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ORIGINAL PAPER

Growth of yellow passion-fruit seedlings in different substrates under salt stress

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Abstract: Salt stress can negatively affect the development of seedlings. However, the use of alternative substrates can mitigate these effects. The present study aimed to evaluate the growth of yellow passion-fruit seedlings in response to irrigation with saline water grown on different substrates. The experiment was developed at the University of International Integration of Afro-Brazilian Lusofonia, Redenção, Ceará, Brazil. The experimental design was entirely randomized, in a 2 × 5 factorial arrangement, composed of two levels of electrical conductivity of the irrigation water (0.3 and 3.0 dS m^{-1}) and five substrate types (S1 = soil; S2 = sand, sandy soil, and bovine manure – 1:1:1; S3 = sand, sandy soil, and carbonized rice husk – 1:1:1; S4 = sand, sandy soil, and biochar – 1:1:1; S5 = sand, sandy soil, and vegetal ash – 1:1:1), with five replications. The S2 substrate containing sand, sandy soil, and bovine manure promoted higher performance of seedling height, stem diameter, shoot dry mass, root dry mass, and total dry mass associated with low salinity water. The S2 substrate was more efficient for leaf area, while S4 substrate was more efficient for number of leaves, root length, and pH. The S1 and S2 substrates presented higher electrical conductivity of the saturation extract using water of higher conductivity.

Keywords: *Passiflora edulis*, salinity, Dickson quality index.

Introduction

Passion fruit belongs to the Passifloracea family, is a fruit tree native to Tropical America, it has more than 150 species that are used for various purposes, such as food, medicine and ornamentation (Freire et al., 2020). The yellow passion fruit (*Passiflora edulis* f. *flavicarpa*), purple passion fruit (*Passiflora edulis*) and sweet passion fruit (*Passiflora alata*) are the most cultivated species in Brazil and worldwide (Paixão et al., 2021; Veimrober Júnior et al., 2022).

With water scarcity, it becomes necessary to use lower quality water for the development of production (Freitas et al., 2021). However, due to the presence of high salt contents in these waters, agriculture becomes relatively restricted for the

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performance of crops not tolerant to salinity, as well as in the production of seedlings (Melo Filho et al., 2017; Guedes et al., 2023).

The production of seedlings is a primordial process for success in orchards, and the type of substrate used has a direct influence on its quality and final cost taking into account the crop that will be used (Cruz et al., 2016; Mendonça et al., 2021; Paixão et al., 2021).

Currently on the market there are several types of commercial substrates, which have a good acceptability and are considered of good quality, but can represent a considerable increase in production cost, in contrast there is the possibility of using alternative substrates, formulated with products available on the property or in the region, thus reducing production costs without affecting the quality of the seedlings produced (Amorim, 2015). Almeida et al. (2020) and Cruz et al. (2016) working with seedlings of *Handroanthus impetiginosus* and umbuzeiro respectively, state that the use of alternative substrates makes the production of these seedlings viable.

In this context, the objective of the present study was to evaluate the development of yellow passion-fruit seedlings in response to irrigation with saline water grown on different substrates.

Material and Methods

The experiment was developed in a protected environment with black shading with 50% shade, in the experimental area of the Aurora Seedling Production Unit, belonging to the University of Integration of Lusofonia Afro-Brasileira (UNILAB), on the Auroras campus, Redenção, Ceará. The region's climate is of type BSh', predominating very high temperatures and rainfall in the summer and autumn seasons (Alvares et al., 2013). Figure 1 shows the climatic data during the conduct of the experiment.

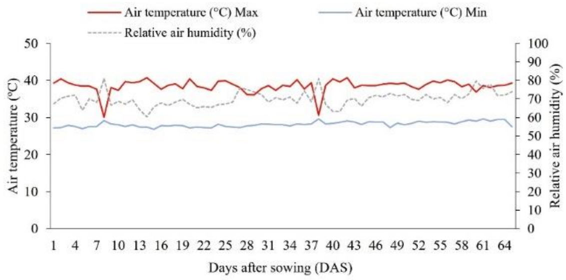


Figure 1. Average values of temperature and relative humidity during the experimental period.

The experimental design was entirely randomized, in a 2 × 5 factorial arrangement, consisting of two levels of electrical conductivity of irrigation water (0.3 and 3.0 dS m^{-1}) and five substrate types (S1 = soil; S2 = sand, sandy soil, and bovine manure – 1:1:1; S3 = sand, sandy soil, and carbonized rice husk – 1:1:1; S4 = sand, sandy soil, and biochar – 1:1:1; S5 = sand, sandy soil, and vegetal ash – 1:1:1), with five repetitions.

For cultivation, black polyethylene bags (19 × 21 cm) were used, filled with the respective substrates mentioned above. The sowing was performed with three seeds per bag, at a 2 cm depth. At 15 days after sowing (DAS) thinning was performed, leaving only one seedling per bag.

Samples of the substrates were sent to the laboratory of the Federal University of Ceará (UFC), where the chemical attributes were determined, as shown in Table 1.

The low-salinity water (0.3 dS m^{-1}) used for irrigation came from the local water supply, provided by the Ceará Water and Sewage Company (CAGECE). The ECw level of 3.0 dS m^{-1} was obtained by adding sodium chloride (NaCl), calcium chloride ($CaCl_2.2H_2O$), and magnesium chloride ($MgCl_2.6H_2O$) to the supply water in the equivalent proportion of 7:2:1. The quantity of salts was determined using the relationship between ECw and its concentration (mmol$_c$ L^{-1} = EC × 10) according to Richards (1954). Irrigation with saline water began 20 DAS.

Table 1: Chemical characteristics of the substrates used

Substrate	OM	N	P	Ca	K	Mg	Na	H + Al	SB	CEC	V	ECse	pH
	--- g kg^{-1} ----		mg kg^{-1}	----------------- $cmol_c$ kg^{-1}						--------------------------	%	dS m^{-1}	H_2O
S1	4.03	0.24	2	2.50	0.06	0.30	0.57	0.33	3.43	3.76	91	0.37	7.6
S2	14.74	0.93	20	4.90	0.58	0.90	0.26	0.33	6.64	6.97	95	1.34	7.0
S3	10.55	0.65	78	4.50	0.56	0.60	0.17	0.99	5.83	6.82	85	0.76	7.2
S4	8.69	0.51	85	2.50	0.51	1.60	0.18	0.66	4.79	5.45	88	0.78	7.1
S5	9.10	0.53	468	14.90	3.18	1.90	3.02	0.00	23.0	23	100	1.22	8.2

S1 – soil; S2 – sand, sandy soil, and bovine manure (1:1:1); S3 – sand, sandy soil, and carbonized rice husk (1:1:1); S4 – sand, sandy soil, and biochar (1:1:1); S5 – sand, sandy soil, and vegetal ash (1:1:1); OM – organic matter; N – total nitrogen; P – phosphorus; Ca – calcium; K – potassium; Mg – magnesium; Na – sodium; SB – sum of bases ($Ca^{2+} + Mg^{2+} + Na^+ + K^+$); CEC – cation exchange capacity [$Ca^{2+} + Mg^{2+} + Na^+ + K^+ + (H^+ + Al^{3+})$]; V – saturation of bases ($Ca^{2+} + Mg^{2+} + Na^+ + K^+$/CEC) × 100; ECse – electrical conductivity of the saturation extract.

Irrigation management was performed using drainage lysimeter according to Bernardo et al. (2019). Daily irrigations were performed to raise the soil moisture to the field capacity. Taking into account a leaching blade of 15%, according to Ayers and Westcot (1989), the volume of water applied to the plants was determined according to Equation 1.

$$VI = \frac{(Vp - Vd)}{(1 - LF)} \quad (1)$$

Where: VI – volume of water to be applied in the irrigation event (mL); Vp – volume of water applied at the previous irrigation event (mL); Vd – volume of drained water (mL); LF – leaching fraction, using the value of 0.15.

The evaluations were performed when the seedlings reached their transplanting point at 65 DAS. According to Gontijo (2017), the transplanting should be performed when the seedlings present a height from 15 to 30 cm. Seedlings were measured for number of leaves (NL), by directly counting the leaves; seedling height (SH, in cm), using a graduated ruler, measuring from the base to the apex of the seedling; stem diameter (SD, in mm), using a digital caliper, measuring at one centimeter height from the substrate; root length (RL, in cm), using a graduated ruler, measuring from the insertion of the main root at the base of the foliage to the root apex; leaf area (LA, cm^2), using a portable leaf area meter (LI-COR Biosciences, Inc.; Lincoln, Nebraska, USA).

For biomass evaluation, seedling samples were identified according to the treatments and packed in paper bags. Afterwards, they were placed for drying in a forced air circulation oven at 60°C for 72 h. Then the shoot dry matter (SDM, in g) and the root dry matter (RDM, in g) were determined using an analytical balance. With the sum of the SDM and RDM data the total dry matter (TDM, in g) was obtained.

After plant collection, soil samples were also collected from each pot to evaluate hydrogen potential (pH) and the electrical conductivity of the saturation extract (ECse), using the methodology of Richards (1954).

From the previous evaluations, the Dickson quality index (DQI) was evaluated according to Equation 2 (Dickson et al., 1960).

$$DQI = \frac{TDM\ (g)}{\frac{SH\ (cm)}{SD\ (mm)} + \frac{SDM\ (g)}{RDM\ (g)}} \quad (2)$$

The data were subjected to analysis of variance (ANOVA) by the F test, and the means were compared with Tukey's test at $p \leq 0.05$, using the Assistat computer program. 7.7 Beta (Silva and Azevedo, 2016).

Results and Discussion

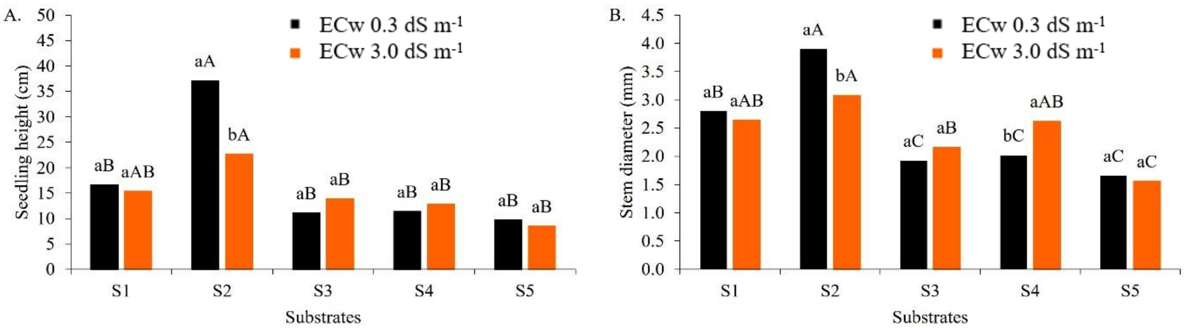
The analysis of variance showed a significant effect ($p \leq 0.01$) for the interaction between levels of electrical conductivity of the irrigation water (ECw) and substrate types for seedling height (SH) and stem diameter (SD) of passion-fruit seedlings (Table 2). The substrate types significantly influenced ($p \leq 0.01$) leaf area, root length, and number of leaves in addition to SH and SD. ECw levels significantly affected ($p \leq 0.05$) only number of leaves.

The follow-up analysis on the interaction of the SH (Figure 2A), there was no significant difference for S1, S3, S4, and S5 substrates among the studied ECw. The SH values were statistically highest using S2 substrate, regardless of ECw. ECw levels provided values of 37.12 and 22.70 cm under cultivation without salt stress (ECw 0.3 dS m^{-1}) and under salinity (ECw 3.0 dS m^{-1}), respectively.

Table 2: Summary of the analysis of variance for seedling height (SH), stem diameter (SD), leaf area (LA), root length (RL), and number of leaves (NL) as a function of the levels of electrical conductivity of the irrigation water (ECw) and substrate types (ST)

SV	DF	Mean square				
		SH	SD	LA	RL	NL
ECw	1	80.39^{ns}	0.02^{ns}	240.67^{ns}	9.59^{ns}	8.82^{*}
ST	4	671.88^{**}	5.11^{**}	9738.69^{**}	266.19^{**}	31.47^{**}
ECw × ST	4	118.08^{**}	0.69^{**}	435.23^{ns}	8.95^{ns}	2.47^{ns}
Residue	40	22.62	0.10	171.61	15.42	1.80
CV (%)	-	29.90	13.14	31.15	16.78	15.28

SV – source of variation; DF – degree of freedom, CV – coefficient of variation; ** and * significant at $p \leq 0.01$ and $p \leq 0.05$, respectively, and ns – not significant by F-test.



S1 – soil; S2 – sand, sandy soil, and manure; S3 – sand, sandy soil, and carbonized rice husk; S4 – sand, sandy soil, and biochar; S5 – sand, sandy soil, and vegetal ash. Lowercase letters compare the means of the ECw levels in each substrate type, and uppercase letters compare the means of the substrate types in each ECw level by the Tukey's test ($p \leq 0.05$).

Figure 2: Follow-up analyses of the interaction between levels of electrical conductivity of the irrigation water (ECw) and substrates types for seedling height (A) and stem diameter (B) of passion-fruit seedlings.

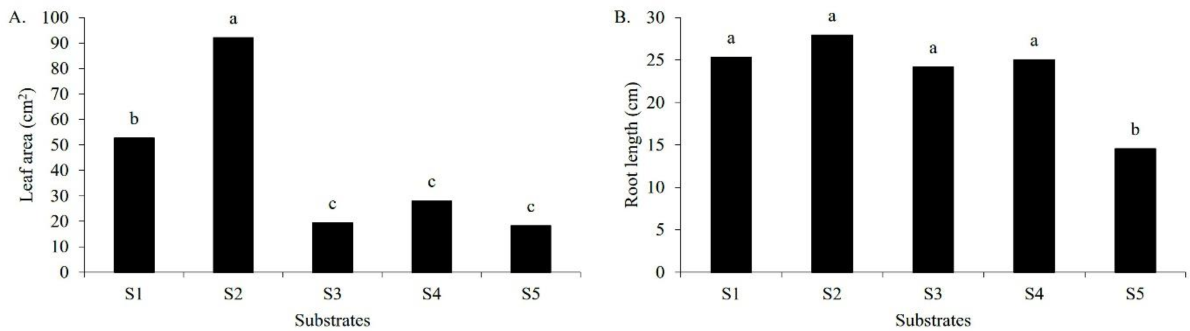
The greater performance of the seedlings in the S2 substrate associated without salt stress may be related to the presence in high quantity of organic matter, i.e., offering stimulants capable of inducing plant growth (Salles et al., 2017), contributing even under conditions of higher salinity, as comparing the substrates only under salt stress, S2 provided the best response.

These results corroborate those found by Almeida et al. (2020) working with *Handroanthus impetiginosus* seedlings in substrates with organic compost and irrigated with low salinity water. Similar to the data presented in this study, Ramos et al. (2022) studying passion-fruit seedlings observed a reduction in their height due to the increase in the ECw.

As for the follow-up analysis on the interaction of the stem diameter (SD), the S2 substrate associated with the use of water of lower salinity (ECw 0.3 dS m^{-1}) promoted higher mean (3.90 mm) than the other substrates (Figure 2B). Under salt stress (ECw 3.0 dS m^{-1}), the means obtained according to S1, S2, and S4 substrates did not significantly differ, but S3 substrate was statically equal to the S1 and S4.

The higher value of SD in the S2 substrate are possibly linked to the nutritional contribution of organic matter that releases essential nutrients such as nitrogen, phosphorus, and potassium, which are fundamental for the development of the seedling stem diameter (Silva et al., 2020). When irrigated with water of higher salinity, organic matter promotes a better adjustment of the osmotic potential of the soil, showing a greater development of crops (Sousa et al., 2018).

Similar to the SH and SD, the S2 substrate promoted higher mean of leaf area (92.06 cm^2) than the other substrates (Figure 3A). This result is related to the greater presence of nitrogen in this substrate, evidencing greater leaf expansion. Similar results were verified by Silva et al. (2019) working with yellow passion fruit tree in substrates with bovine manure as a source of organic matter.



S1 – soil; S2 – sand, sandy soil, and manure; S3 – sand, sandy soil, and carbonized rice husk; S4 – sand, sandy soil, and biochar; S5 – sand, sandy soil, and vegetal ash. Lowercase letters compare the means by the Tukey's test ($p \leq 0.05$).

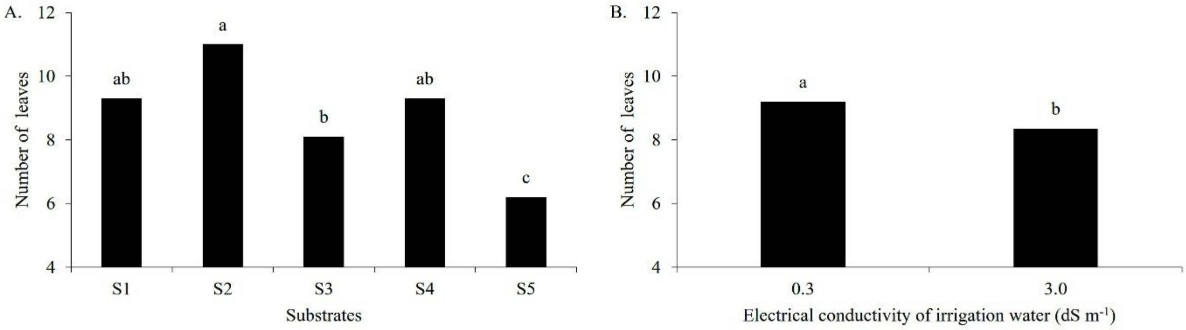
Figure 3: Leaf area (A) and root length (B) of passion-fruit seedlings as a function of the substrate types.

For root length (Figure 3B), the S5 substrate showed the lowest value (14.52 cm), differing from the other substrates. This may be associated with the accumulation of salts present in this S5 substrate type, presented in Table 1. The presence of salts in the soil reduces the osmotic potential of the soil, consequently there is a greater difficulty in the absorption of water by the roots (Rodrigues et al., 2020). Similar trends to this study were found by Mendonça et al. (2021) when using carnauba bagasse as substrate for root length in passion-fruit seedlings.

For the number of leaves (Figure 4A), the S1, S2 and S4 substrates showed better results, but S3 substrate was statically equal to the S1 and S4. Similar results were found by Silva et al. (2020) working with tamarind seedlings grown in substrates based on bovine manure. There was a significant decrease of 9.13% in number of leaves with salinity (ECw 3.0 dS m^{-1}) compared to the control (ECw 0.3 dS m^{-1}) (Figure 4B).

This reduction in the number of leaves as the salinity of the irrigation water increased is linked to the process of inhibition of leaf emission, which is a plant adaptation mechanism to minimize water loss through transpiration (Freitas et al., 2021). Diniz et al. (2018) found that in papaya seedlings there was a reduction in the number of leaves with increasing salinity. Similar results were also found by Melo Filho et al. (2017) working with pitombeira seedlings, where they observed a negative effect of salinity on the number of leaves.

The interaction between ECw and substrate types significantly affected ($p \leq 0.01$) the shoot dry matter (SDM), root dry matter (RDM), total dry matter (TDM), Dickson quality index (DQI), and electrical conductivity of the saturation extract of the substrate (ECse). The isolated effects of ECw levels and substrate types significantly affected ($p \leq 0.01$) the pH (Table 3).



S1 – soil; S2 – sand, sandy soil, and manure; S3 – sand, sandy soil, and carbonized rice husk; S4 – sand, sandy soil, and biochar; S5 – sand, sandy soil, and vegetal ash. Lowercase letters compare the means by the Tukey's test ($p \leq 0.05$).

Figure 4: Number of leaves of passion-fruit seedlings as a function of the substrate types (A) and electrical conductivity of irrigation water (B).

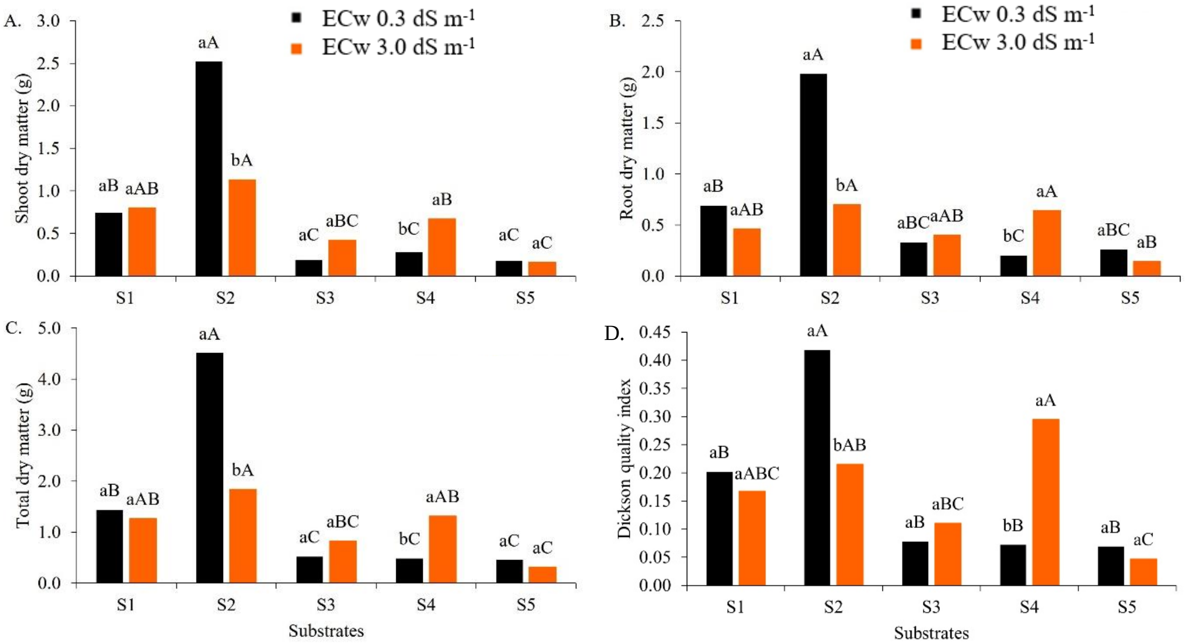
Table 3: Summary of the analysis of variance for shoot dry matter (SDM), root dry matter (RDM), total dry matter (TDM), Dickson quality index (DQI), pH, and electrical conductivity of the saturation extract (ECse) as a function of the levels of electrical conductivity of the irrigation water (ECw) and substrate types (ST)

SV	DF	Mean square					
		SDM	RDM	TDM	DQI	pH	ECse
ECw	1	0.26^{*}	0.62^{**}	1.69^{**}	0.00002^{ns}	17.88^{**}	107.98^{**}
ST	4	4.40^{**}	1.97^{**}	12.26^{**}	0.10^{**}	0.59^{**}	6.58^{**}
ECw × ST	4	1.27^{**}	1.03^{**}	4.55^{**}	0.05^{**}	0.04^{ns}	3.51^{**}
Residue	40	0.06	0.07	0.16	0.007	0.01	0.25
CV (%)	-	34.8	35.43	31.32	30.70	3.33	22.35

SV – source of variation; DF – degree of freedom, CV – coefficient of variation; ** and * significant at $p \leq 0.01$ and $p \leq 0.05$, respectively, and ns – not significant by F-test.

Similar to the SH, SD, and leaf area, the S2 substrate promoted higher means of SDM (Figure 5A), RDM, (Figure 5B), TDM (Figure 5C), and DQI (Figure 5D) than the other substrates under cultivation without salt stress (ECw 0.3 dS m^{-1}). The high content of organic matter provided greater water retention and better uptake of nutrients such as nitrogen.

Similar to the present study for SDM (Figure 5A), best results were obtained with substrates containing organic compost for growing seedlings of umbuzeiro (Cruz et al., 2016) e *Handroanthus impetiginosus* (Mart. ex DC) (Almeida et al., 2020).



S1 – soil; S2 – sand, sandy soil, and manure; S3 – sand, sandy soil, and carbonized rice husk; S4 – sand, sandy soil, and biochar; S5 – sand, sandy soil, and vegetal ash. Lowercase letters compare the means of the ECw levels in each substrate type, and uppercase letters compare the means of the substrate types in each ECw level by the Tukey's test ($p \leq 0.05$).

Figure 5: Follow-up analyses of the interaction between levels of electrical conductivity of the irrigation water (ECw) and substrates types for shoot dry matter (A), root dry matter (B), total dry matter (C), and Dickson quality index (D) of passion-fruit seedlings.

For the results of RDM (Figure 5B), similar results were found with organic substrates for growing seedlings of *Handroanthus impetiginosus* (Mart. ex DC) (Almeida et al., 2020) e passion-fruit (Paixão et al., 2021). The TDM (Figure 5C) was also influenced by organic compost. Likewise, substrate containing bovine manure promoted higher means in the work by Moreira et al. (2015) for growing seedlings of guapuruvú (*Schizolobium parahyba* (Vell.) S. F. Blake).

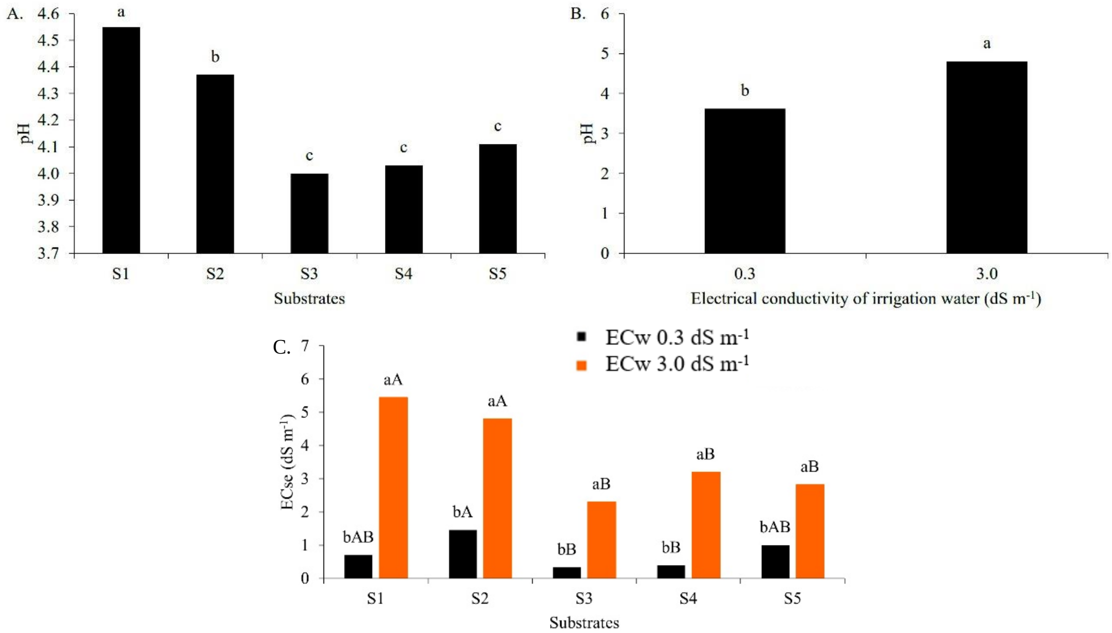
For Dickson's quality index (Figure 5D), the association between the substrate containing manure (S2) and low salinity water showed the highest mean value (0.41). Similar trend was observed for the association between the substrate containing biochar (S4) and the water of higher salinity, with the value of 0.29.

The use of organic matter aims to provide greater water and nutrient retention for the seedlings (Caldeira et al., 2008). Thus, bovine manure becomes an alternative to compose the substrate for the production of seedlings under lower salinity. Under higher conductivity due to its adsorption capacity, biochar is able to make plants minimize sodium uptake through transient binding with Na^+, causing less osmotic stress (Akhtar et al., 2015).

Similar results were observed by Almeida et al. (2020) in seedlings of *Handroanthus impetiginosus*, in which the highest DQI was observed in the substrate containing organic compost irrigated with low salinity water. Melo Filho et al. (2017) observed a decrease in DQI due to the increase in salinity of irrigation water in pitombeira seedlings.

Figure 6A shows that the pH was decreased in all substrates used at the end of the experiment compared to the initial values (Table 1). The S1 substrate was statistically highest to the other substrates. This result may be associated with the leaching of basic cations from the substrate through irrigation, favoring higher concentrations of H^+ and Al^{3+} ions, thus causing acidity in the substrates. Oliveira et al. (2008) evaluating the use of green coconut powder as an alternative substrate for the production of eggplant seedlings observed that after cultivation, there were reductions in the pH of all substrates used.

As shown in Figure 6B, there was a 32.87% increase in pH as the electrical conductivity of irrigation water increased. The results obtained in the present study differ from those found by Dias et al. (2015) working with yellow passion fruit and by Pereira Filho et al. (2017) working with cowpea, where they found that increasing the ECw provided a lower value of soil pH.



S1 – soil; S2 – sand, sandy soil, and manure; S3 – sand, sandy soil, and carbonized rice husk; S4 – sand, sandy soil, and biochar; S5 – sand, sandy soil, and vegetal ash. Figures A and B – lowercase letters compare the means by the Tukey's test ($p \leq 0.05$). Figure C – lowercase letters compare the means of the ECw levels in each substrate type, and uppercase letters compare the means of the substrate types in each ECw level by the Tukey's test ($p \leq 0.05$).

Figure 6: pH of the substrates as a function of substrate types (A) and electrical conductivity of irrigation water – ECw (B) and follow-up analyses of the interaction (substrate types and ECw) for electrical conductivity of the saturation extract (ECse) of the substrates (C).

The highest values of the electrical conductivity of the saturation extract of the substrates were obtained in the treatments irrigated with water of higher salinity, regardless of the substrate (Figure 6C). The increase in ECse due to higher ECw, is due to deposition of salts in the soil through irrigation water (Souza et al., 2019). Similar results were found by Pereira Filho et al. (2017) in which increasing the electrical conductivity of irrigation water increased the electrical conductivity of the saturation extract.

Conclusions

The S2 substrate containing sand, sandy soil, and bovine manure in its composition provides higher performance of seedling height, stem diameter, shoot dry matter, root dry matter, and total dry matter, associated with low salinity water. In addition to providing better quality seedlings. However, its performance reduced dramatically under high salinity conditions.

The soil (S1) and S2 substrates had higher electrical conductivity of the saturation extract for the higher conductivity water.

References

Akhtar, S. S.; Andersen, M. N.; Liu, F. Residual effects of biochar on improving growth, physiology and yield of wheat under salt stress. Agricultural Water Management, v. 158, p. 61-68, 2015. https://doi.org/10.1016/j.agwat.2015.04.010

Almeida, D. M.; Silva, B. R. F.; Ucella Filho, J. G. M.; Sousa, A. N.; Costa, T. L. N.; Santana, J. A. S. Efeito de diferentes substratos no desenvolvimento inicial de mudas de *Handroanthus impetiginosus* (Mart. ex DC). Brazilian Journal of Development, v. 6, n. 5, p. 24619-24631, 2020. https://doi.org/10.34117/bjdv6n5-060

Alvares, C. A.; Stape, J. L.; Sentelhas, P. C.; Gonçalves, J. L. M.; Sparovek, G. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift, v. 22, n. 6, p. 711-728, 2013. https://doi.org/10.1127/0941-2948/2013/0507

Amorim, Y. F. Produção de mudas de abobrinha híbrida em diferentes substratos e níveis de estresse salino. Ciência Agrícola, v. 13, n. 1, p. 27-32, 2015. https://doi.org/10.28998/rca.v13i1.1600

Ayers, R. S.; Westcot, D. W. Water quality for agriculture. Rome: Food and Agriculture Organization of the United Nations, 1989. 97p. (FAO – Irrigation and Drainage, Paper 29 Rev. 1).

Bernardo, S.; Mantovani, E. C.; Silva, D. D.; Soares, A. A. Manual de irrigação. 9. ed. atual. ampl. Viçosa: Editora UFV, 2019. 545p.

Caldeira, M. V. W.; Rosa, G. N.; Fenilli, T. A. B.; Harbs, R. M. P. Composto orgânico na produção de aroeira-vermelha. Scientia Agraria, v. 9, n. 1, p. 27-33, 2008. http://dx.doi.org/10.5380/rsa.v9i1.9898

Cruz, F. R. S.; Andrade, L. A.; Feitosa, R. C. Produção de mudas de umbuzeiro (*Spondias Tuberosa* arruda câmara) em diferentes substratos e tamanho de recipientes. Ciência Florestal, v. 26, n. 1, p. 69-80, 2016. https://doi.org/10.5902/1980509821092

Dias, T. J.; Freire, J. L. O.; Cavalcante, L. F.; Nascimento, E. S.; Dantas, L. A.; Dantas, M. M. M. Atributos químicos do solo irrigado com águas salinas e uso de mitigadores no maracujazeiro amarelo. Revista Principia, v. 52, n. 27, p. 19-29, 2015. http://dx.doi.org/10.18265/1517-03062015v1n27p19-29

Dickson, A.; Leaf, A. L.; Hosner, J. F. Quality appraisal of white spruce and white pine seedling stock in nurseries. The Forest Chronicle, v. 36, n. 1, p. 10-13, 1960. https://doi.org/10.5558/tfc36010-1

Diniz, G. L.; Sales, G. N.; Sousa, V. F. O.; Andrade, F. H. A.; Silva, S. S.; Nobre, R. G. Produção de mudas de mamoeiro sob salinidade da irrigação e adubação fosfatada. Revista de Ciências Agrárias, v. 41, n. 1, p. 218-228, 2018. https://doi.org/10.19084/RCA17067

Freire, J. L. O.; Nascimento, G. S.; Medeiros, A. K. A. Teores e acúmulos de nutrientes em mudas de maracujazeiros sob salinidade hídrica e uso de urina de vaca. Nativa, v. 8, n. 4, p. 464-475, 2020. https://doi.org/10.31413/nativa.v8i4.10103

Freitas, A. G. S.; Sousa, G. G.; Sales, J. R. S.; Silva Junior, F. B.; Barbosa, A. S.; Guilherme, J. M. S. Morfofisiologia da cultura do amendoim cultivado sob estresse salino e nutricional. Revista Brasileira de Agricultura Irrigada, v. 15, n. 1, p. 48-57, 2021. http://dx.doi.org/10.7127/rbai.v1501201

Gontijo, G. M. Cultivo do maracujá: informações básicas. Brasília: Emater, 2017. 21p. (Coleção Emater, n. 26).

Guedes, L. R.; Cavalcante, L. F.; Souto, A. G. L.; Maciel, L. H.; Cavalcante, Í. H. L.; Diniz Neto, M. A.; Lima, G. S.; Melo, T. S.; Souza, J. C. G. Liquid fertilizers on photochemical efficiency and gas exchange in yellow passion fruit under saline stress. Revista Brasileira de Engenharia Agrícola e Ambiental, v. 27, n. 11, p. 839-847, 2023. http://dx.doi.org/10.1590/1807-1929/agriambi.v27n11p839-847

Melo Filho, J. S.; Véras, M. L. M.; Alves, L. S.; Silva, T. I.; Gonçalves, A. C. M.; Dias, T. J. Salinidade hídrica, biofertilizante bovino e cobertura vegetal morta na produção de mudas de pitombeira (*Talisia Esculenta*). Scientia Agraria, v. 18, n. 3, p. 131-145, 2017. http://dx.doi.org/10.5380/rsa.v18i3.54307

Mendonça, A. M.; Natale, W.; Sousa, G. G.; Silva Junior, F. B. Morphophysiology and nutrition of yellow passion fruit seedlings grown in substrates based on carnaúba palm bagana. Revista Brasileira de Ciências Agrárias, v. 16, n. 3, e132, 2021. https://doi.org/10.5039/agraria.v16i3a132

Moreira, W. K. O.; Alves, J. D. N.; Leão, F. A. N.; Oliveira, S. S.; Okumura, R. S. Efeito de substratos no crescimento de mudas de guapuruvú (*Schizolobium parahyba* (Vell.) S. F. Blake). Enciclopédia Biosfera, v. 11, n. 22, p. 1067-1075, 2015.

Oliveira, A. B.; Hernandez, F. F. F.; Assis Júnior, R. N. Pó de coco verde, uma alternativa de substrato na produção de mudas de berinjela. Revista Ciência Agronômica, v. 39, n. 1, p. 39-44, 2008.

Paixão, M. V. S.; Denardi, B. E. F.; Faian, M. S.; Nandorf, R. J.; Felisberto, R. T. Substrates, emergence and initial development of passion frruit seedlings. Comunicata Scientiae, v. 12, n. 1, e3515, 2021. https://doi.org/10.14295/cs.v12.3515

Pereira Filho, J. V.; Bezerra, F. M. L.; Silva, T. C.; Pereira, C. C. M. S.; Chagas, K. L. Alteração química do solo cultivado com feijão caupi sob salinidade e dois regimes hídricos. Revista Brasileira de Agricultura Irrigada, v. 11, n. 8, p. 2206-2216, 2017. http://dx.doi.org/10.7127/rbai.v11n800717

Ramos, J. G.; Lima, V. L. A.; Lima, G. S.; Pereira, M. O.; Silva, A. A. R.; Nunes, K. G. Growth and quality of passion fruit seedlings under salt stress and foliar application of H_2O_2. Comunicata Scientiae, v. 13, n. 1, e3393, 2022. https://doi.org/10.14295/cs.v13.3393

Richards, L. A. Diagnosis and improvement of saline and alkali soils. Washington: United States Department of Agriculture, 1954. 160p. (Agriculture Handbook 60).

Rodrigues, V. S.; Bezerra, F. M. L.; Sousa, G. G.; Fiusa, J. N.; Leite, K. N.; Viana, T. V. A. Yield of maize crop irrigated with saline waters. Revista Brasileira de Engenharia Agrícola e Ambiental, v. 24, n. 2, p. 101-105, 2020. https://doi.org/10.1590/1807-1929/agriambi.v24n2p101-105

Salles, J. S.; Steiner, F.; Abaker, J. E. P.; Ferreira, T. S.; Martins, G. L. M. Resposta da rúcula à adubação orgânica com diferentes compostos orgânicos. Revista de Agricultura Neotropical, v. 4, n. 2, p. 35-40, 2017. http://dx.doi.org/10.32404/rean.v4i2.1450

Silva, A. K.; Costa, E.; Curi, T. M. R. C.; Salles, J. S.; Binotti, F. F. S.; Binotti, E. D. C.; Vieira, G. H. C.; Zoz, T. Tamarind tree seedlings in protected environments and substrate. Revista de Agricultura Neotropical, v. 7, n. 4, p. 111-121, 2020. http://dx.doi.org/10.32404/rean.v7i4.4838

Silva, F. A. S.; Azevedo, C. A. V. The Assistat Software Version 7.7 and its use in the analysis of experimental. African Journal Agricultural Research, v. 11, n. 39, p. 3733-3740, 2016. http://dx.doi.org/10.5897/AJAR2016.11522

Silva, L. G. F.; Sales, R. A.; Rossini, F. P.; Vitória, Y. T.; Berilli, S. S. Emergência e desenvolvimento de plântulas de maracujá-amarelo em diferentes substratos. Energia na Agricultura, v. 34, n. 1, p. 18-27, 2019. https://doi.org/10.17224/EnergAgric.2019v34n01p18-27

Sousa, G. G.; Rodrigues, V. S.; Soares, S. C.; Damasceno, Í. N.; Fiusa, J. N.; Saraiva, S. E. L. Irrigation with saline water in soyber (*Glycine max* (L.) Merr.) in a soil with bovine biofertilizer. Revista Brasileira de Engenharia Agrícola e Ambiental, v. 22, n. 9, p. 604-609, 2018. https://doi.org/10.1590/1807-1929/agriambi.v22n9p604-609

Souza, M. V. P.; Sousa, G. G.; Sales, J. R. S.; Freire, M. H. C.; Silva, G. L.; Viana, T. V. A. Saline water and biofertilizer from bovine and goat manure in the Lima bean crop. Revista Brasileira de Ciências Agrárias, v. 14, n. 3, e5672, 2019. http://dx.doi.org/10.5039/agraria.v14i3a5672

Veimrober Júnior, L. A. A.; Silva, A. J. P.; Gheyi, H. R.; Nascimento, F. A. L.; Silva, M. G.; Vellame, L. M. Water productivity of passion fruit under different forms of propagation and soil-based irrigation management criteria. Irrigation Science, v. 40, n. 3, p. 423-433, 2022. https://doi.org/10.1007/s00271-021-00766-8