plant growth (Boraste et al., 2009; Patil, 2010).

As for stem diameter, the values in saline-sodic soil with biofertilizer, at the first evaluation period (40 DAS), were 0.24 mm. As verified for the emergence and growth in height, seedlings withered and died possibly due to chemical conditions in function of the high alkalinity shown by pH, high salinity (ECse) and high sodicity (ESP), as observed by Campos et al. (2011a) and physical impairment due to the low proportion of macropores in relation to water dynamics and nutrients in relation to seedlings (Cavalcante et al., 2009).

As shown by the growth in height, stem diameter values of seedlings developed in the saline soil also demonstrate mitigation of the biofertilizer in relation to the degenerative effects of mineral salts on the seedlings of yellow passion fruit (Table 6). By the relation between the 0.11 and 1.01 mm values in soil with and without bovine biofertilizer, at the first evaluation period (40 DAS), it is observed that the input inhibited 89.1% of the compromising effects of salinity on stem diameter of the seedlings. In the third evaluation (80 DAS), a growth in stem diameter was verified only in the soil with common biofertilizer, with no development of seedlings occurring in the treatment without bovine biofertilizer. Freire et al. (2012), studying the same crop under salt stress and biofertilization in a greenhouse protected against water loss, found that the stem diameter of yellow passion fruit was greater in the treatments using a natural input. This phenomenon occurs due to humic substances, such as biofertilizer, providing the production of organic solutes such as organic acids, carbohydrates, sugars (such as sucrose), proteins and enzymes with a vital importance (Boraste et al., 2009; Patil, 2010), which reduce the intensity of the depressive action of salinity on plants.

As recorded for height and stem diameter, the salinity and sodicity character of the soils damaged the leaf expansion of yellow passion fruit during the formation of the seedlings, but as with the emergence and the variables of initial growth, with a less intensity in plants from treatments with bovine biofertilizer (Table 7). The values of leaf area at 40 DAS were 10.35 cm^2 for seedlings in the saline-sodic soil with bovine biofertilizer. They confirm, as seen in the emergence and initial growth (Table 6), that the biofertilizer stimulated the expansion of leaf area in the saline soil compared to the saline-sodic soil. This statement is because in the treatments without biofertilizer, seedlings did not emerge in the saline-sodic soil, and those that emerged in the saline soil did not survive the salt stress, as recorded for height and stem diameter from 40 DAS (Table 6). Regarding leaf area in the saline soil with organic input, despite lower than 83.61 cm^2, as obtained by Campos et al. (2011b) in a sodic Luvisol with biofertilizer, they grew differently to levels of 33.1 and 291.7% at 60 and 80 DAS, respectively. These increases express the stimulus of the biofertilizer to promote the reduction of the degenerative effects of salts, resulting, even in an incipient way, in an increased and gradual osmotic adjustment of plants under salt stress by the action of humic substances derived from biofertilizer. This contributes to the adjustment of the osmotic potential in the root zone, which is reflected in an increased cell division and therefore in a further expansion of the leaves (Baalousha et al., 2006; Taiz & Zeiger, 2013).

Table 7 - Mean values of leaf area, length of the main root, root diameter and total dry mass of yellow passion fruit plants grown in saline-sodic and saline soils with and without bovine biofertilizer at three evaluation periods (40, 60 and 80 days after sowing - DAS).

Soil type	[(1)]Bovine Biofertilizer					
	Days after sowing - DAS					
	40	60	80	40	60	80
	Without			With		
	Leaf area (cm^2)					
Saline-sodic	0.00 aBα	0.00 aAα	0.00 aAα	10.35 aAα	0.00 bAβ	0.00 bAβ
Saline	1.99 aBα	0.00 aBα	0.00 aBα	9.97 cAα	13.27bAα	39.05 aAα
	Length of main root (cm)					
Saline-sodic	0.00 aBβ	0.00 aAα	0.00 aAα	5.13 aAα	0.00 bAβ	0.00 bAβ
Saline	1.90 aBα	0.00 bBα	0.00 bBα	3.64 bAβ	4.32 abAα	4.53 aAα
	Diameter of main root (mm)					
Saline-sodic	0.00 aBα	0.00 aAα	0.00 aBα	0.36 aAβ	0.00 bAβ	0.00 bAβ
Saline	0.11 aBα	0.00 aBα	0.00 aBα	1.14 aAα	1.11 aAα	1.09 aAα
	Total dry matter (g)					
Saline-sodic	0.00 aBβ	0.00 aAα	0.00 aAα	0.11 aAβ	0.00 bAβ	0.00 bAβ
Saline	0.08 aBα	0.00 bBα	0.00 bBα	0.19 bAα	0.20 bAα	0.35 aAα

[(1)] Means followed by the same lowercase letters in lines among the different periods, in the same use conditions of bovine biofertilizer, uppercase letters in lines among the different conditions of use of bovine biofertilizer in the same age, and the same Greek letters in columns do not differ statistically from each other by Tukey test ($P < 0.05$).

The length of the main root of plants grown in the saline-sodic soil with biofertilizer at 40 DAS, although low, was 5.13 cm, but the seedlings did not survive the adverse effects of sodicity. On the other hand, in the saline soil, the organic input promoted increases from 3.64 to 4.32 and 4.53 cm, referring to 18.7 and 23.4% from 40 to 60 and 80 DAS, respectively. An increase of 91.6% in root length of seedlings of the soil with and without biofertilizer is also observed by the relation of the values 1.90 and 3.64 cm. This increase is reflected in a 47.8% mitigation of the biofertilizer regarding the harmful effects of soil salinity compared to soil seedlings without the input. By comparison, the results are in agreement with those obtained Cavalcante et al. (2009) in seedlings of yellow passion fruit grown in a saline soil with a 5.0 dS m^{-1} ECse with biofertilizer applied before sowing and 30 days after seedling emergence.

The growth assessed by root diameter, as well as other variables, was significantly higher in the saline soil. In treatments without biofertilizer, there was no emergence in saline-sodic soils and the plants that emerged in the saline soil did not survive after 40 DAS (Table 7). In cases with the biofertilizer, normal seedlings emerged in the saline-sodic soil with a low diameter (0.11 mm). They did not tolerate the high sodicity and did not survive after 40 DAS. On the other hand, in the saline soil, despite the decreasing values from 1.14 to 1.11 and 1.09 mm, not considering age at 40, 60 and 80 DAS, it can be seen that the organic input reduced the inhibitory action of salinity during the initial growth of seedlings. The results are in agreement with Nunes et al. (2012), who verified that the root diameter of neem seedlings (*Azadirachta indica*) irrigated with saline water was higher in treatments with the biofertilizer when irrigated with water with an increasing salinity.

The statistical behavior of the mass of total dry matter of yellow passion fruit was similar to the other variables assessed, with superiority of seedlings developed in soils with bovine biofertilizer (Table 7). In the saline-sodic soil, plants were only able to survive in the treatments with biofertilizer up to 40 DAS. In the saline soil, in treatments without biofertilizer, plants only evolved up to 40 DAS, reaching senescence from that age (Table 7). As shown in Table 6, the biofertilizer attenuated the effects of sodium in the saline soil, where it can be seen that at the first period of evaluation (40 DAS), the mean values were 0.08 and 0.19 g in the soil with and without biofertilizer, respectively, representing an increase of 137.5% in the treatments with organic input.

Data produced by Campos et al. (2011b) allow concluding that bovine biofertilizer applied in liquid form to a sodic Luvisol stimulates the growth in height and stem diameter, main root length, leaf expansion and production of dry biomass of yellow passion fruit seedlings. A positive action, as evidenced in the data at hand, according to Boraste et al. (2009), Patil (2010) and Taiz & Zeiger (2013), is due to the positive effects of humic substances, which stimulate an enzymatic activity for improving mineral nutrition, root growth and production of organic solutes such as soluble carbohydrates, proteins and enzymes, which provide the osmotic adjustment of plants under adverse salt conditions. In addition to the chemical and biological effects, there are also positive effects on physical improvement, increasing soil aeration for water, and air and root growth dynamics (Mellek et al., 2010).

Conclusions

Bovine biofertilizer exerts a more effective action on reducing salinity than soil sodicity, but it raises the saline content of the soil.

In treatments without the organic input, seedlings did not emerge in the saline-sodic soil and those that did emerge did not survive after 40 days after sowing.

In the saline soil, the biofertilizer stimulated the growth in height, stem diameter, leaf area, root diameter, root length and mass production of total dry matter of plants after 40 days after sowing. Under the same conditions in the saline-sodic soil, seedlings emerged and did not survive.

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