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Development of seedlings of watermelon cv. Crimson Sweet irrigated with biosaline water

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A B S T R A C T

The limited access and the scarcity of good quality water for agriculture are some of the major problems faced in agricultural areas, particularly in arid and semiarid regions. The aim of this study was to evaluate the quality of watermelon seedlings (cv. Crimson Sweet), irrigated with different concentrations of biosaline water of fish culture. The experimental design was completely randomized with five treatments, corresponding to biosaline water at different concentrations (0, 33, 50, 67 and 100%), and four replicates of 108 seedlings. Watermelon seeds were sown in plastic trays filled with commercial substrate and irrigated with different solutions of biosaline water. Seedlings were harvested for biometric analysis at 14, 21 and 28 days after sowing. The use of biosaline water did not affect emergence and establishment of seedlings until 14 days after sowing, the period recommended for transplantation. However, the use of biosaline water affected the development of seedlings with longer exposure time.

Palavras-chave:
Citrullus lanatus
água residuária
salinidade
germinação

Desenvolvimento de mudas de melancia cv. Crimson Sweet em água biossalina

R E S U M O

A limitação ao acesso e a escassez de água de boa qualidade para a agricultura são alguns dos principais problemas enfrentados em áreas agrícolas principalmente em regiões áridas e semiáridas. Objetivou-se, neste trabalho, avaliar a qualidade das mudas de melancia cv. Crimson Sweet, irrigadas com diferentes concentrações de água biossalina de cultivo de peixe. O delineamento experimental foi inteiramente casualizado com cinco tratamentos correspondendo a soluções de água biossalina em diferentes concentrações (0, 33, 50, 67 e 100%) e quatro repetições, de 108 mudas. As sementes de melancia cv. Crimson Sweet foram semeadas em bandejas plásticas preenchidas com substrato comercial e irrigadas com as diferentes soluções de água biossalina. As mudas foram coletadas para realização das análises biométricas aos 14,21 e 28 dias após a semeadura. O uso de água biossalina não afetou a emergência nem o estabelecimento das plântulas até os 14 dias após a semeadura, período recomendado para o transplantio; entretanto, a utilização de água biossalina afetou o desenvolvimento de mudas com maior período de exposição.

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Introduction

Watermelon (*Citrullus lanatus* (Thunb.) Mansf.) is cultivated in almost all the states in Brazil, especially in the Northeast region, where the state of Bahia produces 212,248 tons in an area of 10,828 ha (IBGE, 2013).

In the Brazilian semiarid region, mean annual rainfall range from 250 to 600 mm, with irregular spatial and temporal distribution. The mean annual temperature is 27 ºC and the mean annual evapotranspiration is 3000 mm (Cirilo, 2008). These characteristics are responsible for the scarcity of water in the region.

The decrease in water availability, whether due to climatic problems, increase in water consumption or its deterioration, has become increasingly serious, both in quantity and in quality all over the world (Rocha et al., 2010).

The quality of irrigation water directly influences the production and development of vegetable seedlings and is a determinant factor for agricultural activities (Alves et al., 2012). The use of saline groundwater and saline-sodic soils, or a combination of both, for the agricultural production is referred to as biosaline agriculture (Masters et al., 2007), which has been implemented in order to use waters with medium to high salinity to substitute water of better quality in agriculture.

Based on the above, this study aimed to evaluate emergence, establishment, development and quality of seedlings of watermelon (*Citrullus lanatus* (Thunb.) Mansf.), cultivar Crimson Sweet, irrigated with biosaline water, in order to verify the viability of seedlings production in biosaline agriculture.

Material and Methods

The experiment was carried out from May 2 to 30, 2012, in a greenhouse covered with shading screen (25% shading), in Petrolina-PE, Brazil (09º 23' S; 40º 30' W; 350 m). During the experiment, the mean temperature was 27.3 ºC and the relative air humidity was 58%.

The experimental design was completely randomized, with five treatments and four replicates, each one with 108 seedlings. The treatments consisted of different concentrations of biosaline water (BSW) diluted in normal water (NW) (Table 1): 0, 33, 50, 67 and 100% of BSW. After preparing the solutions, the electrical conductivity was measured and the following values were observed: 0.007, 2.21, 3.20, 4.16 and 5.95 dS m^{-1}, respectively. The biosaline water was collected from saline water tanks used for tilapia (*Oreochromis* sp.) farming, located at the Caatinga Experimental Field of the Embrapa Semi-arid.

The experiment used pesticide-free seeds of watermelon (cv. Crimson Sweet) from the line ISLA-PRO (ISLA® - Seed lot nº 28595), crop season of 12/2010, with water content of 8%. The seeds were planted in plastic trays with 36 cells, filled with the commercial substrate Plantmax® and then taken to the greenhouse. The trays were daily irrigated with the same volume of water for all the treatments (2 L $treatment^{-1}$).

Table 1. Composition of the biosaline water used in the irrigation of seedlings of Crimson Sweet watermelon (*Citrullus lanatus* (Thunb.) Mansf)

Determinations		Normal water	Biosaline water
Description	Unit	(NW) - 0%	(BSW) - 100%
Calcium	$mmol_c\ L^{-1}$	0.70	12.7
Magnesium	$mmol_c\ L^{-1}$	0.3	29.45
Sodium	$mmol_c\ L^{-1}$	0.15	28.4
Potassium	$mmol_c\ L^{-1}$	0.09	0.62
Sum	$mmol_c\ L^{-1}$	1.24	71.2
Carbonate	$mmol_c\ L^{-1}$	0.0	0
Bicarbonate	$mmol_c\ L^{-1}$	0.6	4.5
Sulfate	$mmol_c\ L^{-1}$	0.013	3.64
Chloride	$mmol_c\ L^{-1}$	0.7	73.5
Sum	$mmol_c\ L^{-1}$	1.313	81.6
EC – 25 ºC	dS m^{-1}	0.08	5.95
SAR*	$(mmol\ L^{-1})^{0.5}$	0.21	6.18

* SAR - Sodium Adsorption Ratio

The emerged seedlings were daily counted from 5 to 14 days after sowing (DAS) (Brasil, 2009). Then, emergence percentage (E%), emergence speed index (ESI), mean emergence time (MET) and mean emergence speed (MES) were calculated (Ranal & Santana, 2008).

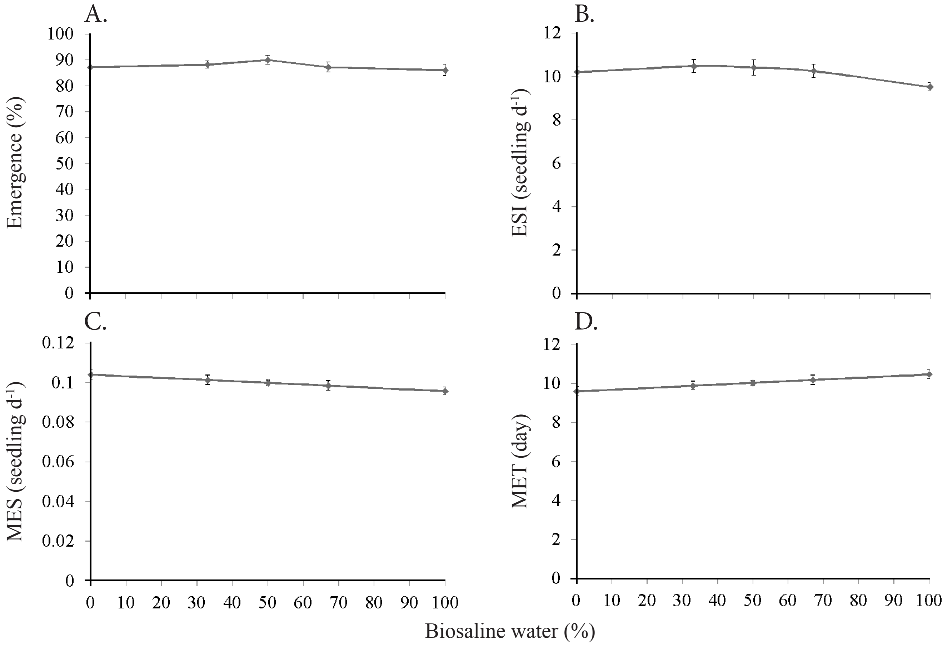
At 14, 21 and 28 DAS, plant material was collected for biometric analysis. Ten watermelon seedlings were used for growth evaluations: length, fresh matter and dry matter of roots and shoots. Shoot and root lengths were determined using a millimeter ruler. Then, the seedlings were weighed using a precision scale in order to obtain the fresh matter content. After that, the seedlings were placed in paper bags and kept in an oven at ± 65 °C for 72 h, in order to obtain the dry matter content. From these data, the absolute growth rate and the relative growth rate were calculated (Benincasa, 1988).

The mean values of the variables were subjected to the analysis of homogeneity and polynomial regression (without data transformation), and the best fit ($P < 0.05$) was chosen. For the equations that did not fit, the mean standard error was used and shown in the graphs as vertical bars. All the analyses were performed using the software Assistat, version 7.6 (Beta) (Silva, 2012).

Results and Discussion

Irrigation with biosaline water (BSW) did not affect emergence percentage and speed index (Figure 1A, B). These results are probably due to the low electrical conductivity (EC) of the BSW used, which was below 6.0 dS m^{-1} (Table 1) and due to the germination and emergence of cucurbits like watermelon and melon (*Cucumis melo* L.) and cucumber (*Cucumis sativus* L.). These crops are only harmed by EC levels higher than 11 dS m^{-1} (Torres, 2007; Secco et al., 2010, Matias et al., 2015b). In addition, the use of BSW with EC of approximately 4.0 dS m^{-1} did not affect the germination of cucumber seeds (Matias et al., 2015a).

The mean emergence speed showed a linear decreasing trend, while the mean emergence time increased with the use of BSW. In spite of that, the difference between the values of the treatments with 0 and 100% of BSW was very small for



Vertical bars in curves that did not fit regression models represent the mean standard error

Figure 1. Emergence percentage (A), emergence speed index – ESI (B), mean emergence speed – MES (C) and mean emergence time – MET (D) of seedlings of Crimson Sweet watermelon (*Citrullus lanatus* (Thunb.) Mansf.) irrigated with biosaline water

both variables (Figure 1C, D). Similar results were observed for the kinetics of germination of cucumber seeds in biosaline water (Matias et al., 2015b).

Shoot length and root length at 14 DAS were not influenced by the use of BSW (Figure 2A, B). At 21 and 28 DAS, no difference was observed in the roots between the treatments (Figure 2D, F).

Over time, the excess of soluble salts in the irrigation water increases salt concentration in the substrate, promotes the reduction of water potential and directly affects plant development (Medeiros et al., 2010). In this study, the toxicity of salts from BSW led to the reduction in the length of seedlings as salinity increased. This result was observed at 14 DAS in watermelon (Torres, 2007) and melon seedlings (Ferreira et al., 2007). However, BSW induced the reduction of shoot length only after 21 DAS (Figure 2C, E). Despite the reduction in shoot length at 21 and 28 DAS (Figure 2C, E), it must be considered that, in the production of watermelon seedlings, the transplanting phase occurs approximately at 14 DAS. During this period, the use of BSW did not affect the growth of seedling shoots (Figure 2A).

The tolerance to salinity is described as the ability to avoid, through a saline regulation, that the excessive salt contents from the substrate reach the protoplasm and/or as the ability to tolerate the toxic and osmotic effects associated with the increase in the saline concentration in the protoplasm (Larcher, 2004).

The increase in irrigation water salinity linearly reduced shoot height of seedlings of the melon hybrid Daimiel (Queiroga et al., 2006), while the hybrids Honey Dew, Red Flesh and My Mark did not tolerate salinity levels above 2.15 dS m^{-1} (Costa et al., 2008) and the cultivar 'Eldorado 300' tolerates salinity levels of up to 16 dS m^{-1} (Secco et al., 2010). Therefore, it can be inferred that the tolerance of different cultivars of the same species can vary widely.

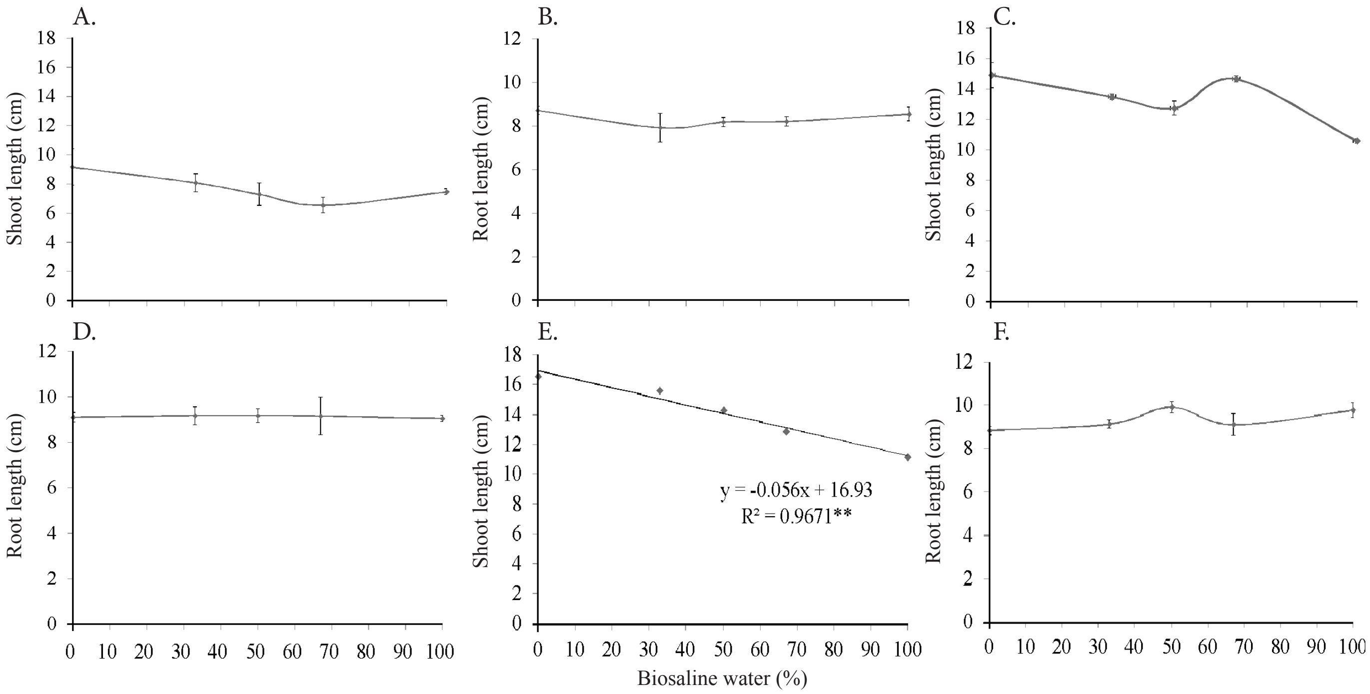
There was a reduction of approximately 50% in shoot fresh matter between the control, irrigated with normal water, and the treatment with 100% BSW in the three evaluated periods (Figure 3A, C, E). Root fresh matter was not affected until 14 DAS.

However, at 21 DAS, root fresh matter decreased linearly with the increase in BSW concentration in the irrigation water. At 28 DAS, root fresh matter did not show significant difference between the treatments (Figure 3B, C, F).

Shoot dry matter showed a linear decreasing trend in all the evaluated periods (Figure 4A, C, E). Root dry matter showed a linear decreasing trend at 14 and 28 DAS (Figure 4B, F).

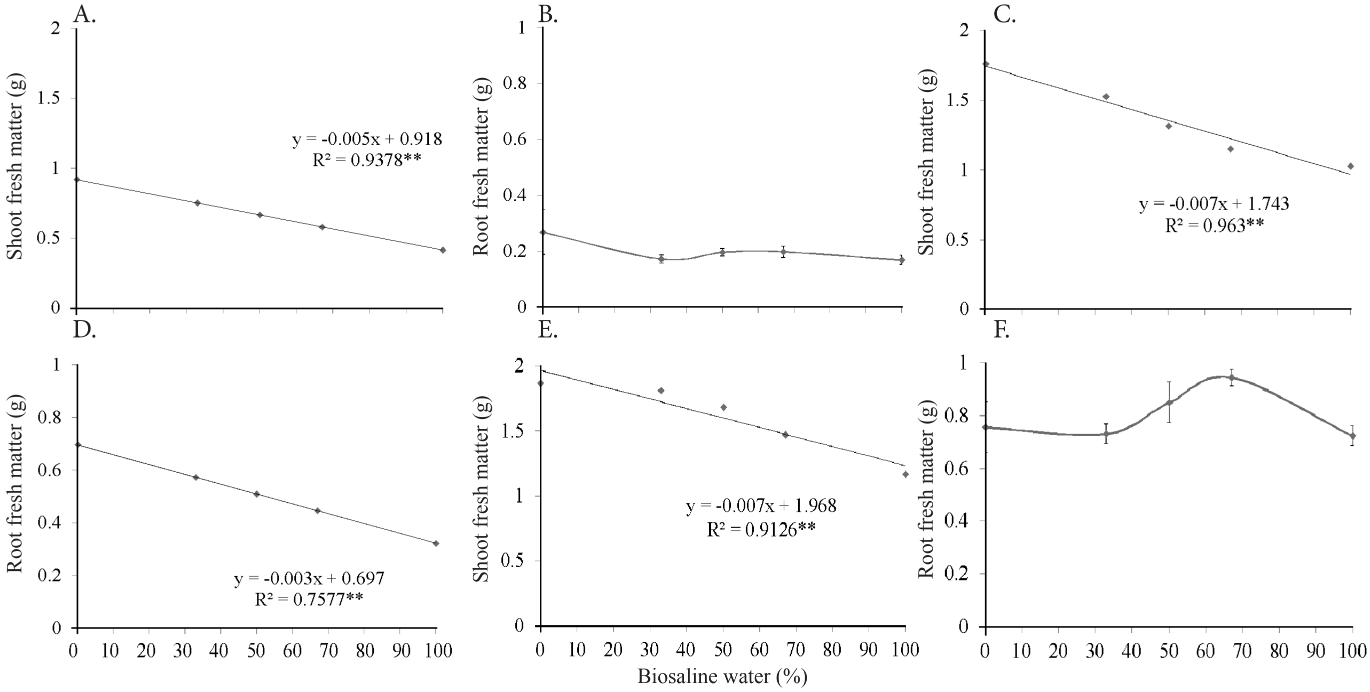
Similar results were obtained in seedlings of different cucurbits, like watermelon, melon and gherkin (*Cucumis anguria* L.) (Torres, 2007; Freitas et al., 2007; Oliveira et al., 2012), in which there was a biomass reduction with the increase in salinity. The decrease in water potential in the substrate affects plant development. In addition, plants develop mechanisms for protection and metabolism adjustment, especially through antioxidant enzymes (Dantas et al., 2015), due to damages caused by the toxicity of ions to the membranes, leading to a reduction in the accumulation of dry matter (Machado et al., 2004). However, the use of BSW promoted higher shoot and root dry matter, respectively, in seedlings of cucumber (Matias et al., 2015b). Thus, the benefit for seedling development can be related to the nutrient-rich water from fish farming.

The use of BSW promoted a negative effect on the seedlings, represented by the lowest absolute growth rate (Figure 5A, C, E). The absolute growth rate was the characteristic most affected by salinity in the cultivation of castor bean (*Ricinus communis* L.) (Soares et al., 2012) and melon (Gurgel et al., 2010), corroborating the results observed in this study.



Vertical bars in curves that did not fit regression models represent the mean standard error

Figure 2. Shoot length (A, C, E) and root length (B, D, F) of seedlings of Crimson Sweet watermelon (*Citrullus lanatus* (Thunb.) Mansf.) irrigated with biosaline water, at 14 (A, B), 21 (C, D) and 28 (E, F) days after sowing

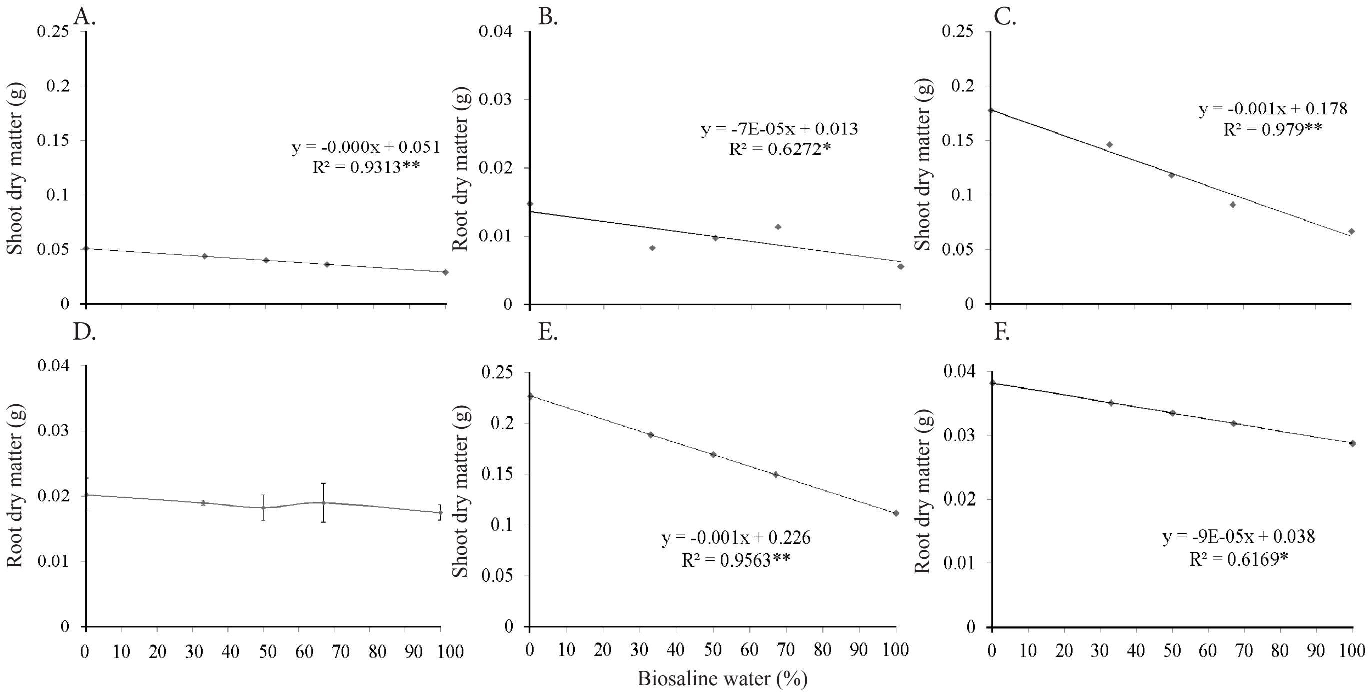


Vertical bars in curves that did not fit regression models represent the mean standard error

Figure 3. Shoot fresh matter (A, C, E) and root fresh matter (B, D, F) of seedlings of Crimson Sweet watermelon (*Citrullus lanatus* (Thunb.) Mansf.) irrigated with biosaline water, at 14 (A, B), 21 (C, D) and 28 (E, F) days after sowing

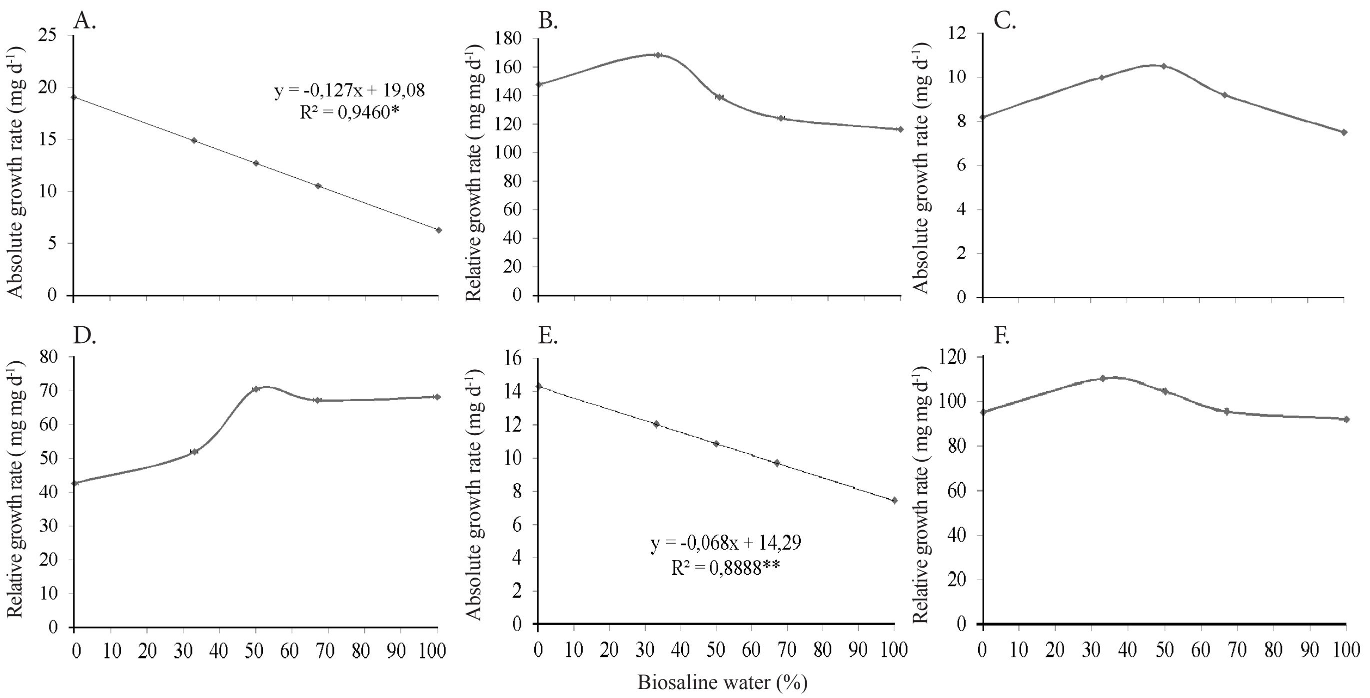
Usually, plant development processes are sensitive to the effect of salts, so that the growth rate and biomass production are the criteria used for the evaluation of the level of stress and the capacity of the plant to overcome saline stress (Larcher, 2004). The damage caused by salinity in biomass accumulation during the initial phase of watermelon seedlings can be observed through the behavior of the treatments with respect to the relative growth rate. However, considering the interval from 14 to 28 DAS, there was no significant difference between the treatments (Figure 5B, D, F), which also occurred in Gold Mine melon (Farias et al., 2003)

Given the challenges for the access to better quality water, the use of wastewater is an alternative for agriculture. The reuse of these waters allows a better utilization of water resources in arid and semiarid regions, besides decreasing the risk of environmental damages to soils and water sources. The results obtained in this study show that the use of biosaline water is an alternative for the production of seedlings of Crimson Sweet



Vertical bars in curves that did not fit regression models represent the mean standard error

Figure 4. Shoot dry matter (A, C, E) and root dry matter (B, D, F) of seedlings of Crimson Sweet watermelon (*Citrullus lanatus* (Thunb.) Mansf.) irrigated with biosaline water, at 14 (A, B), 21 (C, D) and 28 (E, F) days after sowing



Vertical bars in curves that did not fit regression models represent the mean standard error

Figure 5. Absolute growth rate (A, C, E) and relative growth rate (B, D, F) of seedlings of Crimson Sweet watermelon (*Citrullus lanatus* (Thunb.) Mansf.) irrigated with biosaline water, in the periods of 14-21 (A, B); 21-28 (C, D) and 14-28 (E, F) days after sowing

watermelon, since the vigor of seedlings produced during this study was similar to that of seedlings produced using normal water, in the period indicated for transplantation.

Conclusion

1. Biosaline water can be used for the production of seedlings of Crimson Sweet watermelon without negative effects until 14 days after sowing, indicating the tolerance of this cultivar to salinity conditions until the period of transplantation.

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