

SALINE WATER AND ORGANOMINERAL FERTILIZATION IN LEAF COMPOSITION, PRODUCTION OF *Passiflora edulis* AND IN EDAPHIC SALINITY

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ABSTRACT: An experiment was carried out in Remígio county, Paraíba State, Brazil from July/2013 to May/2014, in order to evaluate effects of saline water irrigation, bovine biofertilizer and potassium types on soil salinity, leaf composition in macronutrients and on production of yellow passion fruit plants cv BRS Gigante Amarelo. Treatments were distributed in randomized blocks arranged in factorial design $2 \times 2 \times 2$, referring to electric conductivity water of 0.35 and 4.00 dS m⁻¹, in soil without and with bovine biofertilizer applied via water (volume of 6 L plant⁻¹ of mixture) one day before and every 90 days after transplanting and conventional potassium chloride (KCl) and coated with organic polymers supplied monthly. The soil salinity in beginning of plants flowering, was increased of initial value of 0.36 dS m⁻¹ to respectively 3.43 and 5.43 dS m⁻¹ between plants irrigated with non-saline and saline water. Fertilization with coated KCl reduced the potassium contents compared to conventional KCl. Except in nitrogen and potassium plants were deficient in other macronutrients but produced in promising level since the productivity was superior the Brazilian average, Brazilian Northeast and average of the Paraíba State Brazil.

KEYWORDS: Yellow passion fruit, saline water, mineral composition

ÁGUA SALINA E ADUBAÇÃO ORGANOMINERAL NA COMPOSIÇÃO FOLIAR, PRODUÇÃO DE *Passiflora edulis* E NA SALINIDADE EDÁFICA

RESUMO: Um experimento foi conduzido no município de Remígio, Paraíba, no período de julho/2013 a maio/2014, para avaliar os efeitos da salinidade da água de irrigação, biofertilizante bovino e potássio na salinidade do solo, composição foliar e produção do maracujazeiro amarelo cv BRS Gigante Amarelo. Os tratamentos foram distribuídos em blocos

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casualizados arranjados em fatorial $2 \times 2 \times 2$, referente a condutividade elétrica das águas de 0,35 e 4,00 dS m^{-1} , no solo sem e com biofertilizante bovino diluído em água não salina na prorrogação de 50% e aplicado, via água em (volume de 6 L planta⁻¹ da mistura) um dia antes do transplântio e a cada 90 dias e cloreto de potássio convencional e revestido com polímeros orgânicos fornecidos mensalmente. A salinidade do solo no início da floração, foi elevada do valor inicial de 0,36 para 3,43 e 5,43 dS m^{-1} entre as plantas irrigadas com água não salina e salina. A adubação com KCl revestido reduziu os teores de potássio em comparação ao KCl convencional. Exceto em nitrogênio e potássio, as plantas estavam deficientes nos demais macronutrientes, mas produziram em nível promissor com rendimento superior a média nacional, do Nordeste brasileiro e do Estado da Paraíba.

PALAVRAS-CHAVE: Maracujazeiro amarelo, água salina, composição mineral.

INTRODUCTION

The salinity of water or soil can cause negative effects on plant nutrition, including yellow passion fruit, which characterizing itself as a culture sensitive to the effects of salts. However, in some parts of the Northeastern semiarid the Passifloraceae has been irrigated with waters of electric conductivity above 3 dS m^{-1} (Cavalcante et al., 2005). Thus in these regions the culture has produced as moderately sensitive and up until moderately tolerant salts (Dias et al., 2012).

One of the most common agricultural limitations refers to production costs of crops with the acquisition and distribution of inputs, such as synthetic mineral fertilizers. A way of reducing costs is by applying slow-release mineral fertilizers or controlled-release ones (Melo Júnior et al., 2015). This practice provides sufficient availability to plants for a longer period and with lower losses of the nutrient from the roots by leachate (Bernardes et al., 2015).

Currently, worldwide investments in most sustainable basic farming are taking place, aiming to reduce damages of natural resources, and organic fertilizers are good alternatives in agricultural crops (Nascimento et al., 2016). Among the used inputs, bovine biofertilizer stands out on many different cultures, such as the yellow passion fruit. In this sense, Dias et al. (2013) verified that when the refereed organic input is applied on soil in liquid form, it attenuates the aggressive effects of irrigation water salts on growth, plants production and quality of fruits. For the above, this study aimed to evaluate the effects of irrigation with increasing salinity of

water, cattle and potassium biofertilizers, from conventional source and slow release in the nutritional status and production of the variety BRS Gigante Amarelo passion fruit.

MATERIAL AND METHODS

The experiment was conducted during the period from July/2013 to May/ 2014, in Remígio county, Paraíba State, Brazil, located per geographic coordinates $7^{\circ} 00' 1.95''$ S, $35^{\circ} 47' 55''$ W and 562 m of altitude, inserted in micro region of Occidental Curimataú, semi - arid area of the Brazilian Northeast Climatic conditions of the municipality, as Köppen, is As', which means hot and humid with a rainy period from March to July and average pluviosity of 640 mm, during the experimental period. According to criteria of the Brazilian System of Soil Classification - SiBCS (EMBRAPA, 2013), the soil was classified as Dystrophic Regolitic Neosol, non-saline (Richards, 1954). Treatments were designed in randomized blocks with three replicates and 12 plants per plot, by the factorial scheme $2 \times 2 \times 2$, referring to electric conductivity values of irrigation waters of 0.35 and 4.00 dS m^{-1} , on soil without and with bovine biofertilizer at 0 and 50% of the recommended dose of 15 L m^{-2} (Dias et al., 2013) and fertilization with two sources of potassium (60% K_2O), conventional and slow-release potassium chloride (coated with polymers). In terms of elementary composition, this input does not differ from the conventional KCl, however this coating allows a gradual liberation of potassium over time, keeping it available for plants during a longer period.

The irrigation water of low salinity (0.35 dS m^{-1}) was derived of a superficial dam, while the 4.00 dS m^{-1} was obtained by diluting non-iodized sodium chloride (92% purity) in dam water. The biofertilizer was produced by anaerobic fermentation of fresh bovine manure and water (Dias et al., 2013) provide in a 6 L m^{-2} blade, corresponding to 50% of the recommended blade of 15 L m^{-2} , after dilution at the dam, on the proportion 1:1, one day and each 90 days after seedlings transplantation - DAT, in an area of 0.8 m^2 of a circumference with 50 cm of ray, with the plant located in the middle of the pit. In each application of the biofertilizer, plants without this input were irrigated with the same volume of each type of water used for irrigation, discounting the value of the water blade.

Plants irrigation was taken every 48 hours, during 115 DAT, based on maximum daily water blade of evapotranspiration of the crop, of 14 $\text{L plant}^{-1} \text{ day}^{-1}$, obtained by the product of evaporation of class "A" tanks ($\text{ETa} \times 0.75$), installed on the location of the experiment ($\text{ETo} = \text{ETc} \times 0.75$) and by each cultivation coefficient – Kc of 0.2; 0.4; 0.8 and 1.2 ($\text{ETc} = \text{ETo} \times \text{Kc}$), respectively referred to first 60 DAT, from 60 to 90, 90 to 115 and from flowering to harvest

(Souza et al., 2016). On treatments with 4.00 dS m^{-1} water, despite the sandy texture of soil, a 10% superior irrigation blade was applied, in order to reduce risks of salinity by lixiviation of the salts present on the radicular environment (Ayers & Westcot, 1999).

At the same time, the fourth leaf from the apical meristem of intermediate productive and healthy branches was sampled (Malavolta et al., 1997), totaling 24 leaves of each treatment, in order to evaluate the plants' nutritional status, concerning macro (N, P, K^+ , Ca^{2+} , Mg^{2+} and S), besides the sodium on the dry matter of the foliar tissue, by means of the methodologies suggested by Embrapa (2009). Then, fruits were conditioned in plastic boxes, in order to quantify the average mass. Results were submitted to a variance analysis by the F test, with the means compared by the Tukey test at 5% probability, with the aid of the software Statistical Analysis System (SAS/STAT 9.3, 2011).

RESULTS AND DISCUSSION

Irrigation with non-saline water (0.35 dS m^{-1}), in comparison to initial situation of the soil, as Richards (1954), increased the condition from non-saline ($\text{CEes} < 2 \text{ dS m}^{-1}$) to slightly saline ($2 < \text{CEes} < 4 \text{ dS m}^{-1}$) and with saline water (4 dS m^{-1}) to averagely saline ($4 < \text{CEes} < 8 \text{ dS m}^{-1}$) from the plants transplantation to its initial flowering, regardless of the treatments with potassium or bovine biofertilizer (Figure 1).

On soil with non-saline irrigation, slow-release KCl, in function of the granules coated with organic polymers, a lixiviation of salts was probably promoted, thus significantly reducing the electric conductivity of the saturation extract - CEes in 14.1%, but did not differ from conventional KCl on soil irrigated with saline water (Figure 1A). The positive action of organic composts increases the pore space, water dynamics and, with an effect, salts lixiviation of the root environment of plants, especially on soils with a sandy texture. As showed in Figure 1B, soil salinity irrigated with non-saline water did not differ among treatments without and with the biofertilizer, but both referred input and the saline water elevated soil salinity in 16.9%, when compared to the treatment without the respective input.

When connecting N levels to leaf dry matter of yellow passion fruit of 44.76 and 46.36 g kg^{-1} , between treatments with non-saline and saline water (Figure 2A), respectively, it was verified that plants irrigated with high electric conductivity water (4.0 dS m^{-1}) presented average contents of N, 3.5% superior in relation to plants irrigated with low conductivity water (0.35 dS m^{-1}). According to Malavolta et al. (1997), the amplitude admitted as sufficient for N is

between 40 and 50 g kg⁻¹, indicating that, regardless of electric conductivity of the irrigation water, plants were adequately supplied in nitrogen.

Phosphorus levels in the leaf dry matter of plants irrigated with low and high salinities did not differ between treatments without and with biofertilizer (Figure 2B). However, by relating leaf contents of P of the different electric conductivity, when subjected to the absence of the organic input, it was noted that plants irrigated with saline water were 1.7% superior on phosphorus contents in leaf tissues (2.73 g kg⁻¹), compared to plants irrigated with non-saline water (2.33 g kg⁻¹).

The leaf contents of potassium in plants irrigated with non-saline water and fertilized with coated KCl overcame in 6.9% (37.45 g kg⁻¹) the average levels of plants irrigated with saline water. An inverse behavior was observed on soil fertilized with conventional KCl, in which the average leaf K content was 9.8% (38.93 g kg⁻¹) higher in plants irrigated with saline water (35.45 g kg⁻¹) (Figure 3A). The reduction on K leaf contents in plants irrigated with saline water and fertilized with coated KCl may have occurred due to the competition between Na⁺ and K⁺ on the absorptive sites of the cell membranes (Cruz et al., 2006). Regarding plants fertilized with conventional KCl, the continuous availability of K⁺ on soil, due to monthly fertilizations, may have contributed to ion's predominance in relation to Na⁺ on the exchange site of the soil irrigated with saline water, promoting its availability, absorption and accumulation of the essential nutrient on foliar tissue of plants (Marschner, 2012). Despite such variation, as highlighted by Malavolta et al. (1997), leaf potassium contents are within the range of 35 and 45 g kg⁻¹, considered as adequate for the culture.

Sulphur contents in plants treated with biofertilizer were reduced from 2.89 to 2.71 g kg⁻¹ (Figure 3B). These values are below the optimum range (4.0 to 4.6 g kg⁻¹) registered by Cruz et al. (2006) for yellow passion fruit plants grown in nutritious solutions of high electric conductivity and also below the adequate range for this culture, which is between 3.0 and 4.0 g kg⁻¹ (Malavolta et al., 1997). Although the soil was fertilized bimonthly with simple superphosphate (8% S), decreased levels of this macronutrient in plants which received biofertilizer may have occurred due to the microbial population of the organic input (Marrocos et al., 2012), which influences sulphur transformations on the soil. Fertilization with slow release KCl increased sodium contents from 2.52 to 2.89 g kg⁻¹, representing a 14.7% increment (Figure 3C). According to Dias & Blanco (2010), sodium leaf contents above 2.5 g kg⁻¹ may provoke toxicity and compromise the photosynthetic activity of plants.

The average fruits mass decreased with increased electric conductivity of the irrigation water (Figure 4). By relating the values of 221.26 and 200.92 g fruit⁻¹, on treatments irrigated

with non-saline and saline water, respectively, a 10.1% reduction in fruits mass was observed, when plants were irrigated with saline water (4.0 dS m⁻¹). This fact probably occurred due to the greatest osmotic adjustment of plants, provided by the soil's physical characteristics, increasing the ratio K⁺/Na⁺ by monthly fertilizations with KCl and also by the benefits of humic substances deriving from the biofertilizer. The osmotic adjustment enables water absorption in elevated salinity conditions, thus contributing to plants growth and production, even in modest levels.

CONCLUSION

Increase of water saline concentration and soil fertilization with both types of potassium chloride elevated the soil salinity from non-saline to saline.

The plantas of BRS Gigante Amarelo passion fruit, on beginning blooming, except in nitrogen and potassium were deficient in another macronutrients.

The biofertilizer increasing soil salinity and inhibited the leaf accumulation of sodium in e yellow passion fruit plants.

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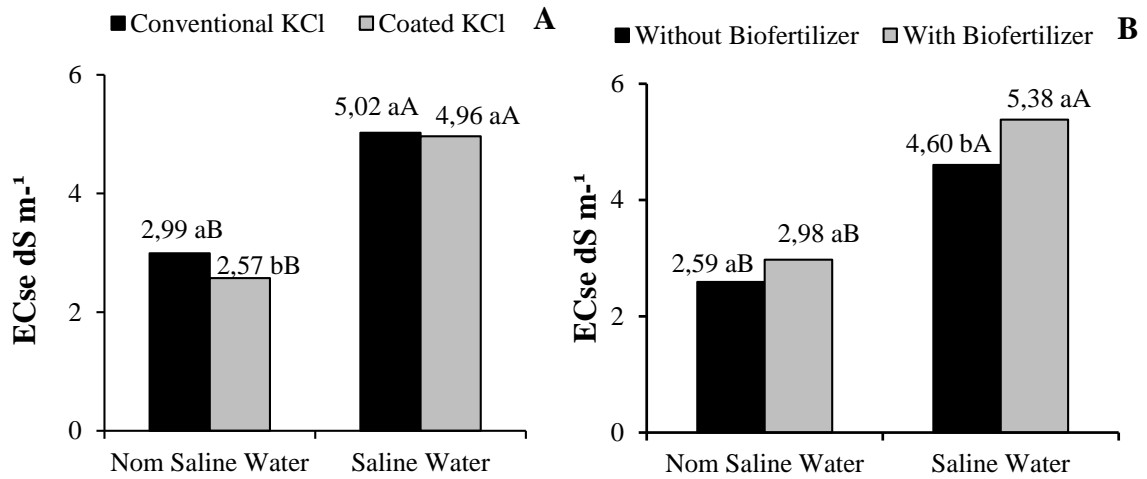


Figure 1. Electric conductivity of the soil’s saturation extract in the 0-40 layer at the beginning of flowering of yellow passion fruit plants, at 115 DAT, in function of water salinity, soil without and with biofertilizer, with conventional and coated KCl with organic polymers.

Columns with equal lowercase letters on the interactions water x potassium within biofertilizer, uppercase on the interactions water x biofertilizer within potassium and the same Greek letters between potassium x biofertilizer, within different waters, did not statistically differ with each other by the Tukey’s test ($P \geq 0.05$).

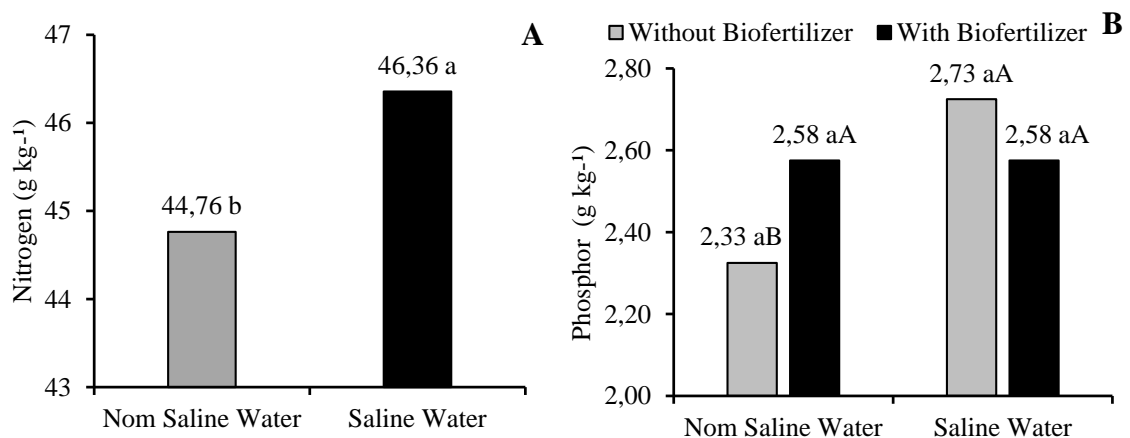


Figure 2. Nitrogen and phosphorus contents in the leaf dry matter of yellow passion fruit, in function of irrigation with non-saline and saline water (A), on soil without and with biofertilizer and types of potassium (B).

Columns with equal lowercase letters for phosphorus leaf content did not differ as the absence or presence of biofertilizer with the same type of water, and columns with the same uppercase letter did no differ as the type of water in the absence or presence of biofertilizer, according to the Tukey’s test ($P \leq 0.05$).

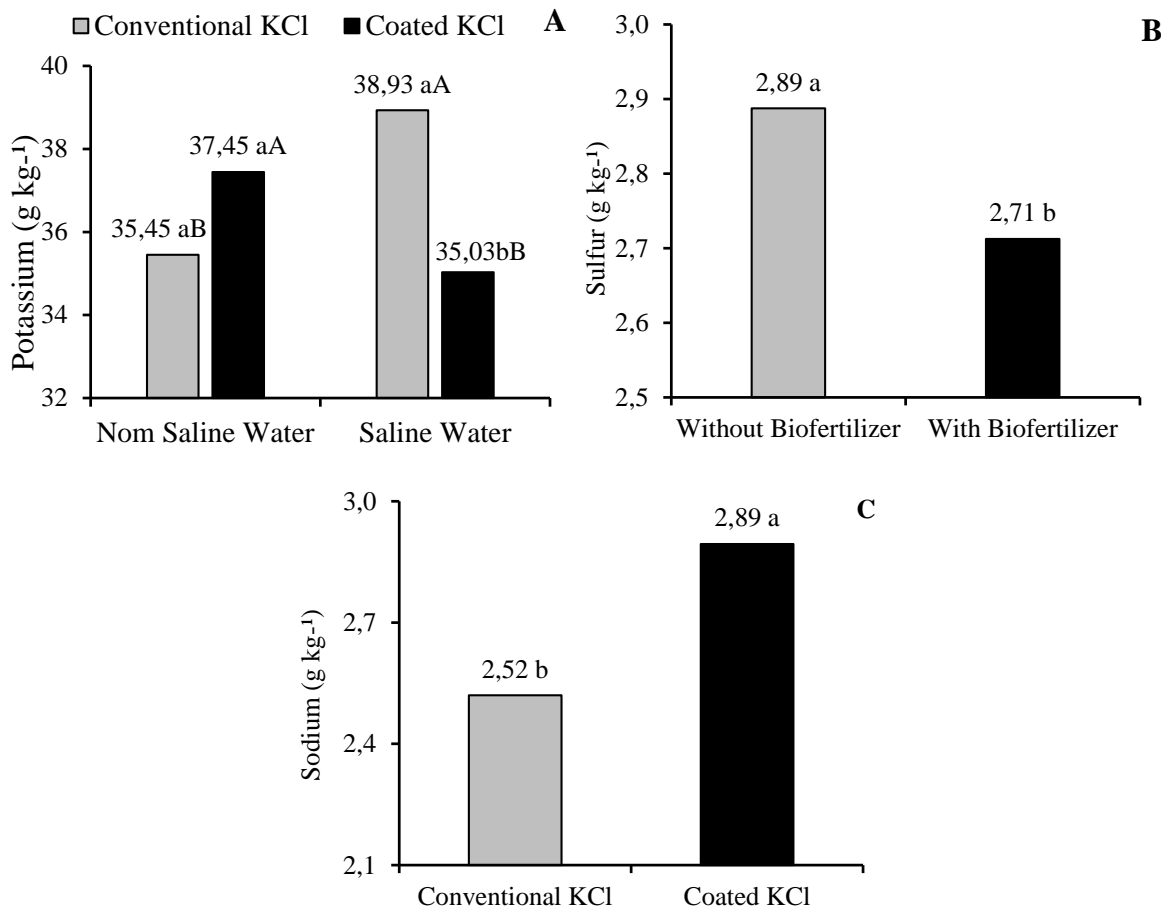


Figure 3. Potassium, sulphur and sodium levels in the leaf dry matter of yellow passion fruit plants, in function of the interaction between types of potassium and irrigation with non-saline and saline water (A), on soil without and with bovine biofertilizer (B) and types of potassium (C).

Columns with the same lower case letters for leaf contents of potassium did not differ as the type of potassium, in the same water, while columns with the same upper case letter did not differ as the type of water with the same potassium kind, by the Tukey's test ($p \leq 0.01$).

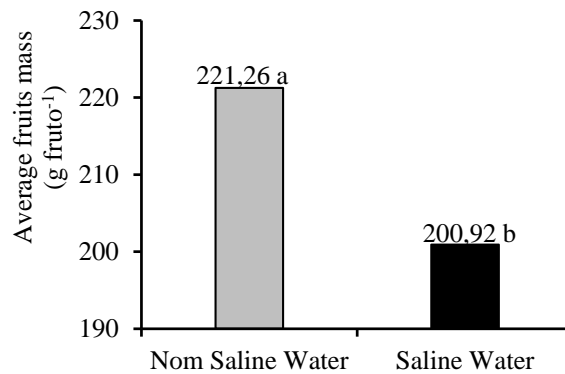


Figure 4. Average fruit mass of yellow passion fruit plants under irrigation with non-saline and saline water.