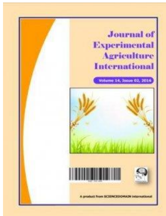

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# Growth and Development of Passion Fruit Seedlings under Irrigation with Salt Water and Biofertilizer

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author FOM performed the study or project and performed the statistical analysis. Author PLBR managed the literature searches. Author ACMM carried out the activities related at the results and discussions. Author JLNC conducted the reading of the article. Author TSR realized the collection of data's. Authors AGLS, FRA and SSM participated of the collection and organization of data. Author ROB participated of the normalization of article and reference. All authors read and approved the final manuscript.*

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## ABSTRACT

The yellow passion fruit is a plant climbing botanically that has a good geographical distribution in Brazil, with more than 150 species in the country. The presence of salts in soil and irrigation water is one of the main obstacles in agriculture in the world, caused by low rainfall and high evapotranspirative rates causing the salts to accumulate in the soil. However, alternatives have

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been sought to try to mitigate such limitations of seedling production, such as the use of biofertilizers in the soil. In this way, the objective was to evaluate the growth and development of yellow passion fruit seedlings under the effects of irrigation water salinity and the use of bovine biofertilizer on the substrate. An experiment was carried out in a greenhouse in the Center for Agrarian Sciences and Biodiversity, from october/2017 tomarch/2018, in county of Crato-Ceara, Brazil. The substrate used was the first 20 cm material of a yellow Red Argisol. The experimental design was completely randomized design (C.R.D) in a factorial scheme 5x2, referring to the electrical conductivity values of the irrigation water: 0.5; 1.0; 2.0; 3.0 and 4.0 dS $m^{-1}$, in the soil without and with common biofertilizer, with three replicates. The biofertilizer, after being diluted in non-saline water (0.5 dS $m^{-1}$) in the ratio of 1:3, was applied only once to 10% of the substrate volume two days before sowing. The increase in the salinity of irrigation water negatively affected the initial behavior of the passion fruit seedlings in terms of growth and development, especially in the treatments that did not receive the organic feed.

*Keywords: Abiotic stress; biofertilization; Passifloraceae; sanilization.*

## 1. INTRODUCTION

The passion fruit (*Passiflora edulis* Sims F. flavicarpa Deg.), popularly known as passion fruit, accounts for about 98% of productivity in Brazil [1,2]. For the small producer, passion fruit is a crop that represents great economic importance, because it presents a source of profit during the year and because of its good adaptability to the fruit market in natura.

The fruits passion is a species native to tropical America, with more than 150 species native to Brazil, intensely cultivated in tropical and subtropical countries. The most commercially important, yellow passion fruit, accounting for 95% of the orchards in the country, is also the most planted species in the world [3,4].

The growing need to increase food production constitutes a serious scientific and technological challenge and has required the expansion of new cultivated areas. However, the use of degraded areas, such as soil affected by salts, and waters considered of inferior quality, such as those with high saline contents, are recurrent alternatives mainly in semiarid regions [5].

The production and demand for high-quality seedlings are now growing, through well-defined agronomic characteristics, in order to improve the knowledge of the multiplication process, and thus to develop and adapt propagation technologies for this fruitful species. However, mainly in arid and semi-arid regions, where water scarcity has become a preponderant factor, the production of seedlings is performed using groundwater, which in most cases contains high concentrations of soluble salts, impairing the germination and their growth [6].

Saline water has hampered agricultural activity both by the direct effects on the plant and by its accumulation in the superficial layers of the soil. The effects of salinity are related to the reduction of the osmotic potential, reducing the availability of water to the plants, the toxic effect of specific ions such as NaCl ions, and the nutritional effect [7,8]. Thus, as passion fruit does not tolerate saline stress, therefore, its sensitivity may be even higher in the early stages of development [9]. With this, in addition to the care with the water quality, special attention must also be given to the substrate. This should be of good quality, with nutrients in adequate amounts and preferably with mechanisms of controlled release, avoiding losses by leaching and volatilization [10].

There is a need to adopt cultivation technologies that attenuate the deleterious effects of excess salts on irrigation water during the entire plant growth phase, especially during emergence and seedling formation. Among the materials used, we highlight the bovine biofertilizer associated with humic substances, where these inputs provide greater osmotic adjustment between the roots and the soil solution, minimizing the toxic effects of the salts on the plants [2], thus increasing the efficiency of water and nutrient absorption and, consequently, stimulating plant growth [11,12].

The objective of this study was to evaluate the effects of irrigation water salinity on initial growth of passion fruit seedlings and with direct application of common biofertilizer in soil.

## 2. MATERIALS AND METHODS

### 2.1 Characterization of the Area

An experiment was carried out in a protected environment (greenhouse), with yellow sour passion fruit variety BRS SC1, from october/2017 to march/2018, at the Center for Agricultural Sciences and Biodiversity (CCAB), Federal University of Cariri (CCA-FUCA), in the county of Crato, CE, Brazil.

The county of Crato is situated at 422 above sea level, situated under the geographical coordinates of latitude 7º23'26'' (S) and longitude of 39º36'94''(W) of Greenwich. According to the classification of Köppen, the region's climate is of type Aw (tropical climate with dry winter season). The county of Crato has average temperature in the order of 25.10°C. It has an average annual rainfall of 1086 mm, concentrating in the months of January to May, according Köppen and Geiger. The rainy season is concentrated in the period from March to June, with average rainfall of 1.400 mm per year. The average air temperature is around 23.50ºC [13].

### 2.2 Experimental Design

The treatments were distributed in a completely randomized design (CRD) and a factorial scheme 5x2, with three replicates, referring at the salinity values of irrigation water of 0.5; 1.0; 2.0; 3.0 e 4.0 dS $m^{-1}$, in the treatments without biofertilizer + common bovine biofertilizer, conditioning in black polyethylene bags with a maximum capacity of 5.0 kg, totaling 30 treatments.

### 2.3 Preparation of Salines Waters

For obtaining of the value of electrical conductivity from each type of water used for irrigation constituted the addition of NaCl in water from CCAB/FUCA. In the preparation of the five water treatments with different saline compositions, the water used was from a local pool, of low salinity and without addition of chlorine (ECw = 0.35dS $m^{-1}$), and after that, was added NaCl in the preparation of other waters for additional irrigation of 1.0; 2.0; 3.0 and 4.0 dS $m^{-1}$ according proceeded [14,15]. For the measurements and control of the electrical conductivities of the waters, It utilized a portable digital conductivity, from model Hi98304 manufacturer Hanna.

### 2.4 Physical, Chemical and as to Salinity Characterization

The substrate used was a Red-Yellow Latosol of sandy texture, non-saline Embrapa [16] submitted to laboratory analysis to determine the physical and chemical attributes regarding fertility and salinity indicated in Table 1, according to Embrapa [16] and Richards [17].

**Table 1. Physical and chemical characterization of soil as to fertility and salinity in layer of 0-20 cm. Crato-CE, Brazil. 2018**

| Physical attributes | Value | Fertility attributes | Value | Salinity attributes | Value |
|---|---|---|---|---|---|
| Sd (g $cm^{-3}$) | 1.54 | pH in water (1:2.5) | 4.98 | CEEC (dS $m^{-1}$) | 0.95 |
| Pd (g $cm^{-3}$) | 2.72 | OM (g $Kg^{-1}$) | 4.18 | pH | 4.63 |
| Tp ($m^3$ $m^{-3}$) | 0.42 | P (mg $dm^{-3}$) | 5.23 | $Ca^{2+}$ ($mmol_cL^{-1}$) | 1.42 |
| Sand (g $kg^{-1}$) | 849 | $K^+$ (mg $dm^{-3}$) | 39.92 | $Mg^{2+}$ ($mmol_cL^{-1}$) | 0.62 |
| Silte (g $kg^{-1}$) | 68 | $Ca^{+2}$ ($cmol_c$ $dm^{-3}$) | 0.75 | $Na^+$ ($mmol_cL^{-1}$) | 2.15 |
| Clay (g $kg^{-1}$) | 97 | $Mg^{+2}$ ($cmol_c$ $dm^{-3}$) | 0.56 | $K^+$ ($mmol_cL^{-1}$) | 72.41 |
| CDw (g $kg^{-1}$) | 18 | $Na^+$ ($cmol_c$ $dm^{-3}$) | 0.16 | $Cl^-$ ($mmol_cL^{-1}$) | - |
| GF (%) | 81.44 | $H^+$ + $Al^{+3}$($cmol_c$ $dm^{-3}$) | 1.65 | $CO_3^{2-}$ ($mmol_cL^{-1}$) | - |
| ID (%) | 13.74 | $Al^{+3}$ ($cmol_c$ $dm^{-3}$) | 0.20 | $HCO_3^-$($mmol_cL^{-1}$) | - |
| $U_{cc}$ (g $kg^{-1}$) | 14.63 | SB ($cmol_c$ $dm^{-3}$) | 1.47 | $SO_4^{2-}$($mmol_cL^{-1}$) | - |
| $U_{pmp}$(g $kg^{-1}$) | 2.67 | CEC ($cmol_c$ $dm^{-3}$) | 3.12 | RSA ($mmolL^{-1}$)$^{1/2}$ | 3.11 |
| Ad (g $kg^{-1}$) | 4.37 | V (%) | 47.11 | PES (%) | 68.91 |

*SD = Soil Density; PD = Particle density; TP = Total porosity; CDW = Clay dispersed in water; DF= Degree of flocculation; DI= Dispersion index; $U_{cc}$ e $U_{pmp}$ = respectively, humidity of the soil to the – 0,01 e -1,5 Mpa; AW = Available water; OM = Organic matter; SB = Sum of bases ($Na^+ + K^+ + Ca^{2+} + Mg^{2+}$); CEC = Cation exchange capacity = SB + ($H^+ + Al^{3+}$); V = Saturation value by bases (100 x SB/CTC); SEEC = Saturation extract electric conductivity; RSA = Relationship of sodium adsorption = $Na^+ \times [(Ca^{2+} + Mg^{2+})/2]^{-1/2}$; PES = Percentage of exchangeable sodium (100 x $Na^+$/ CTC)*

At the sowing were placed five seeds of the yellow passion fruits in each experimental unit with 93% viability. At the 15 days after emergence, was done the thinning of the seedlings, maintaining the most vigorous and the irrigation with each saline level was accomplished daily in a volume established according to the water requirement of the culture, ranging from 150 to 350 mL of water until the end of the experiment, respecting the conditions of the soil field capacity.

The substrate or soil used in this experiment to fill the bags of black polyethylene was removed from the layers 0-20 and 21-40 cm of deep, from the vicinity of the department, where it presents the following chemical properties of this soil analyzed (Table 2).

### 2.5 Preparation of the Biofertilizer Common

The common biofertilizer it was obtained by the anaerobic fermentation of equales parts of non-saline and non-chlorinated water with fresh bovine manure of the cows in lactating during 30 days [18]. To maintain the system, every 10 days a mixture was made to accelerate the microbial process and facilitate fermentation. For the maintenance of each hermetically sealed system, where the end of a 4 mm diameter hose was connected to the upper base of the biodigester and the other end immersed in a vessel with water. The agricultural gypsum used contained 26% CaO, 14.7% S and 5% moisture by matter [15].

### 2.6 Chemical Characterization of Water and of the Biofertilizer Common

The chemical composition of irrigation water and of the two types of biofertilizers in the liquid form was made using the methodologies suggested by [19]. Before application of input, each type of biofertilizer was diluted in water in proportion of 1:3, applied once, two days before of the sowing, in volume equivalent at 10% of the substrate volume (3.5 L). The chemical composition of water for irrigation and fertilizers in liquid form (Table 2) was based on the methodologies suggested by Melo et al. [20], and Silva et al. [21], these analyzes were made in laboratory of analytical center, Federal University of Cariri/Campus of Juazeiro do Norte-CE.

Five days prior to sowing, the biofertilizer was diluted in good water (control) using a 1:3 dilution ratio and applied once, equivalent to 10% of the substrate volume of 4000 mL (400 mL), as also [22]. The chemical composition of water for irrigation and biofertilizers in liquid form (Table 3) was done using the methodologies suggested by [17].

As for sowing, five seeds of yellow passion fruit were inserted in each experimental unit (in each bag), which presented viability of 91%. At 15 days after emergence, the thinning of the seedlings was done, maintaining the most vigorous and irrigation with each saline level was performed daily in a volume established according to the water requirement of the culture, varying from 150 to 400 mL of water to the end of the experiment, respecting the conditions of the soil field capacity.

**Table 2. Physical and chemical characterization of the soil on fertility and salinity in the 0-20 cm layer. Crato-CE. 2018**

| Parameters | Sample 1 (0 – 20 cm) | Sample 2 (21 – 40 cm) |
|---|---|---|
| Hp in water (1:2.5) | 4.90 | 5.90 |
| P (mg $dm^{-3}$) | 6.27 | 5.72 |
| $K^+$ (mg $dm^{-3}$) | 49.93 | 74.42 |
| $Na^+$($cmol_c$ $dm^{-3}$) | 1.24 | 1.10 |
| $Ca^{+2}$ + $Mg^{2+}$ ($cmol_c$ $dm^{-3}$) | 1.35 | 2.03 |
| $Ca^{+2}$($cmol_c$.$dm^{-3}$) | 0.79 | 1.53 |
| $Mg^{+2}$($cmol_c$ $dm^{-3}$) | 0.56 | 0.50 |
| $Al^{+3}$ ($cmol_c$ $dm^{-3}$) | 0.00 | 0.00 |
| $H^+$ + $Al^{+3}$ ($cmol_c$ $dm^{-3}$) | 1.85 | 1.04 |
| SB ($cmol_c$ $dm^{-3}$) | 1.35 | 2.26 |
| CEC ($cmol_c dm^{-3}$) | 3.38 | 3.30 |
| V (%) | 45.27 | 68.48 |

*Hp = hydrogen potential; SB = Sum of Bases ($Na^+$ + $K^+$ + $Ca^{2+}$ + $Mg^{2+}$); CTC = Cation exchange capacity = SB + ($H^+$ + $Al^{3+}$); V = Saturation value by bases (100 x SB/CTC); ECw = Electrical conductivity of water; RAR = Sodium adsorption ratio = $Na^+ \times [(Ca^{2+} + Mg^{2+})/2]^{-1/2}$; PEES= Percentage of exchangeable sodium (100 x $Na^+$/ CTC)*

The soil samples were collected in each experimental unit, through the soil pipe with the capacity of 10 $cm^3$ of this material to evaluate the electrical conductivity of saturation Extract (ECSe) and pH of the solution, respectively. After carefully selecting all the samples, the solution pH was quantified in a volume equivalent to 10 $cm^3$ of soil + 25 mL of distilled water, left in a disposable cup in a time interval of 1 hour, and then to perform the same readings also in the digital pH meter and electrical conductivity of the aqueous solution [23].

**Table 3. Characterization of irrigation water, of the common biofertilizer and enriched with milk, molasses and agricultural gypsum Crato-CE. 2018**

| Components | Water | Common |
|---|---|---|
| pH | - | 7.34 |
| CE (dS $m^{-1}$) | 0.25 | 4.78 |
| RSA (mmol $L^{-1})^{1/2}$ | 1.36 | 6.41 |
| $Ca^{+2}$ ($mmol_c$ $L^{-1}$) | 1.35 | 8.03 |
| $Mg^{+2}$ ($mmol_c$ $L^{-1}$) | 0.94 | 1.81 |
| $Na^{+}$ ($mmol_c$ $L^{-1}$) | 1.46 | 18.21 |
| $K^{+}$ ($mmol_c$ $L^{-1}$) | 0.13 | 3.85 |
| $Cl^{-}$ ($mmol_c$ $L^{-1}$) | 0.00 | 0.00 |
| $HCO^{-}_3$ ($mmol_c$ $L^{-1}$) | 0.00 | 0.42 |
| $CO^{-2}_3$ ($mmol_c$ $L^{-1}$) | 0.01 | 0.01 |
| $SO^{-2}_4$ ($mmol_c$ $L^{-1}$) | 0.76 | 0.23 |

*EC = Electric conductivity; RAR = Sodium adsorption ratio = $Na^{+}$ x $[((Ca^{+2} + Mg^{+2})/2)]^{-1}$*

At the end of the experiment, at 180 DAE (days after emergence), the following physical and morphological parameters were evaluated: soil electrical conductivity, soil pH (these two physicochemical readings were performed with benchtop conductivity meter), plant height (with a caliper), stem diameter (with digital caliper) and number of leaves, stem diameter (with digital caliper), root diameter (with digital caliper) and main root length (with graduated ruler) according to Mesquita et al. [15].

The results were submitted to analysis of variance by the F test, and when significant the water salinity levels were submitted to the Polynomial Regression analysis, while the biofertilizers and the passion fruits were compared by the Tukey test ($p < 0.05$) [24]. For the data processing was used the SISVAR software version 5.6, Build 86 - DEX-UFL Alivre [25].

## 2.7 Variables Analyzed at the End of the Experiment

At the end of the experiment, at 180 DAE (days after emergence), the following morphological parameters were evaluated: Plant height (PH), Leaf number (LN), root length (RL), all using a graduated ruler; root area through leaf disc weights proposed by Melo et al. [20] and Mesquita et al. [15], using a well with a known area (1.0 $cm^2$), where leaf discs of the basal, medial and apical portions were highlighted. The root area was estimated through the known area of leaves discs (KALD) featured of leaf discs weight (LDW) and total of leaf weight (TLW), all analyzed in analytical balance. The total leaf area was estimated applying the following formula: AF = PTF x ACD / PDF.

For the quantification of dry matter (Root and leaves), the seedlings were cut close to the soil, and soon after, were removed carefully all roots, stems and root. Then, were subjected to the washing process with distilled water for withdrawal of soil excess and dried to remove excess water. The separate parts (root, stem and leaves) was added in a safe place, in the nutrition's laboratory of soil at the FUCA [15]. After, was measured the fresh matter of each one of the plants organs in digital precision balance. Posteriorly, the dry vegetable material (root + leaves) was obtained after oven in kiln-drying with forced air circulation at a temperature of 65°C up to constant matter. After the drying, was obtained dry matter in digital electronic balance with of .01 g.

The morphological parameters of the seedlings and their relationships used in the evaluating the results were: height of aerial part (HAP), stem diameter (SD), Number of leaves (NL), Area Leaf (AL) and Root Length (RH) how did it proceed [18], in Indian neem seedlings (*Azadiracta indica* A. Juss), [26] in the seedlings of neem [27] in the culture of the yellow passion fruits [28].

## 2.8 Statistical Analysis

The results were submitted to analysis of variance by the "F" test, and when significant, the salinity levels of the water were submitted to the Polynomial Regression analysis, while the biofertilizers and the yellow passion fruits were compared by the Tukey ($p<.05$) [29]. For the data processing, the free version of the SISVAR software was used 5.6, Build 86 - DEX-UFL Alivre [26].

# 3. RESULTS AND DISCUSSION

Based on Table 4 it is possible to observe several biological interactions and also some isolated effects of salinity (S) and biofertilizer (B). The single or double interactions concern the effect of BxS, with respect to all variables evaluated. According to the Table, the yellow passion fruit seedlings responded positively to the isolated effects of salinity (S) and biofertilizer (B) in relation to all evaluated variables. For the interaction S x B, the effects of the yellow passion fruit seedlings evaluated on the substrate did not respond positively to soil pH, soil electrical conductivity (SEC), plant height (AH) and root length (RL), except for the number of leaves (NL), where a significant effect was observed at a 5% probability by the Tukey test.

Based on the mentioned Table, it is observed that the electrical conductivity of the soil responded positively only to the factor isolated salinity (S), tested at the level of 5% of probability by the test F.

As shown in Fig. 1, there was an isolated effect of irrigation water salinity (soil irrigated with different salinities) evaluated at the end of the experiment at 180 days. When comparing the electrical conductivity values of the seedlings substrate at the end of the experiment, it was observed that these substrates irrigated with continuous use of the water of different saline compositions, suffered increases of electrical conductivity by the successive accumulation of salts present in the daily irrigations. These S.C values ranged from 0.40 to 1.50 dS $m^{-1}$, corresponding to the estimated salinity levels of 0.50 to 4.0 dS $m^{-1}$, respectively.

This increase of salts in the substrate surface is due to the irrigation of the yellow passion fruit seedlings of increasing salinity up to the maximum level of 4.0 dS $m^{-1}$, causing it to raise the saline level of the soil, favoring a percentage increase of 275.30%. The salinity of the substrates was increased by the addition of salts to the soil by the successive irrigations and also

**Table 4. Summary of mean squares and diagnosis of significance regarding solution pH, solution salinity (CE),plant height (AP), leaf number (NF), stem diameter (DC), area leaf (AF) and Root length (RL) of passion fruit seedlings yellow for the purposes of salinity (S) and biofertilizer (B) evaluated at 180 DAE**

| Variation factor (V.F) | GL | pH | S.C (dS $m^{-1}$) | A.H (cm) | L.F - | A.F ($cm^2$) | S.D (mm) | R.L (cm) |
|---|---|---|---|---|---|---|---|---|
| S (salinity) | 4 | $0.0022^{NS}$ | $1.31^{**}$ | $337.71^{*}$ | $9.71^{NS}$ | $63451^{NS}$ | $1.64^{*}$ | $89.30^{*}$ |
| B (Bio) | 1 | $0.0011^{NS}$ | $0.0001^{NS}$ | $554.71^{*}$ | $19.20^{*}$ | $1461952^{**}$ | $6.62^{**}$ | $24.30^{NS}$ |
| S x B | 4 | $0.0028^{NS}$ | $0.0372^{NS}$ | $185.78^{NS}$ | $11.45^{*}$ | $170033^{NS}$ | $1.51^{*}$ | $14.63^{NS}$ |
| Erro | 20 | | | | | | | |
| C.V% | | 1.98 | 26.02 | 40.83 | 13.66 | 38.79 | 12.66 | 19.16 |
| Average | | 5.51 | 0.88 | 24.76 | 14.06 | 708.62 | 5.12 | 28.56 |
| **Total** | 29 | | | | | | | |

*Ns = Not significant; (*) e (**) respectively, as a function of the Tukey test at the levels of 5 and 1% of probability by the F test; GF = Degree of freedom; CV = Coefficient of variation*

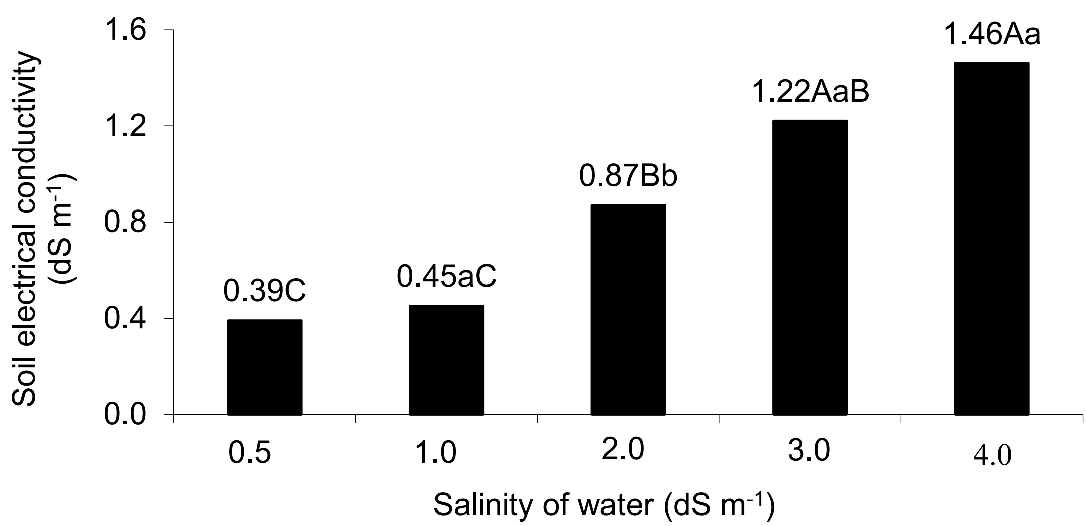


**Fig. 1. Soil electric conductivity (SEC) of substrates grown with yellow passion fruit seedlings evaluated at 180 DAE**

*Note: Letters represent the symbology of significance by the Tukey test, where upper and lower case letters in the lines represent variation in the variables, and lowercase in the columns are significant at 1 and 5% probability* to the salts contained in the common bovine biofertilizer, as seen in Table 3, in the ordinal value of 4.78 dS $m^{-1}$.

According to Ayers and Westcot [30], yellow passion fruit is considered to be sensitive to the effects of salts with waters that offer moderate (ECw > 2.50 dS $m^{-1}$) or severe (ECw > 3.0 dS $m^{-1}$) restrictions. However, according to Rodrigues et al. [27], these organic inputs, despite providing an increase in the electrical conductivity of the substrate, stimulate the growth and production of vegetal biomass. The results are in agreement with [31], [29], and [12] when they noticed increase in the concentration of salts of the soil with irrigation of waters with increasing salinity.

For the variable response height of passion fruit seedlings, a significant influence of saline and biofertilizer use was observed, with quadratic reductions as a function of the addition of salts in the irrigation water (Fig. 2). The increase in water salinity levels reduced the growth of yellow passion fruit during the formation of seedlings. However, the substrate with a common bovine biofertilizer showed significant statistical superiority at the height of the seedlings in relation to the treated soil without the organic input. In this sense, the seedlings had their highest height of 37.56 cm in the estimated salinity of 0.98 dS $m^{-1}$. After this point, the seedlings had a sharp fall of 41.34% at plant height up to the maximum salinity of 4 dS $m^{-1}$.

The behavior of the observed data for plant height is compatible with data found by Ayers and Westcot [30] and [32] when they recognize that salinity is indicated as an abiotic reason more restrictive to the growth and development of plants, especially for cultures with sensitivity to salts, for example yellow passion fruit.

This attenuating effect of salinity with the use of the common bovine biofertilizer is mainly due to being a protein source, a source of fermented organic matter, which can stimulate the release of humic substances when applied to the soil causing an increase in the production of organic solutes, such as sugars, free amino acids, proline and betaine, glycine, which positively affects plant nutrition [14,33].

Although the interaction between salinity of water and biofertilizer exerted significant effects on stem diameter and leaf number, data on biofertilizer treatments did not fit any regression model (Fig. 3). As confirmed in Fig. 3, the seedling diameter of the seedlings plants in the soil without biofertilizer decreased by up to 3.86 mm in the estimated salinity of 2.36 dS $m^{-1}$, where from that point, the seedlings had their diameter increased to 4.83 mm, corresponding to the estimated salinity of the maximum water of 4.0 dS $m^{-1}$. This response may be related to the genetic variability or resistance of yellow passion fruit seedlings to abiotic stress.

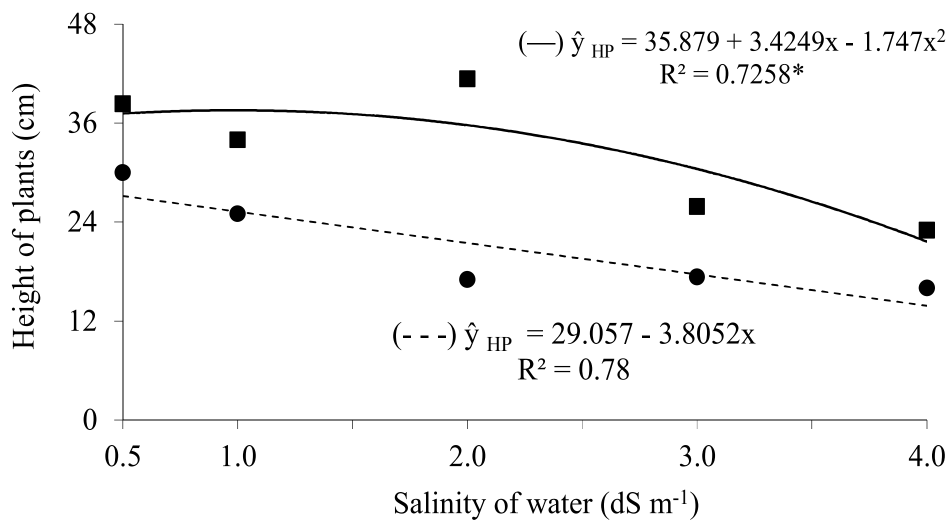


**Fig. 2. Height of seedlings (HP) of yellow passion fruit seedlings tested on substrates without biofertilizer (- - -) and with common biofertilizer (—) increasing salinity waters and evaluated at 180 DAE**

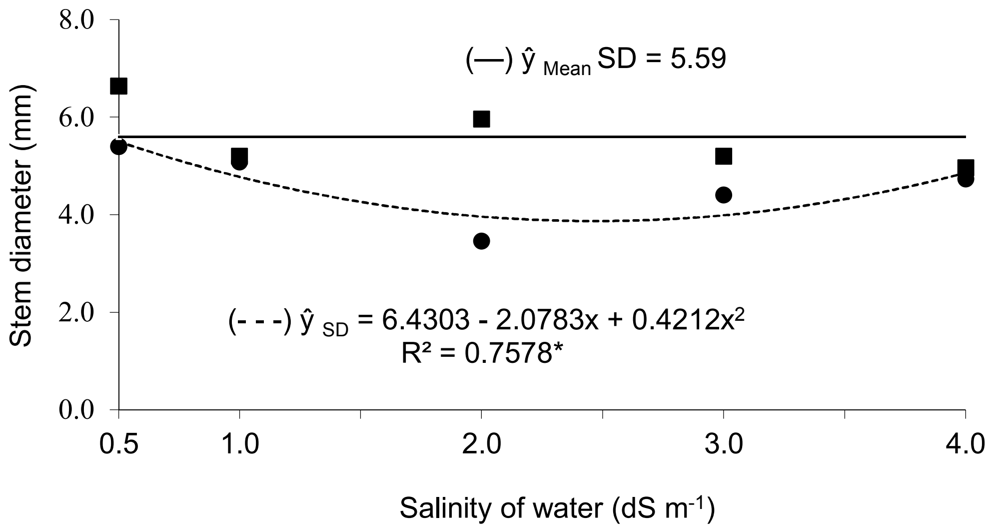


**Fig. 3. Stem diameter (SD) of yellow passion fruit seedlings treated in the soil without biofertilizer (- - -), in the presence of common biofertilizer (—) as a function of the irrigation water salinity**

In the soil with biofertilizer, the values referring to the growth of the culminating diameter of the Passiflora edulis seedlings did not fit any regression model. In spite of the high dispersion of the data, due to the stress caused by the salinity of the irrigation water and even not adjusting to any regression model, the biofertilizer promoted greater growth and development of the seedlings in relation to the soil without the respective input with average value of 5.59 mm. It is observed that the organic input promoted an increase in the order of 25.33% in terms of the stem diameter of passion fruit plants when compared to the soil without its input.

Santos et al. [34] studying the jatropha, [28] with yellow passion fruit and [18] with sunflower also found that there was a decline in plant diameter in the crops, according to the higher salinity level of irrigation water used. This reduction is due to the stress caused by the salts present in the irrigation water, these salts act in the reduction of the photosynthetic rate and stomatal conductance, and consequently decreases the rate of assimilation of $CO_2$, compromising the growth of the plants [35].

The results concerning the number of leaves (NL) of the yellow passion fruit seedlings treated in the soil without the organic input (Fig. 4), conformed to the linear polynomial regression model. Being this value represented by the estimated $R^2$ of 73.23% of statistical reliability to explain the biological response of the seedlings after 180 DAE.

The increase in water salinity levels of 0.5 to 4.0 dS $m^{-1}$ reduced the number of leaves during the formation of *Passiflora edulis* seedlings in the order of 15 to 11, evaluated in the substrate without the common biofertilizer (Fig. 4). This is due to the fact that saline stress limits the photosynthetic rate and the stomatal conductance, which consequently decreases the rate of assimilation of $CO_2$, compromising the amount of leaves, leaf area and consequently the growth and development of the plants [22,20].

Evaluating seedlings in the soil with a common biofertilizer (Fig. 4), the seedlings did not present a mathematical model adjustment with an increase in irrigation water salinity of 0.5 to 4.0 dS $m^{-1}$, but even so, NL was represented by the average value of 15.27. Once the biofertilizer applied to the soil, besides contributing to the improvement of the soil, stimulating the soil microbiota, it produces proline, glycine, nucleic acids and membranes combined with other complexed elements, in addition, it increases the retention capacity of soil water, stimulates the activity of beneficial microorganisms that causes plant food elements in the soil to be readily available to plants by reducing salinity and soil erosion [36].

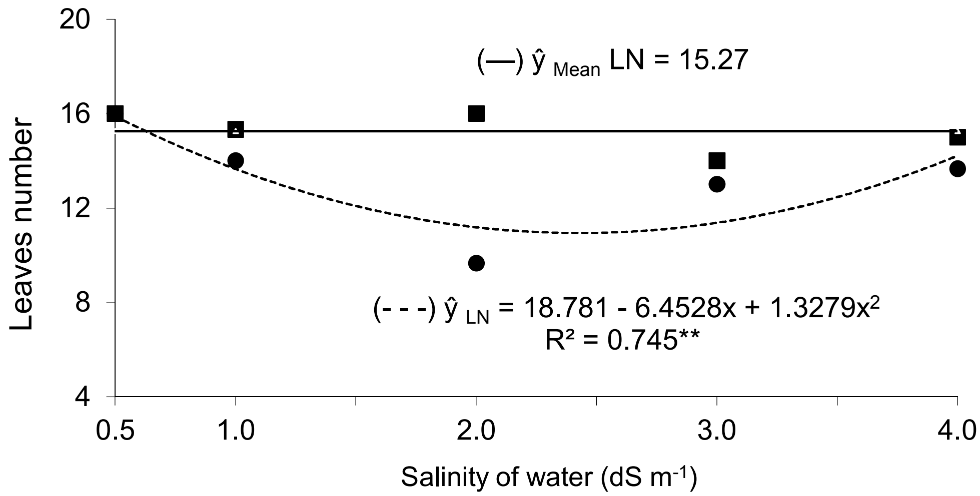


**Fig. 4. Leaves number (LN) of the yellow passion fruit seedlings treated in the soil without biofertilizer (- - -), in the presence of a common biofertilizer (─) as a function of irrigation water salinity**

The salinity affected the growth of the seedlings, especially in the early stages of growth, as observed in yellow passion fruit [15], papaya [37], [31], and oiticica [38]. This is due to the fact that saline stress limits the photosynthetic rate and stomatal conductance, which consequently decreases the rate of $CO_2$ assimilation, compromising plant growth [22].

Despite the superiority of the data with and without bovine biofertilizer as to the stem diameter of the treated passionflower seedlings, it is observed that the RD evaluated at 180 days after emergence was drastically reduced from 7.60 to 5.52 with the increase of the salinity of the waters of 0.5 to 4.0 dS $m^{-1}$. This decrease caused a 27.36% inhibition in the stem diameter of plants irrigated with water of 0.5 to 4.0 dS $m^{-1}$ (Fig. 5). However, when data were collected in the absence of the application of the organic input, R.D data did not fit any regression model, so it was represented by a mean of 5.62 mm.

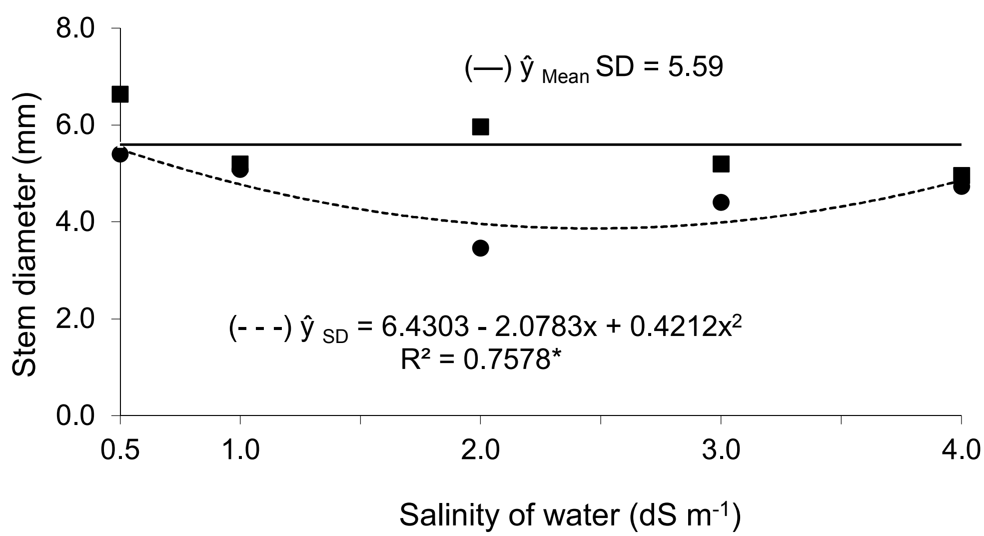


**Fig. 5. Root diameter (RD) of yellow passion fruit seedlings treated in the soil without biofertilizer (- - -), in the presence of bovine common biofertilizer (─) as a function of salinity of irrigation water**

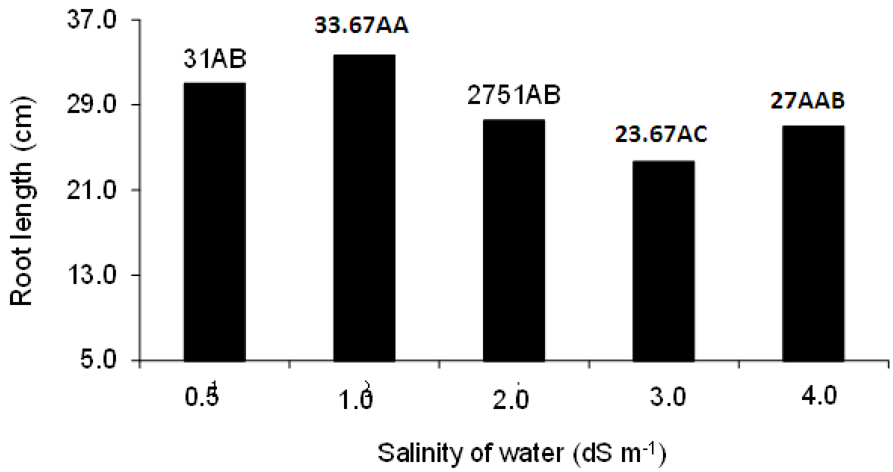


**Fig. 6. Root length (RL) of the yellow passion fruit seedlings treated in the soil without bovine biofertilizer (- - -), in the presence of a common biofertilizer (—) as a function of the salinity of the irrigation water**

*Note: Letters represent the symbology of significance by the Tukey test, where upper and lower case letters in the lines represent variation in the variables, and lowercase in the columns are significant at 1 and 5% probability*

With regard to the decline in main root diameter in treatments without biofertilizer, [8] reported that inhibition on root growth under saline conditions can be attributed to the reduction of photosynthesis; in saline conditions the number and size of the leaves of glycophytic plants are reduced due to the low availability of water, increase in the saline concentration of the solution and the toxicity by the high concentration of salts in the root environment.

These results are in agreement with [32] found superiority in the root development of yellow passion fruit seedlings on a biofertilizer substrate and irrigated with salt water and also by [15] when evaluating the diameter of the main root of yellow passion fruit seedlings, irrigated with salt water without and with bovine biofertilizer.

Based on (Fig. 6), the root length results of passion fruit seedlings exerted significant effects only for the isolated salinity factor (S), that is, this morphological parameter was statistically evaluated at the 1 and 5% probability level by test F.

The seedlings of yellow passion fruit had their main root length ranging from 23 to 33.67 cm, that is, the seedlings had this behavior reduced under the degenerative effect of water salinity of 0.5 to 4.0 dS $m^{-1}$. The seedlings had inhibition as to the root length from salinity 2.0 dS $m^{-1}$.

This variation in root length as a function of the increase of salts in the treatments that received different saline waters + the control is due to the fact that passion fruit cultivation tolerates moderate levels of up to 2.0 dS $m^{-1}$ against severe levels up to 4.0 dS $m^{-1}$, according to [30]. As it was irrigating the seedlings with different saline waters, the plants presented a fall in their root length of 33.67 to 23.67 cm. This drop in root system growth reflected a percentage loss in length of up to 29.70% [39].

This behavior of the seedlings may be related to the process of inhibition of the root system as a strategy to avoid direct contact of the deleterious effect of the salts. According to Taiz et al. [36], this inhibition of growth caused by salinity is due to the osmotic effect, which promotes physiological drought, as well as causes the toxic effect, resulting from the concentration of ions in the protoplasm.

## 4. CONCLUSION

Irrigation with saline water affected the morphology and quality of yellow passion fruit seedlings; hence, the seedlings were higher on the substrates with the common biofertilizer.

The growth of the seedlings was little affected by the use of fermented organic compounds, as in the case of bovine biofertilizer being rich in humics substances.

The soil salinity increased with water salinity, but with less intensity in biofertilizer treatments.

The passion fruit seedlings were more affected in the soil without biofertilizer and with the increase of the salinity of water.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES


1. Agrianual. Yearbook of Brazilian agriculture. São Paulo: FNP Consultoria e Comércio; 2015.
2. Aydin A, Kant C, Turan M. Humic acid application alleviate salinity stress of bean (*Phaseolus vulgaris* L.) plants decreasing membrane leakage. African Journal of Agricultural Research, Naiorobi. 2012;7 (7):1073-1086.
3. Faleiro FG, Farias NETO, AL, Ribeiro Junior WQ. Pre-improvement, improvement and post-improvement: strategies and challenges. 1st ed. Planaltina, Embrapa Cerrados; 2008.
4. Meletti LMM. Advances in passion fruit culture in Brazil. Brazilian Journal of Fruit Crops. 2011;33(Special number):83-91.
5. Ribeiro H, Jaime PC, Ventura D. Food and sustainability. Advanced Studies. 2017;31 (89):185-198.
6. Oliveira FIF, Souto AGL, Cavalcante LF, Medeiros WJF, Medeiros SAS, Oliveira FF. Biomass and chloroplast pigments in jackfruit seedlings under saline stress and nitrogen fertilization. Revista Caatinga, Mossoro. 2018;31(3):622-631.
7. Epstein E, Bloom AJ. Mineral nutrition of plants: principles and perspectives. Londrina: Editora Planta. 2006;403.
8. Munns R, Tester M. Mechanisms of salinity tolerance. Annuario Journal Plant Biology. 2008;1(59):651-81.
9. Morais FA, Araujo FMMC, Machado AV, Ricarte FDN. Sales junior, R. influence of the modified atmosphere under the post-harvest shelf life of papaya. Revista Verde, Mossoro. 2010;5(4):01-09.
10. Simões D, Silva RBG, Silva MR. Substrate composition on the development, quality and cost of seedling production of Eucalyptus grandis Hill ex. Maiden x Eucalyptus urophylla s. T. Blake. Forest Science. 2012;22(1):91-100.
11. Matsi TH, Lithourgidis AS, N Barbayiannis. Effect the fliquid cattle manure on soil chemical properties and corn growth in Northern Greece. Experimental Agriculture, Cambridge, 2015;51:43:5-450.
12. Oliveira AMP, Rebouças CAM, Dias NS, Sousa Junior FS, Sá FVS, Sousa Neto ON, Lima AO, Fernandes CS. Dynamics of Ions in soils irrigated with saline reject. Journal of Agricultural Science. 2017;9 (11):190-197.
13. Francisco de O, Mesquita Ana C, Meireles M, José LN, Cardoso Carlos, Oliveira W, Patrycia LB. Roguides. Use of salines waters and biofertilizers in quality of the seedlings from *Passiflora edulis* evaluated by the Dry Phytomass, Journal of Agricultural Science. 2019;11( 5)
14. Mesquita EF, Sa FVS, Bertino AMP, Cavalcante LF, Paiva EP, Ferreira NM. Effect of soil conditioners on the chemical attributes of a saline-sodic soil and on the initial growth of the beaver plant. Semina: Agrarian Sciences. 20153;6(4):2527-2538. DOI:10.5433/1679-0359.2015v36n4p25 27.
15. Mesquita FO, Cavalcante LF, Pereira WE, Rebequi AM, Lima Neto AJ, Nunes JC. Production of yellow passion fruit seedlings submitted to salinity in soil with bovine biofertilizer. Soil Science. 2012;30 (1):31-41.
16. Embrapa. National soil research center. Brazilian system of soil classification. 3ª. ed. Embrapa Solos, Brasília, Brazil. . 2013; 353.
17. Richards LA. Diagnosis and improvement of saline and alkaline soils. United States Salinity Laboratory Staff, Washington, USA. Document Agriculture, 60). 1954; 160.
18. Ribeiro PHP, Gheyi HR, Uyeda CA, Teixeira MB, Soares FAL, Dias NS. Growth rate and yield of sunflower irrigated with saline water under nitrogen doses. Irriga, Botucatu, Special Edition, Great Cultures. 2016;223-247.
19. Malusá E, Sas-Paszt L, Ciesielska J. Technologies for beneficial microorganisms inocula used as biofertilizers. The Scientific World Journal. 2012;491206. DOI: 10.1100/2012/491206
20. Melo Filho JS, Véras MLM, Alves LS, Silva TI, Gonçalves ACM, Dias TJ. Water salinity, bovine biofertilizer and dead plant cover in the production of pitombeira

seedlings (*Talisiae sculenta*). Scientia Agraria. 2017;18(3):131-145.
21. Silva AF, Pinto JM, France CRRS, Fernandes SC, Gomes TCA, Silva MSL, Matos ANB. Preparation and use of liquid biofertilizer. Technical Communiqué, Petrolina. 2007;1(130):4.
22. Freire AL, Ramos CLR, Almeida EGA, Duarte WFD, Schwan RF. Study of the physicochemical parameters and spontaneous fermentation during the traditional production of yakupa, an indigenous beverage produced by Brazilian Amerindians. World Journal of Microbiology and Biotechnology. 2014;30 (2);567-577.
23. Almeida OJ. Production of Isabel vine (*Vitis labrusca* L.) due to the application of liquid biofertilizers. TCC (Undergraduate) - Agricultural sciences course, Department of Agrarian and Exact Sciences, State University of Paraíba, Catolé do Rocha. 2015;44.
24. Banzatto DA, Kronka SN. 2008. Agricultural experimentation. 4th ed. Jaboticabal: UNESP. 2008;247.
25. Ferreira DF. Sisvar: A computer statistical analysis system. Science and grotchnology, Lavras. 2011;35(6):1039 1042.
26. Lima JF, Peixoto CP, Ledo CAS. Physiological indexes and initial growth of papaya (*Carica papaya* L.) under greenhouse conditions. Science and agro-technology, Lavras, 2017;31(5):1358-1363.
27. Rodrigues RM, Cavalcante LF, Souto AGL, Gheyi HR, Mesquita FO. Growth and regrowth of neem after cutting in saline - sodic soil treated with organic inputs. Revista Caatinga, 2017;30(1):116-124.
Available:http://dx.doi.org/ 10.1590 / 1983-21252017v30n 113rc.
28. Ribeiro AA, Filho MS, Moreira FJC, Menezes AS, Barbosa MC. Effect of salinity on the initial growth of Yellow Passionflower (*Passiflora edulis* sims, F. Flavicarpa deg.). Revista Agrogeoambiental. 2014; 6(3):1-8.
29. Carneiro MA, Lima AMN, Cavalcante IHL, Cunha JC, Rodrigues MS, Lessa TBS. Soil salinity and yield of mango fertigated with potassium sources. Brazilian Journal of Agricultural and Environmental Engineering. 2017;21(5):310-316.
Available:http://dx.doi.org/10.1590/1807-1929/agriambi.v21n5p310-316.
30. Ayers RS, Westcot DWA. Water quality in agriculture. 2nd ed. Campina Grande: UFPB. FAO Studies Irrigation and Drainage. 1999;29:153.
31. Lima Neto AJ, Cavalcante LF, FO Mosque, Souto AGL, Santos GP, Santos JZ, Mesquita EF. Papaya seedlings irrigation with saline water in soil with bovine biofertilizer. Chilean Journal of Agricultural Research. 2016;76: 235-241.
DOI: 104067 / S0718-583920160002000 14.
32. Cavalcante LF, Silva GF, Gheyi HR, Dias TJ, Alves JC, Costa APM. Growth of yellow passion fruit seedlings in saline soil with fermented liquid bovine manure. Brazilian Journal of Agricultural Sciences (Recife). 2009;4(4):414-420.
33. Birth JAM, Cavalcante LF, Cavalcante IHL, Pereira WE, Dantas SAG, Medeiros SAS. The impacts of biofertilizer and mineral fertilization on the growth and production of yellow passion fruit irrigated with moderately saline water. Science and Agricultural Research. 2016;43(2):253-262.
DOI: 10.4067 / S0718-162020160002000 08.
34. Santos DB, Machado MS, ASR Bishop, Santos AFJ, Araujo AF. Development of fermented food type "Sauerkraut" with the use of jamb (floral axis) of jaca (*Artocarpus integrifolia* L.). Encyclopedia Biosphere - Knowing Scientific Center, Goiânia. 2012;8(15):590-596.
35. Fernandez-García Olmos E, Bardisi E, Garma JDD, Lopez-Berenguer G, Rubio-Asensio JS. Intrinsic water use efficiency controls the adaptation to high salinity in a semi-arid adapted plant, henna (*Lawsonia inermis* L.). Journal of Plant Physiology, Stuttgart. 2014;171(1):64-75.
36. Taiz L, Zeiger E, Moller IM, Murphy. Plant physiology. 6th ed. Porto Alegre: Artmed. 2017;818.
37. Sa FVS, Brito MEB, Melo AS, Antonio Neto P, Fernandes PD, Ferreira IB. Production of papaya seedlings irrigated with saline water. Brazilian Journal of Agricultural and Environmental Engineering. 2013;17(10):1047-1054.

38. Diniz Neto MA, Silva IF, Cavalcante LF, Diniz BLMT, Silva JCA, Silva EC. Oiticica seedlings irrigated with saline waters in the soil with bovine and potassium biofertilizer. Brazilian Journal of Agricultural and Environmental Engineering, Campina Grande. 2014; 18(1):10-18.

39. Mesquita FO, Cavalcante LF, Batista RO, Medeiros FR, Rodrigues RM, Santos WO. Evaluation of the absolute growth rate of Hawaii papaya under the saline and biofertilizer effect: Part I. Magistra, Cruz das Almas. 2014;26 (4):443-455.



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