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Production of zucchini seedlings under saline stress in different environments and substrates

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Abstract

The interaction between agricultural environment and alternative substrates can attenuate salt stress in zucchini seedlings. Based on that, the objective of this work was to evaluate the production of zucchini seedlings irrigated with saline water and cultivated in different types of environments and substrates. The experimental design was completely randomized, using a split-split plots scheme, with the plot being the three cultivation environments (AM1= full sun; AM2= red screen with 50% shading; AM3= black screen with 50% shading), subplot the three substrates (SB1= biochar + soil; SB2= carbonized rice husk + soil; SB3= cattle manure + soil) and the subplot the two irrigation waters (AI1= 0.8 and AI2= 2.5 dS m^{-1}), with four replications of twenty-five seeds. The variables analyzed were: emergence percentage (EP), emergence speed index (ESI), mean time of emergence (MTE), mean speed of emergence (MSE), stem diameter (SD), seedling height (SH), root length (RL), shoot dry mass (SDM), root dry mass (RDM) and total dry mass (TDM). The AM3 environment presented better conditions for the variables: EP, ESI and MSE. The environment AM2 presented better conditions for the variable MTE with the use of substrates SB2 and SB3 regardless of the salinity of the irrigation water. The SB3 substrate showed better growth conditions for the variables: SH, SD, SDM and TDM. The SB2 substrate provided better conditions for the variable RDM.

Keywords: *Cucurbita pepo* L., protected environment, salinity

Introduction

Zucchini (Cucurbita pepo L.) also known as Italian zucchini, belongs to the Cucurbitaceae family with its center of origin in central Mexico (Filgueira, 2012). In Brazil the production of the cultivar 'Caserta' stands out for presenting high acceptance by consumers and high productivity (Azambuja et al., 2015). According to data from IBGE (2019) the national production of zucchini reached 228,500 tons in 2018 distributed in 34,858 agricultural establishments, concentrated mostly in the Southeast region (48.00%) being responsible for 75.35% of the national production of the crop.

In the horticultural production system, the production of seedlings represents one of the most important steps for the success of the crops, being necessary the use of quality inputs, highlighting the substrate (Goes et al., 2019). The use of waste, especially organic waste, for the production of seedling substrates can be found in works in the literature, such as that of Oliveira et al. (2019) with cowpea seedlings using substrate formulated from bovine manure + sand + arisco.

Because zucchini production is concentrated in the South and Southeast regions, there is a low availability of studies related to its cultivation and seedling production in the Northeast region, where there is a more pronounced production of pumpkins (Cucurbita moschata) and strawberries (C. maxima) (Guerra et al., 2020). However, for zucchini cultivation in the Northeast region it is necessary to take into account that the water resources available for irrigation present, most of the time, certain limitations regarding the concentration of salts (Lima et al., 2017).

The use of these resources for irrigation promotes a reduction in crop productivity by decreasing the water potential in the soil and exerts negative effects by specific ions (Silva et al., 2016). In relation to seedling production,

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this effect is more pronounced, because at this stage the seedlings are more susceptible to the effects of salts (Silva Junior et al., 2020).

A high quality seedling with high vigor has better conditions for establishment and survival in the final planting site. For the production of quality seedlings several factors are involved, such as the quality and health of seeds, irrigation, and technologies such as types of container or protected environment (Lima et al., 2016).

The use of the protected environment promotes ideal conditions for obtaining quality seedlings, because this technique reduces the adverse effects of excess rainfall, high incidence of solar radiation and extremes of air temperature (Reis et al., 2012) besides being able to mitigate salt stress (Sousa et al., 2021). In view of the above, the objective of this work was to evaluate the production of zucchini seedlings under salt stress in different environments and substrates.

Material and Methods

The experiment was conducted in September 2019 at the Auroras Seedling Production Unit (UPMA) belonging to the Universidade da Integração Internacional da Lusofonia Afro-Brasileira (UNILAB), Auroras Campus, Redenção-CE. The region's climate is of type Aw', characterized as rainy tropical, very hot, with predominant rainfall in the summer and fall seasons.

The experimental design was entirely randomized with subdivided plots, where the plot is composed of three growing environments (AM1= full sun; AM2= red screen with 50% shading; AM3= black screen with 50% shading), and three substrates (SB1= biochar + soil - 1: 1; SB2= carbonized rice husk + soil - 1:1, SB3= bovine manure + soil - 1:1) and the subplot by two irrigation waters (AI1= 0.8 and AI2= 2.5 dS m^{-1}), with 4 repetitions of 25 seeds.

The soil used in the preparation of the substrates, according to Embrapa (2018) was Yellow Red Argissolo. **Table 1** describes the chemical characteristics of the substrates used in the experiment.

The meteorological data obtained during the experimental period are shown in **Table 2**. During the experimental period there was a precipitation of 2.4 mm.

Zucchini seeds were planted in Styrofoam trays with 200 cells of 40 cm^3 volume. Each cell received one seed at a depth of 2 cm. The amount of NaCl, $CaCl_2.2H_2O$ and $MgCl_2.6H_2O$ salts used to prepare the irrigation water was determined in order to obtain the desired ECw (electrical conductivity of water) in a 7:2:1 ratio (Rhoades et al., 2000). Irrigation was performed manually through a daily watering shift, until drainage was observed at the bottom of the trays (Marouelli & Braga, 2016).

Until 14 days after sowing (DAS), the emergence percentage (EP) was evaluated, where a correlation was made between the number of normal seedlings emerged in relation to the number of seeds sown, the emergence speed index (ESI), following the methodology recommended by Maguire (1962) through daily counts of emerged seedlings, the mean time to emergence (MTE), through daily counts of the seeds, according to the methodology proposed by Labouriau (1983), with the result expressed in days, and the mean speed of emergence (MSE) according to the methodology proposed by Carvalho & Carvalho (2009) with the result also expressed in days.

At the same interval (14 DAS) the seedlings were also evaluated for: seedling height (SH) measured from the base to the apex with a ruler graduated in centimeters, root length (RL) also using a ruler graduated in centimeters and stem diameter (SD) using a digital pachymeter at 1 cm from the substrate, reading in millimeters. With these data the seedlings were placed in paper bags and after being identified they were placed in an oven at 60°C for 72 hours. Afterwards the shoot dry mass (SDM), the root dry matter (RDM) and the total dry mass (TDS) were determined.

The results were submitted to variance analysis and the means were compared by Tukey's test with $p < 0.05$, using the ASSISTAT program. 7.7 Beta program.

Results and Discussion

From the analysis of variance significant interactions were observed among the environments, substrates and salinity of the irrigation water for the variables emergence percentage (EP), emergence

Table 1. Chemical characteristics of the substrates (SB1= biochar + soil, SB2=charred rice husk + soil, SB3=bovine manure + soil) used in the production of zucchini seedlings

	Chemical characteristics											
	MO	N	Ca^{2+}	K^+	Mg^{2+}	Na^+	$H^+ + Al^{3+}$	Al	SB	P	CTC	V
	($g\ kg^{-1}$)		($cmol_c\ kg^{-1}$)							($mg\ kg^{-1}$)		(%)
SB1	14.74	0.93	4.9	0.58	0.90	0.26	0.33	0.00	6.64	20	6.97	95
SB2	5.18	0.31	0.7	0.24	0.50	0.08	0.50	0.05	1.52	20	2.02	75
SB3	4.07	0.24	0.6	0.16	0.40	0.10	0.17	0.00	1.26	10	1.43	88

MO - Organic matter; SB - Sum of bases ($Ca^2 + Mg^{2}+ + Na^+ + K^+$); CTC - Cation exchange capacity - [$Ca^2 + Mg^{2+} + Na^+ + K^+ + (H^+ + Al^{3+})$]; V - Saturation by bases - ($Ca^2 + Mg^{2+} + Na^+ + K^+$/ CTC) x 100.

Table 2. Average values of temperature and relative humidity of the environments (full sun, black shaded roof with 50% shade, and red shaded roof with 50% shade), during the experiment

Environments	Temperature(° C)	Moisture (%)
Full Sun	33.5	50.0
Black screen with 50% shading	33.6	48.2
Red screen with 50% shading	33.6	44.6

Table 3. Summary of analysis of variance (ANOVA) for emergence percentage (EP), emergence speed index (ESI), mean time to emergence (MTE) and mean speed of emergence (MSE) of zucchini seedlings as a function of different environments, substrates and salinity of irrigation water

SV	Mean square				
	DF	EP	ESI	MTE	MSE
Environment (EN)	2	892.66667**	28.41448**	33.11646**	0.03828**
Substrates (SB)	2	2672.66667**	4.31795*	0.27702ns	0.00060ns
Water (WA)	1	450.00000**	11.09205**	10.45007**	0.01773**
EN x SB	4	769.33333**	5.22252**	5.96941**	0.00732**
EN x WA	2	844.66667**	2.81825**	2.80311*	0.00293*
WA x SB	2	1274.00000**	4.09082**	6.08765**	0.00315*
EN x SB x WA	4	400.66667**	1.29849*	2.19431ns	0.00304*
Resíduo – EM	9	74.88889	0.41448	0.41470	0.00048
Resíduo – SB	18	38.44444	0.82387	0.91492	0.00114
Resíduo – WA	27	50.59259	0.44689	0.80475	0.00080
Total	71				
Overall mean		76.83	3.61	6.10	0.17
CV - EN (%)		11.26	16.39	10.55	12.57
CV - SB (%)		8.07	25.14	15.67	19.25
CV - WA (%)		9.26	18.51	14.69	16.12

SV: Source of variation, DF: Degrees of freedom, CV (%): Coefficient of variation, *Significant by F test at 5%; ** Significant by F test at 1%; ns = not significant.

speed index (ESI) and mean speed of emergence (MSE). The mean time to emergence (MTE) was significantly influenced by the interactions between environment and substrate, environment and water salinity and substrate and water salinity (**Table 3**).

Figure 1 shows that the environment AM1 (full sun) influenced the emergence percentage (EP) in the substrate SB1 (biochar) differing statistically from the others, but with higher EP when irrigated with water with higher salinity (2.5 dS m^{-1}). This reaction may be related to the osmotic adjustment of zucchini seeds driven by the presence of carbon dioxide in the biochar and the increased metabolic activity of the seed induced by saline ions (Aguiar et al., 2012).

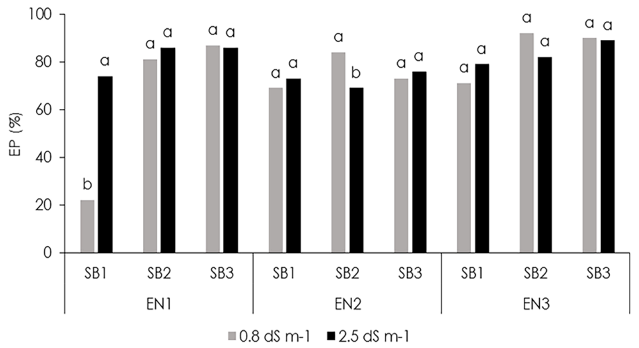

Figure 1. Emergence percentage (EP) as a function of different environments (AM1: Full sun; AM2: Red screen; AM3: Black screen), substrates (SB1: Biochar; SB2: Carbonized rice husk; SB3: Bovine manure) and salinities (AI1= 0.8 dS m^{-1}; AI2= 2.5 dS m^{-1}).

EP was also influenced by environment AM2 (red screen) on substrate SB2 (carbonized rice husk) when high salinity water was used for irrigation. Goes et al. (2019) obtained contrary results evaluating agricultural ambience and salt stress in okra seedlings, where black and red sheds showed no statistical difference for emergence percentage.

Demontiêzo et al. (2016) found similar results in tomato crop, where the concentration of 2.5 dS m^{-1} in the water used for irrigation provided an increase in PE. Silva Junior et al. (2020) when evaluating the EP in watermelon culture irrigated with saline water in substrate containing biochar and cultivated in the same type of environment, also obtained similar results. According to these authors, these results are related to the acclimatization of seeds induced by osmotic adjustment.

Regarding the emergence speed index, it was observed that for seeds submitted to the substrate SB1 in all growing environments, the results showed a similar response, where the use of low salinity water showed lower averages, but increased with the use of high salinity water for irrigation. The stress situation to which the seed was subjected may have induced it to produce organic compounds and thus promote osmotic adjustment of the seed (Silva Junior et al., 2020) (**Figure 2**).

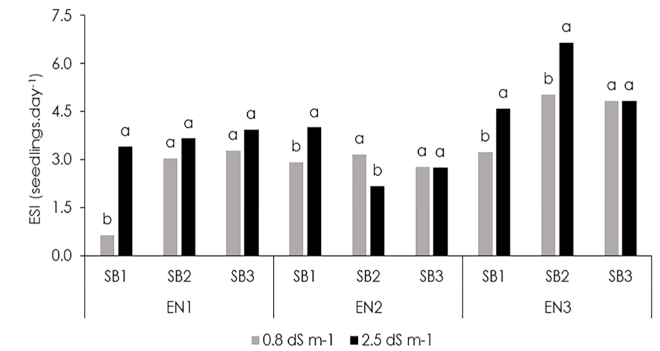

Figure 2. Emergence speed index (ESI) as a function of different environments (AM1: Full sun; AM2: Red screen; AM3: Black screen), substrates (SB1: Biochar; SB2: Carbonized rice husk; SB3: Bovine manure) and salinities (AI1= 0.8 dS m^{-1}; AI2= 2.5 dS m^{-1}).

When evaluating seed emergence and initial development of 'Santa Clara' tomato subjected to different saline water levels and seed preparation conditions, Demontiêzo et al. (2016) found results contrary to the present study. Silva Junior et al. (2020) found no statistical difference in the EVI of watermelon seeds grown under the same conditions (black shaded and full sun) in substrate with biochar and irrigated with high salinity water.

It is also possible to observe in Figure 2 that the ESI was significantly influenced by AM2 with the use of SB2, presenting lower values for the water with higher salinity. The opposite is observed in AM3 with the use of SB2, where the highest values are observed for the higher salinity of water. Goes et al. (2019) observed no statistical difference for ESI between black and red shading meshes in okra seedlings. The same was found by Lima et al. (2016) in passion fruit plants, where the different shading meshes did not influence the ESI.

For the interaction environment "versus" substrate in the variable mean time of emergence (MTE) (**Figure 3**), it was found that environment AM3 presented the lowest values in all substrates, that is, environment AM3 provided better conditions for seed emergence compared to the other two environments. According to Goes et al. (2019) the black shaded roof with 50% shading provides greater thermal comfort inside the protected environment.

Similarly to this study, Silva Junior et al. (2020) also found a lower MTE in watermelon seeds grown under black canvas with 50% shading on different substrates.

It is observed in **Figure 4** that for the interaction between environments and salinity of irrigation water, the MTE was influenced by the water of higher salinity in environment AM1 and AM3. This result may have been caused by an osmotic adjustment in seedlings that received saline water, so they can absorb water and accumulate toxic ions in the vacuole of the cells

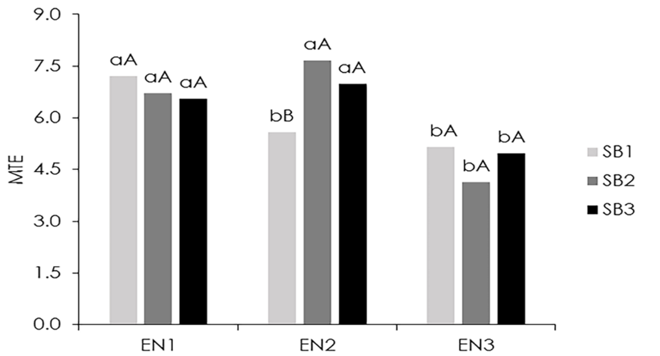

Figure 3. Mean time of emergence (MTE) as a function of different environments (AM1: Full sun; AM2: Red screen; AM3: Black screen), and substrates (SB1: Biochar; SB2: Carbonized rice husk; SB3: Bovine manure). Means followed by the same capital letter for environments and lower case for substrates did not differ by Tukey test (p <0.05).

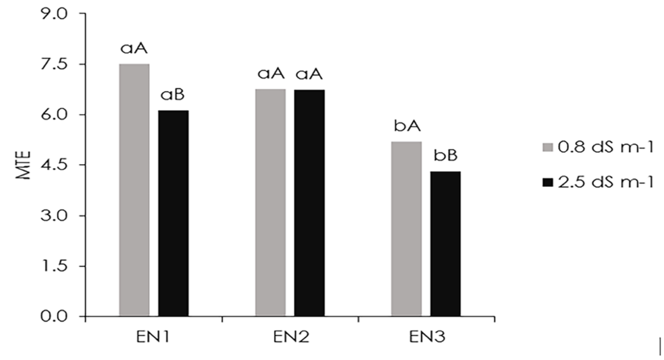

Figure 4. Mean time of emergence (MTE) as a function of different environments (AM1: Full sun; AM2: Red screen; AM3: Black screen) and salinities (AI1= 0.8 dS m^{-1}; AI2= 2.5 dS m^{-1}). Averages followed by the same capital letter for the environments and lower case for the waters did not differ by Tukey test (p <0.05).

preventing such ions from accumulating in the roots (Pereira et al., 2016), i.e., possibly there was an increase in the percentage of emergence and consequently lower mean time of emergence.

In the environment AM3 lower MTE values were also observed (Figure 4) in relation to the other environments. Environments AM1 and AM2 may have stored less thermal energy for the night period, disfavoring the emergence process, and contributed for AM3 to provide better conditions for emission of the seed radicle and, therefore, better conditions for emergence (Oliveira et al., 2015).

It is possible to observe through **Figure 5** that the interaction between substrate and salinity of irrigation water for MTE, in which the water of 2.5 dS m^{-1} influenced the MTE in the substrate SB1, presenting lower value than the other treatments. According to Schulz et al. (2014) biochar when applied to soil can provide positive changes in pH, total organic carbon, total nitrogen, and nutrient availability.

Akhtar et al. (2015) observed that charcoal

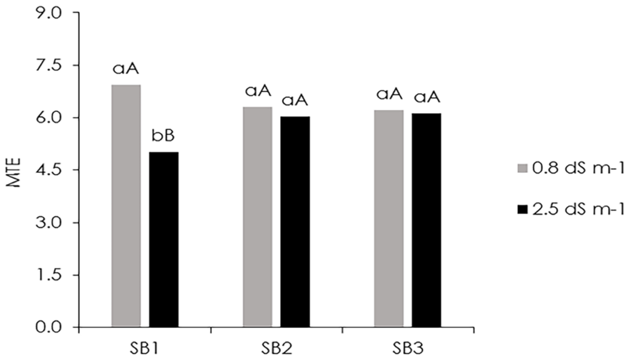

Figure 5. Mean time to emergence (MTE) as a function of different substrates (SB1: Biochar; SB2: Carbonized rice husk; SB3: Bovine manure) and salinities (AI1= 0.8 dS m^{-1}; AI2= 2.5 dS m^{-1}). Means followed by the same capital letter for the substrates and lower case for the waters did not differ by Tukey test (p <0.05).

application reduced sodium uptake by plants through transient binding with Na^+, causing decrease in osmotic stress by increasing soil water content, in addition to the release of nutrients in mineral form such as K^+, Ca^{2+} and Mg^{2+} into the soil solution. This is possible due to the high specific adsorption capacity of charcoal. For the other substrates there was no significant difference between the two levels of water salinity.

Regarding the mean speed of emergence (MSE), it can be seen that for the seeds nourished with the substrate SB1 in all growing environments, the results showed similar response, where the use of low salinity water showed lower averages (**Figure 6**). As in TME these results can be attributed to the characteristics of the substrate used and its composition, where it acted as a mitigator of the salt stress. Since biochar can alter the physical and chemical attributes of the substrate, such as pH and porosity, besides allowing greater water retention and increase in cation exchange capacity (CEC) (Oliveira et al., 2019).

It is possible to observe in **Table 4** that the variables

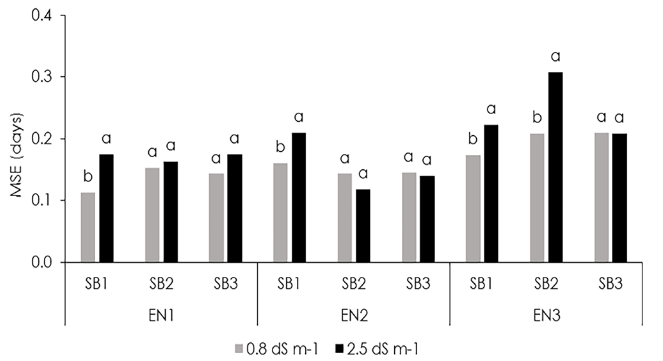

Figure 6. Mean speed of emergence (MSE) as a function of different environments (AM1: Full sun; AM2: Red screen; AM3: Black screen), substrates (SB1: Biochar; SB2: Carbonized rice husk; SB3: Bovine manure) and salinities (AI1= 0.8 dS m^{-1}; AI2= 2.5 dS m^{-1}).

seedling height (SH), stem diameter (SD) and root length (RL) showed significant interaction between environments and salinity of irrigation water, and the latter also showed significant interaction between substrates and salinity of irrigation water. The variables seedling height (SH) and stem diameter (SD) also presented significance for the substrate, but separately.

It was also verified that only the shoot dry mass (SDM) and total dry mass (TDM) showed significant interaction among environments, substrates and salinity of irrigation water. On the other hand, root dry mass (RDM) showed significant effects in isolation for the three factors.

For the interaction environment "versus" salinity of irrigation water in the AP variable (**Figure 7**A), the seedlings that were grown in the black screen with 50% shading (AM3) showed an increase in seedling height compared to the red screen with 50% shading (AM2) of 266.5% and of 299.5% compared to the full sun environment (AM3) when irrigated with low salinity water. For high salinity water the increase was 222% compared to AM1 and 176.1% compared to AM2.

This result may be related to the mitigation of the

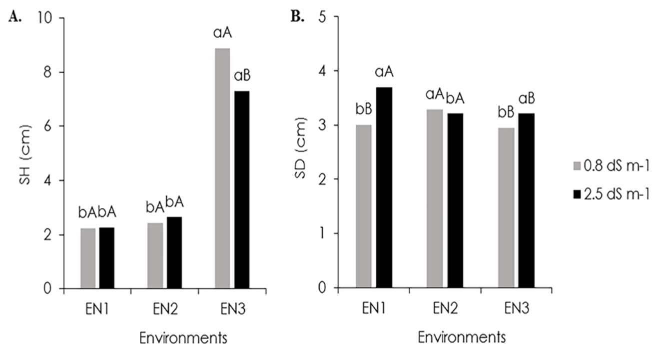

Figure 7. Seedling height (SH) (Figure 7A) and stem diameter (SD) (Figure 7B) as a function of different environments (AM1: Full sun; AM2: Red screen; AM3: Black screen) and salinity of irrigation water (AI1= 0.8 dS m^{-1}; AI2= 2.5 dS m^{-1}). Means followed by the same capital letter for environments and lower case for waters did not differ by Tukey test (p <0.05).

adverse effects of climate by the protected environment (Reis et al., 2012). However, a significant difference was observed between irrigation water in environment AM3 (Figure 7A) for seedling height. This result is due to the deleterious effect of salts present in irrigation water, interfering in the physiology of seedlings and hindering the accumulation of biomass (Albuquerque et al., 2016).

For stem diameter (Figure 7B), environment AM2 showed the lowest degree of variation among the factors, regardless of the irrigation water. This stability can be explained by the favorable conditions that were provided

Table 4. Summary of analysis of variance (ANOVA) for seedling height (SH), root length (RL), stem diameter (SD), shoot dry mass (SDM), root dry mass (RDM) and total dry mass (TDM) of zucchini (Cucurbita pepo L.) seedlings as a function of different environments, substrates and salinity of irrigation water

SV		Mean square					
	DF	SH	RL	SD	SDM	RDM	TDM
Environment (EN)	2	260.106**	113.520**	0.443**	0.148**	0.186**	0.513**
Substrates (SB)	2	2.566**	4.160**	0.495*	0.072**	0.066**	0.063*
Water (WA)	1	3.498**	0.774ns	1.490**	0.055**	0.014*	0.126**
EN x SB	4	0.522ns	0.172ns	0.203ns	0.010**	0.027ns	0.069**
EN x WA	2	5.884**	3.171**	0.896**	0.011ns	0.007ns	0.032*
WA x SB	2	0.752ns	0.910*	0.012ns	0.025**	0.009ns	0.048*
EN x SB x WA	4	0.565ns	0.343ns	0.240ns	0.014*	0.005ns	0.027*
Resíduo – EM	9	0.519	0.359	0.020	0.005	0.009	0.021
Resíduo – SB	18	0.325	0.420	0.090	0.001	0.010	0.011
Resíduo – WA	27	0.277	0.261	0.091	0.003	0.003	0.009
Total	71						
Overall mean		4.28	6.19	3.22	0.43	0.28	0.72
CV - EN (%)		16.83	9.68	447	17.32	32.91	20.44
CV - SB (%)		13.31	10.47	9.34	10.16	35.25	14.96
CV - WA (%)		12.29	8.25	9.35	14.39	20.22	13.37

FV: Source of variation, DF: Degrees of freedom, CV (%): Coefficient of variation, *Significant by F test at 5%; ** Significant by F test at 1%; ns = not significant.

by environment AM2. The shading screens modify the light spectrum and improve seedling performance, since changes occur regarding the quality and quantity of light reaching the plants, varying according to the culture and the color of the screen used (Costa et al., 2018; Guerra et al., 2020). In environments AM1 and AM3 it is observed that the highest averages were obtained with the high salinity water (2.5 dS m^{-1}).

Similar results for seedling height were obtained by Oliveira et al. (2015), when evaluating the production of watermelon seedlings with a 50% shading black screen, when irrigated with low salinity water. As for the effect of salinity, Albuquerque et al. (2016) studying the growth and tolerance of cucumber cultivars to salt stress, observed similar results to this study, where the height of seedlings showed a decline with increasing salinity of irrigation water.

Figure 8 shows that SB1 and SB3 presented higher mean values than SB2 for seedling height (Figure 8A) and stem diameter (Figure 8B), respectively. This result, possibly, is linked to the characteristics of the material for substrate manufacture, since the material used for the production of the SB3 substrate allows a fast and efficient drainage with good oxygenation for the roots, besides presenting low density and pH close to neutrality (Soares et al., 2012).

The biochar used for the production of substrate SB1 presents favorable characteristics for plant development, such as high porosity and high cation exchange capacity (Crispim et al., 2020), which may have helped in its positive effect in relation to SB2.

Similar results were found by Oliveira et al. (2019)

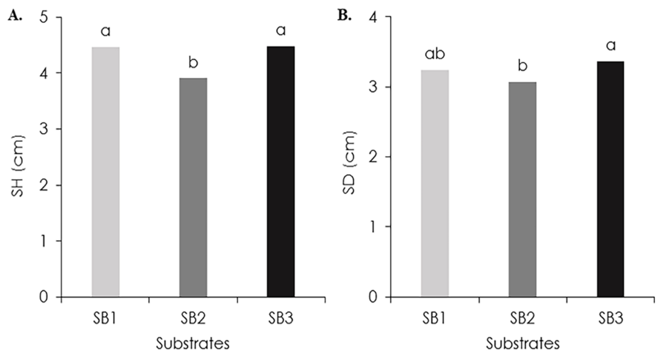

Figure 8. Seedling height (SH) (Figure 8A) and stem diameter (SD) (Figure 8B) as a function of different), substrates (SB1: Biochar; SB2: Carbonized rice husk; SB3: Bovine manure).

when evaluating the initial growth of cowpea bean irrigated with saline water in different substrates, where the highest values for plant height were obtained in the substrate based on bovine manure. The higher concentration of organic matter in the bovine manure, especially nitrogen, may have contributed to the better development of the seedlings. Furthermore, bovine manure provides the soil with a potential for nutrient mineralization and influences the temperature of the substrate. Crispim et al. (2020) working with arugula seedlings in a substrate composed of biochar, observed similar results, obtaining increasing values for seedling height as the proportion of biochar increased.

For the interaction environment "versus" irrigation water salinity in the variable root length (RL) (**Figure 9**A), environment AM3 showed higher values than the others regardless of irrigation water salinity. Goes et al. (2019) found similar results in a study that evaluated salt stress

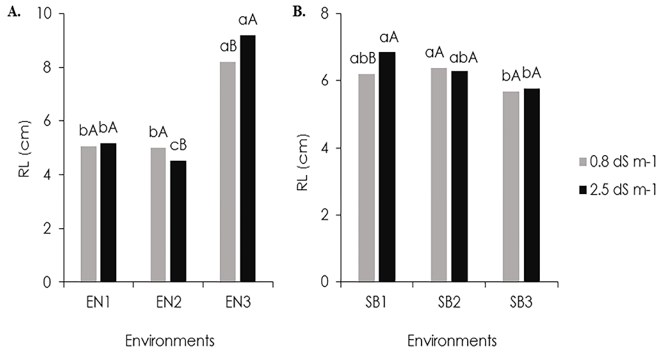

Figure 9. Root length (RL) as a function of different environments (AM1: Full sun; AM2: Red screen; AM3: Black screen) and salinities (AI1= 0.8 dS m^{-1}; AI2= 2.5 dS m^{-1}) (9A), and different substrates (SB1: Biochar; SB2: Carbonized rice husk; SB3: Bovine manure) and water salinities (9B). Means followed by the same capital letter for environments (9A) and substrates (9B), and lower case for water do not differ by Tukey test (p <0.05).

and ambience in okra seedlings, where the highest values for root length were obtained in the environment with black mesh with 50% shading.

This result may be related to the fact that the black screen, under high temperature conditions, reduces the direct incidence of radiation on the seedlings and provides greater dispersion of solar radiation inside, causing an increase in the diffuse solar fraction with greater contribution in the visible range (Costa et al., 2018; Reis et al., 2012).

As for the interaction of substrates "versus" water salinity in RL (Figure 9B), the seedlings grown on substrates SB1 and SB2, regardless of the salinity of the irrigation water showed higher values than substrate SB3. Higher proportions of biochar in the substrate can provide an increase in total organic C and total N (Schulz et al., 2014). The carbonized rice husk present in the substrate SB2 presents a fast and efficient drainage due to its high porosity, which provides good oxygenation to the roots (Steffen et al., 2010), explaining its positive effect in relation to SB3.

Contrary results were found by Oliveira et al. (2019) when evaluating initial growth of cowpea submitted to salinity in different substrates, where the substrate composed of sand, arisco and bovine manure provided the highest values for radicle length.

When analyzing the root dry mass (RDM) variable, there was an isolated significant response to the effects of environments, substrates and waters (**Figure 10**). It is possible to observe that environments AM1 and AM2 were statistically superior to environment AM3 in RDM (Figure 10 A). Possibly, the higher RDM increment in seedlings grown in these environments can be attributed to the greater solar radiation and the greater growth of the root system,

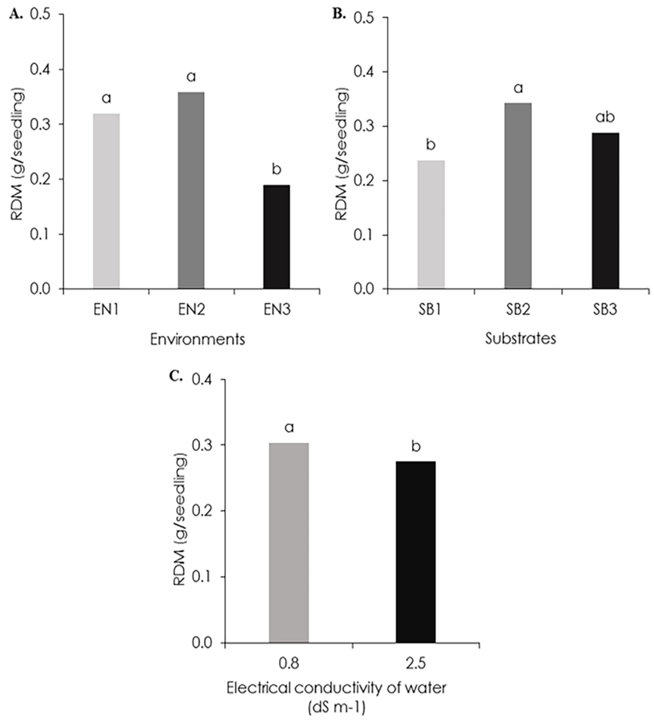

Figure 10. Root dry mass (RDM) as a function of different environments (10A) (AM1: Full sun; AM2: Red screen; AM3: Black screen), substrates (10B) (SB1: Biochar; SB2: Carbonized rice husk; SB3: Bovine manure) and salinities (10C) (AI1= 0.8 dS m^{-1}; AI2= 2.5 dS m^{-1}).

with better use of soil resources (Pereira et al., 2016).

The SB1 substrate, in turn, showed the lowest values of DMR when compared to the other substrates (Figure 10 B). This fact may be related to the low quantity of this material and the short time of evaluation, which was not enough to demonstrate a possible effect on this characteristic (Crispim et al., 2020; Schulz et al., 2014).

In Figure 10 C it is possible to observe that increasing the level of salinity of the irrigation water to 2.5 dS m^{-1} provided a decrease of 9.25% in root dry matter of the seedlings in relation to the water of lower salinity. Possibly this result is related to the inhibition of growth of the root system, because when salts are present in the substrate, alterations in osmotic potential can occur, or even cause toxicity.

As the root system is in direct contact with the aqueous medium of the soil, which has an accumulation of salts, the roots are more affected (Sousa et al., 2014). Oliveira et al. (2019) obtained similar results when evaluating the effect of low and high salinity irrigation water on the initial growth of the cowpea BRS Tumucumaque in different substrates, where irrigation with high salinity water resulted in the lowest values of root dry matter.

Regarding the above shoot dry mas (SDM), it was

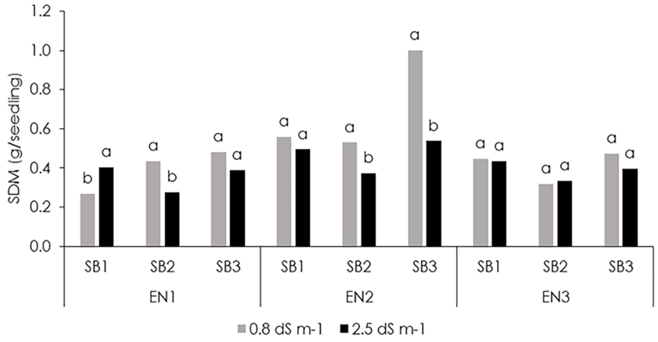

Figure 11. Shoot dry mas (SDM) as a function of different environments (AM1: Full sun; AM2: Red screen; AM3: Black screen), substrates (SB1: Biochar; SB2: Carbonized rice husk; SB3: Bovine manure) and salinities (AI1= 0.8 dS m^{-1}; AI2= 2.5 dS m^{-1}).

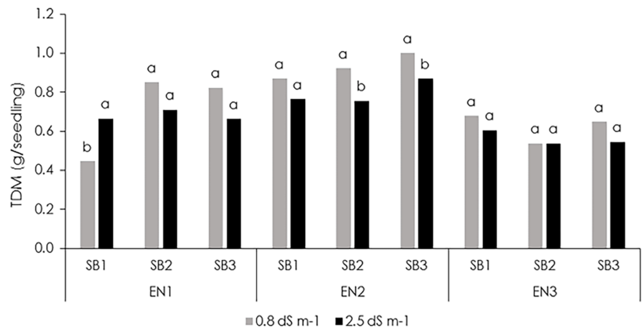

Figure 12. Total dry mass (TDM) as a function of different environments (AM1: Full sun; AM2: Red screen; AM3: Black screen), substrates (SB1: Biochar; SB2: Carbonized rice husk; SB3: Bovine manure) and salinities (AI1= 0.8 dS m^{-1}; AI2= 2.5 dS m^{-1}).

observed that environments AM1 and AM2 influenced negatively the values of SDM in substrates SB2 and SB3 with the use of high salinity water for irrigation of seedlings, when compared to low salinity water (**Figure 11**). The distribution of dry matter among the different organs of a plant composes its own mechanism that differs in each plant species and demonstrates the adaptation of these organisms to different environmental conditions (Costa et al., 2018).

Presenting similar results, Silva Junior et al. (2020) when evaluating salt stress and ambience in the production of watermelon seedlings observed lower SDM values in seedlings emerged in full sun and nourished with substrates containing carbonized rice husk in its composition. The opposite can be observed in AM1 with the use of SB1, in which the water with higher salinity was statistically superior (Figure 11).

The use of biochar in the constitution of substrates favors the germination of seeds and plant growth, because it can act as a physical-chemical conditioner, acting beneficially on fertility by increasing the retention of water and nutrients, in addition, the pyrolysis process also produces materials that can correct soil acidity by increasing pH (Crispim et al., 2020), and can thus mitigate the effects of salts in the substrate.

Similar results were obtained by Akhtar et al. (2015) when investigating the residual effects of biochar on pot-grown wheat under salt stress, in which they found that the increase in growth and yield of wheat plants with alteration of biochar at each level of soil salinity indicates its residual effects in mitigating salt stress.

The data obtained for the total dry mass (TDM) variable are presented in **Figure 12**. In which it is possible to observe that in AM1 the TDM of the seedlings that were obtained with SB1 substrate and irrigated with water of higher salinity, once again, was statistically superior. As in the SDM variable, the physical and chemical characteristics of biochar may have attenuated the effects of salts in the substrate that received high salinity water.

In AM2 there was a decrease of TDM in SB2 and SB3 when using water with a higher salinity. This fact may be related to the fact that the water used for irrigation or soil containing high saline concentrations cause an ionic unbalance in the soil-plant interface and promote toxicity in the plant, affecting its growth and production of dry matter, besides promoting a reduction in the absorption of nutrients (Sousa et al., 2021).

Reduction in dry mass accumulation was also found by some authors working with crops of the same botanical family of zucchini subjected to salinity of irrigation water, such as cucumber (Albuquerque et al., 2016) and in other crops, such as sugar beet (Silva et al., 2016) and cotton (Lima et al., 2017).

Conclusions

1. Environment AM3 presented the best conditions for the variables: emergence percentage, emergence speed index and mean speed of emergence. The environment AM2 presented better conditions for the variable mean time of emergence with the use of substrates SB2 and SB3 independent of the salinity of the irrigation water.
2. The substrate SB3 presented the best growth conditions for the following variables: seedling height, stem diameter, shoot dry mass and total dry mass. The substrate SB2 provided better conditions for the variable root dry mass.
3. The environment AM3 together with the substrate SB3 provided better conditions for the emergence and initial growth of the seedlings.

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