ISSN 1807-1929
Revista Brasileira de Engenharia Agrícola e Ambiental
Brazilian Journal of Agricultural and Environmental Engineering
v.25, n.12, p.847-852, 2021
Campina Grande, PB – http://www.agriambi.com.br – http://www.scielo.br/rbeaa

DOI: http://dx.doi.org/10.1590/1807-1929/agriambi.v25n12p847-852

Growth and yield of beet irrigated with saline water in different types of vegetable mulching[1]

Crescimento e produção de beterraba irrigada com água salina em diferentes tipos de cobertura vegetal

Bruna B. Gadelha[2*], Márcio H. da C. Freire[3], Henderson C. Sousa[3], Francisco H. R. Costa[2], Carla I. N. Lessa[3] & Geocleber G. de Sousa[2]

[1] Research developed at Universidade da Integração Internacional da Lusofonia Afro-Brasileira, Unidade de Produção de Mudas Auroras, Redenção, CE, Brazil
[2] Universidade da Integração Internacional da Lusofonia Afro-Brasileira/Instituto de Desenvolvimento Rural, Redenção, CE, Brazil
[3] Universidade Federal do Ceará/Departamento de Engenharia Agrícola, Fortaleza, CE, Brazil

HIGHLIGHTS:

Irrigation with saline water negatively limited all growth parameters of the beet crop.
Vegetable coverings (rice hulls, carnauba bagana, and crop residues) reduce the harmful effects of salts on beet growth.
The salinity of irrigation water increases soluble solids in beet crop.

ABSTRACT: Vegetal mulching can mitigate the harmful effects of salts present in irrigation water. This study aimed to evaluate the effect of irrigation water salinity and mulching on the growth and yield of beet crops. The experiment was conducted in a greenhouse at Redenção, Ceará State. The experimental design was completely randomized in a 2 × 4 factorial scheme, with five replicates, composed of two levels of electrical conductivity of irrigation water - ECw: tap water - 0.3 dS m^{-1} and saline solution - 5.8 dS m^{-1}; and four types of mulching (rice hulls, carnauba bagana, crop residues, and a control treatment without soil cover). The use of vegetal mulching, mitigated the effects of irrigation with saline water on the variables plant height, leaf area, stem diameter, and tuberous root. The increase of the salt concentration in irrigation water negatively affected the number of leaves, length of the tuberous root, and yield. But, it increased the soluble solids in the beet crop.

Key words: *Beta vulgaris*, soil protection, salt stress

RESUMO: A cobertura morta vegetal poderá atenuar os efeitos deletérios dos sais presentes na água de irrigação. Objetivou-se no presente estudo avaliar o efeito da salinidade da água de irrigação e da cobertura morta vegetal no crescimento e na produção da cultura da beterraba. O experimento foi conduzido em casa de vegetação, em Redenção, Ceará. O delineamento experimental foi inteiramente casualizado, em esquema fatorial 2 × 4, com cinco repetições, correspondentes a dois valores de condutividade elétrica da água de irrigação - CEa: água de abastecimento - 0,3 dS m^{-1} e solução salina - 5,8 dS m^{-1}; e quatro tipos de cobertura morta (casca de arroz, bagana de carnaúba, restos de culturas espontânea e sem cobertura - tratamento controle). O uso de cobertura morta vegetal mitigou os efeitos dos sais da água de irrigação para altura de planta, área foliar, diâmetro do caule e da raiz tuberosa. O aumento da condutividade elétrica na água de irrigação afetou negativamente o número de folhas, comprimento da raiz tuberosa e a produção, porém aumentou os sólidos solúveis da cultura da beterraba.

Palavras-chave: *Beta vulgaris*, proteção do solo, estresse salino

• Ref. 247648 – Received 15 Jan, 2021
* Corresponding author - E-mail: brunab.gadelha@gmail.com
• Accepted 31 May, 2021 • Published 01 Jul, 2021
Edited by: Hans Raj Gheyi

Introduction

Beet (*Beta vulgaris* L.) is a crop that belongs to the family Amaranthaceae and subfamily Chenopodiaceae. This tuberous root is a vegetable extensively grown in Brazil, and its demand has been expanding in recent years for the industrial sector due to its nutritional composition (Santos et al., 2016; Veras et al., 2017).

In several arid and semi-arid regions, irrigation may be a way to guarantee the development and production of crops (Silva et al., 2019). Also, in these regions, the evaporation is greater than the precipitation, causing water scarcity. Due to the scarcity of fresh water, saline waters have often been used for irrigation (Rodrigues et al., 2020).

The salinity of irrigation water negatively affects the growth, plant metabolism and yield of crops; however, salt stress intensity depends on factors such as genotype, irrigation management, and fertilization. (Rodrigues et al., 2020; Sousa et al., 2021). Nevertheless, the scientific community has been looking for strategies to mitigate salt stress, including mulching (Sousa et al., 2018).

The vegetal mulching used in the soil is a conservationist practice that aims to protect the soil, maintaining its moisture, improving biological activity, nutrient recycling, and yield (Malik et al., 2018; Almeida et al., 2020), which is a possible alternative to minimize the harmful effects of salts (Sousa et al., 2018). The study conducted by Lessa et al. (2019) with sorghum irrigated with saline water affirm that soil protection reduces the harmful effects of salts.

This study aimed to evaluate the effect of salinity of irrigation water and mulching on the growth and yield of the beet crop.

Material and Methods

The experiment was conducted in a greenhouse belonging to the Aurora Seedling Production Unit (UPMA), at the University of International Integration of Afro-Brazilian Lusophony (UNILAB), located at Campus das Auroras (4º13'05" S; 38º42'46" W, and 96 m of altitude), in Redenção, Ceará State. According to IPECE (2017), the climate of the region is classified as Tropical Warm Humid and Tropical Warm Sub-humid, with a mean rainfall of 1,062 mm and an average temperature ranging from 26 to 28 °C.

The experimental design was completely randomized, arranged in a 2 x 4 factorial scheme, with five replicates, corresponding to two values of electrical conductivity of the irrigation water - ECw: tap water - 0.3 dS m^{-1} and saline solution - 5.8 dS m^{-1}; and four types of vegetal mulching (rice hulls - RH; carnauba bagana - CB; crop residues - CR; and without cover - WC, control).

The seeds used were of the Early Wonder Super Tall Top type from Topseed®, having characteristics such as large foliage and globular-shaped roots with red coloring. For crop maintenance, the fertilization recommendation was adopted according to Resende & Cordeiro (2007), corresponding to 60 kg ha^{-1} of N, 210 kg ha^{-1} of P, and 120 kg ha^{-1} of K, with three applications (sowing and topdressing at 20 and 35 days after sowing) using urea (45% N), triple superphosphate (46% P_2O_5) and potassium chloride (60% K_2O) as a source. Thus, using a stand of 20,000 plants, the dosage per pot was 3 g of N, 11 g of P, and 6 g of K.

Sowing was carried out in plastic containers with a volumetric capacity of 8 L, adapted as a drainage lysimeter, with five seeds per container at a depth of 2 cm. Thinning was carried out at 13 days after sowing (DAS), leaving only one plant per recipient, filled with substrate containing sand, sandy soil, and cattle manure in the proportion of 5:3:1 (volume basis), respectively. A substrate sample was collected for the determination of chemical attributes (Table 1) according to Teixeira et al. (2017).

The irrigation water was prepared by dissolving soluble salts NaCl, $CaCl_2.2H_2O$, and $MgCl_2.6H_2O$, in the equivalent ratio of 7:2:1, following the relationship between ECw and its concentration ($mmol_c\ L^{-1} = EC \times 10$), according to the methodology contained in Richards (1954), with irrigation applied manually using a 15% leaching fraction according to Ayers & Westcot (1999), at a daily frequency, calculated according to the lysimeter principle of drainage (Bernardo et al., 2019), maintaining the soil at field capacity. The water volume to be applied to the plants was determined by Eq. 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 in the previous irrigation event (mL);

Vd - volume of water drained (mL); and,

LF - leaching fraction of 0.15.

The beginning of treatment application (saline water and vegetal mulching in the containers) occurred at 13 DAS. The mulching was placed in a 5 cm thick layer on the surface of the containers.

At 40 DAS, the following growth variables were analyzed: plant height (PH, in cm) with the aid of a graduated ruler, measuring the distance between the soil surface and the apex

Table 1. Chemical and physical characteristics of the substrate sample before applying treatments

pH H_2O	OM	N	C	P	Ca	Mg	Na	Al	H + Al	K	ECse	ESP	C/N	V
	(g kg^{-1})			(mg kg^{-1})	($cmol_c\ dm^{-3}$)						(dS m^{-1})	(%)		(%)
6.4	14.59	0.93	8.46	27	4.5	0.7	0.67	0.15	1.49	0.78	0.08	8	9	82

SD (g cm^{-3})		CS	FS	Silt	Clay	Textural classification
Bulk	Particle	(g kg^{-1})				
1.47	2.76	665	201	92	42	Loamy Sand

OM - Organic matter; ESP - Percentage of exchangeable sodium; ECse - Electrical conductivity of the soil saturation extract; V - Base saturation; SD - Soil density; CS - Coarse sand; FS - Fine sand of the plant; the number of leaves (NL) through a direct count of the developed leaves; stem diameter (SD, mm) with the aid of a caliper; leaf length (LL, cm) and leaf width (LW, cm). The total leaf area (LA, cm²) was estimated using the following equation: LA = LL × LW indicated for beet according to the methodology proposed by Marrocos et al. (2010).

At 70 DAS, the plants were harvested. The following evaluations were carried out: yield (g per plant), performed on an analytical balance with an accuracy of 0.0001 g; tuberous-root diameter (TRD, mm) and tuberous-root length (TRL, mm), based on the transversal and longitudinal diameters, respectively, using a digital caliper. The soluble solids (SS) also were determined through an analog refractometer (°Brix).

Results were initially analyzed to determine the homogeneity of variance (Bartlett, 1937) and normality with the Kolmogorov-Smirnov test. Next, the data were submitted to analysis of variance and means compared by the Tukey test ($p \leq 0.05$), using the Assistat software, version 7.7 Beta (Silva & Azevedo, 2016).

Results and Discussion

The analysis of variance demonstrated that there was an interaction between the electrical conductivity of the irrigation water (ECw) and vegetal mulching on the plant height (PH), leaf area (LA), and stem diameter (SD). For the number of leaves (NL) there was an isolated effect of the ECw (Table 2).

The highest plant height means were obtained using carnauba bagana and rice hulls (27.00 and 26.28 cm, respectively) as mulching in treatment without salt stress (ECw = 0.3 dS m^{-1}). The lowest mean of PH (20.08 cm) was obtained in saline water (ECw = 5.8 dS m^{-1}) without the mulching.

This reduction indicates a response to greater evapotranspiration in plants without cover due to greater exposure of the soil, in addition to the osmotic effects caused by the presence of salts in the water, which intensified the loss of water, causing a water deficit (Pereira Filho et al., 2019).

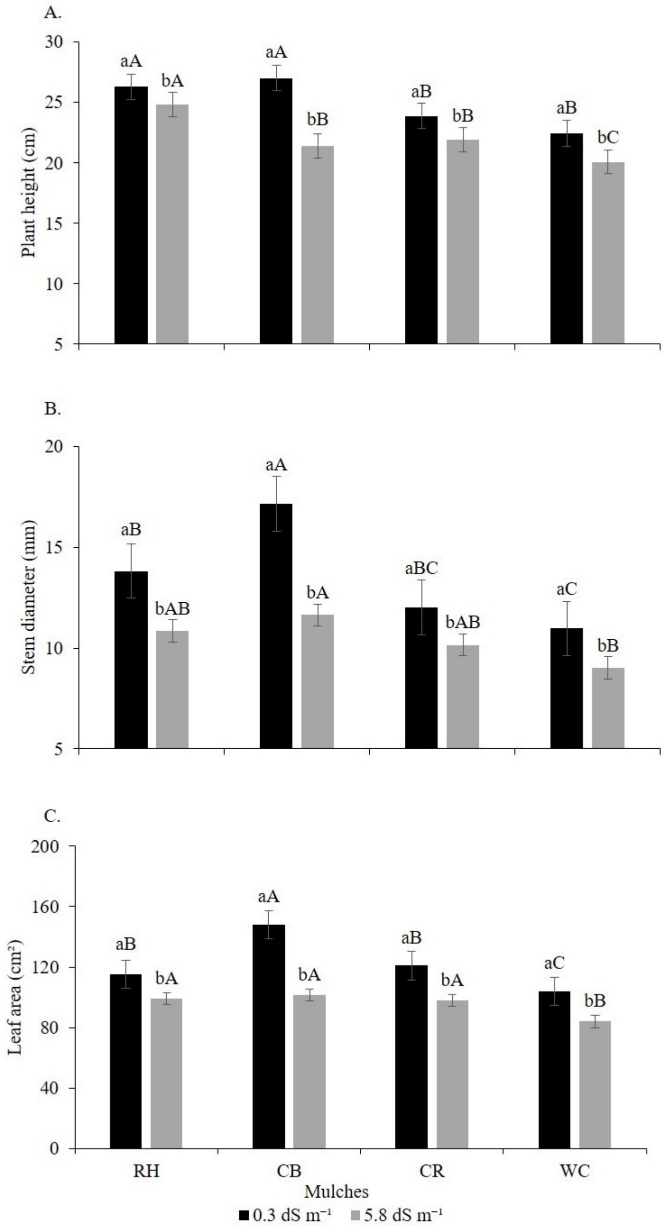
Similarly, Silva et al. (2019) observed a reduction in beet plant height irrigated with water of increasing salinity (0.12 to 6.12 dS m^{-1}) and without using soil protection.

It can be seen in Figure 1B that the highest mean values of stem diameter were obtained with mulching in treatment without salt stress (ECw = 0.3 dS m^{-1}). Saline water (ECw = 5.8 dS m^{-1}) caused a decrease regardless of associated mulching, with the lowest value being 9.02 mm obtained in the absence of soil protection. Although water used in the study corresponds

Table 2. Summary of the analysis of variance for plant height (PH), number of leaves (NL), leaf area (LA), and stem diameter (SD) of beet plants irrigated with saline water (ECw) and different vegetal mulching types

SV	DF	Mean square			
		PH	NL	LA	SD
ECw	1	81.22**	4.90**	6981.71**	94.55**
Mulching	3	33.63**	1.13^{ns}	1587.85**	35.75**
ECw x Mulching	3	8.76**	0.03^{ns}	465.89**	7.31*
Treatments	(7)	208.43**	1.20**	1877.55**	31.96**
Residue	32	28.35	0.41	23.23	7.31
CV (%)	-	4.01	11.89	4.43	11.43

SV - Source of variation; DF - Degrees of freedom; CV - Coefficient of variation; *; **, ns - Significant at $p \leq 0.05$ and $p \leq 0.01$, and not significant, respectively, by F test



Lowercase letters compare the means of the ECw levels in each type of mulching, and uppercase letters compare the means of the mulching types in each ECw by the Tukey test ($p \leq 0.05$); Vertical bars represent standard error (n = 5); RH - Rice hulls; CB - Carnauba bagana; CR - Crop residues; WC - Without cover

Figure 1. Plant height (A), stem diameter (B) and leaf area (C), of beet plants under electrical conductivity of irrigation water and different vegetal mulching types

to the threshold salinity of beet crop, because it is grown in a container, possibly there was a nutritional imbalance due to the antagonistic effect of NaCl with nitrate, the main form of nitrogen absorption, an essential nutrient in the growing phase.

The excess of soluble salts causes a reduction in the osmotic potential of soil, morphological, nutritional, and physiological changes due to hormonal and water imbalance, causing a decrease in stem diameter in plants growing under conditions of salt stress. The results obtained in this study showed that vegetal mulch promotes as a source of moisture retention, favoring chemical reactions and the availability of nutrients. Moreover, it allows greater absorption of minerals such as N and K essential for plant cell expansion, minimizing the effects of salts and promoting higher stem diameter values (Prado, 2008; Sousa et al., 2018).

The use of mulching promoted a better development of leaf area independent of the electrical conductivity of irrigation water. Carnauba bagana was the mulching with the highest performance (614.06 cm^2) concerning the other coverings when irrigated with low salinity water. Still, together with rice hulls cover and cultural remains, they differed statistically from the control treatment (without cover) when irrigated with high salinity water (Figure 1C).

It should be noted that the result shown in Figure 1C can be explained by the greater storage capacity of water in the soil in treatments with the use of mulching, allowing the reduction of temperature and water evaporation, that is, keeping the soil moist for a longer period and neutralizing the harmful effects of ions (Na^+ and Cl^-) on plants (Lima Neto et al., 2013). A similar trend was reported by Lessa et al. (2019) when using mulching in a saline environment. The authors observed a positive effect of sugarcane bagasse as soil protection in sorghum leaf area irrigated with 4.0 dS m^{-1} saline water.

Low salinity water showed a higher mean (5.75) compared to water with high electrical conductivity (5.05) for the number of leaves (NL) (Figure 2).

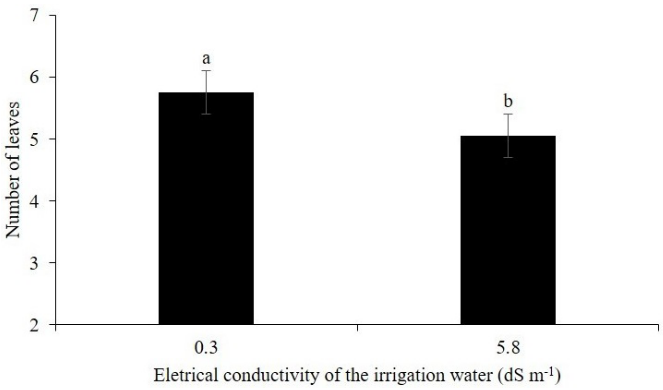
The most common salinity effect is the limitation of plant growth, promoting decreases in water availability and absorption, negatively affecting cell division and elongation (Lima et al., 2021). Causing, consequently, a lower number of leaves in treatments irrigated with water of 5.8 dS m^{-1}.

The reduction of leaf emission of plants due to the salt stress is to avoid the great loss of water due to the low availability of water in the soil, thus affecting morphological and anatomical aspects. Similar results were obtained by Silva et al. (2019) when evaluating the use of different saline levels of irrigation water (0.12, 2.21, 4.12, and 6.12 dS m^{-1}) in the beet crop.

As shown in Table 3, there is an interaction between the electrical conductivity of the irrigation water (ECw) and vegetal mulching, over the tuberous root diameter (TRD) variable. The variables tuberous root length (TRL), soluble solids (SS), and yield (YIELD) were influenced only by the ECw.

Only in the beet cultivation without mulching (WC) the mean of TRD was lower under irrigation with saline water (ECw = 5.8 dS m^{-1}) (Figure 3A).

Soil coverage provides better maintenance of soil moisture and controls temperature variations. However, in the absence, it can cause high water evaporation, which, associated with salinity, can trigger a reduction in the osmotic potential of the



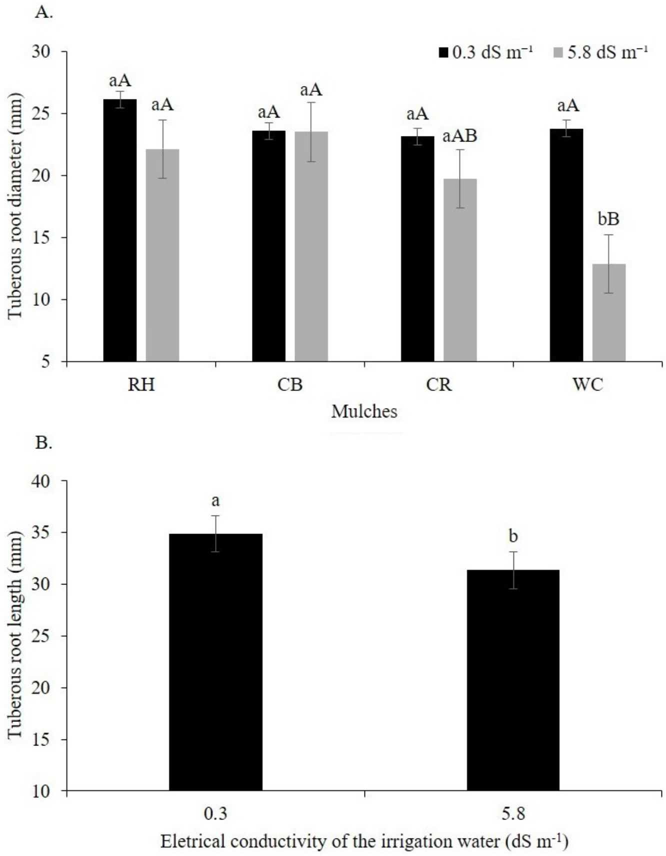
Lowercase letters compare the means by the Tukey test ($p \leq 0.05$); Vertical bars represent standard error (n = 5)

Figure 2. Mean number of leaves of beet plants according to the electrical conductivity of irrigation water

Table 3. Summary of analysis of variance for tuberous root diameter (TRD), tuberous root length (TRL), soluble solids (SS), and yield (YIELD) of beet plants under salinity of the irrigation water (ECw) and different vegetal mulching types

SV	DF	Mean square			
		TRD	TRL	SS	YIELD
ECw	1	212.24**	123.72*	32.40*	40929.28*
Mulching	3	68.95*	24.40^{ns}	10.96^{ns}	7147.77^{ns}
ECw x Mulching	3	51.81*	5.77^{ns}	11.93^{ns}	5.86^{ns}
Treatments	(7)	82.08**	30.60^{ns}	14.44^{ns}	8912.88^{ns}
Residue	32	16.77	22.33	7.13	5568.90
CV (%)	-	18.74	24.27	13.88	26.32

SV - Source of variation; DF - Degrees of freedom; CV - Coefficient of variation; *; **, ns - Significant at $p \leq 0.05$ and $p \leq 0.01$, and not significant, respectively



Lowercase letters compare the means of the ECw levels in each type of mulching, and uppercase letters compare the means of the mulching types in each ECw by the Tukey test ($p \leq 0.05$); Vertical bars represent standard error (n = 5); RH - Rice hulls; CB - Carnauba bagana; CR - Crop residues; WC - Without cover

Figure 3. Tuberous root diameter (A), in beet plants under electrical conductivity of irrigation water and different vegetal mulching types. Tuberous root length (B), under electrical conductivity of the irrigation water

soil and water absorption by the plant due to the presence of a large number of ions in the soil solution (Santos et al., 2018; Melo Filho et al., 2020).

According to Figure 3B, the TRL of the beet was lower under saline water (ECw = 5.8 dS m^{-1}), approximately 10% compared to the condition without salt stress (ECw = 0.3 dS m^{-1}). Despite being a salinity-tolerant crop, cultivation in pot conditions may have increased the excess of salts present near the plant root, which may reduce the absorption of water and nutrients, affecting cell division and expansion and biochemical processes (Silva et al., 2015; Melo Filho et al., 2020).

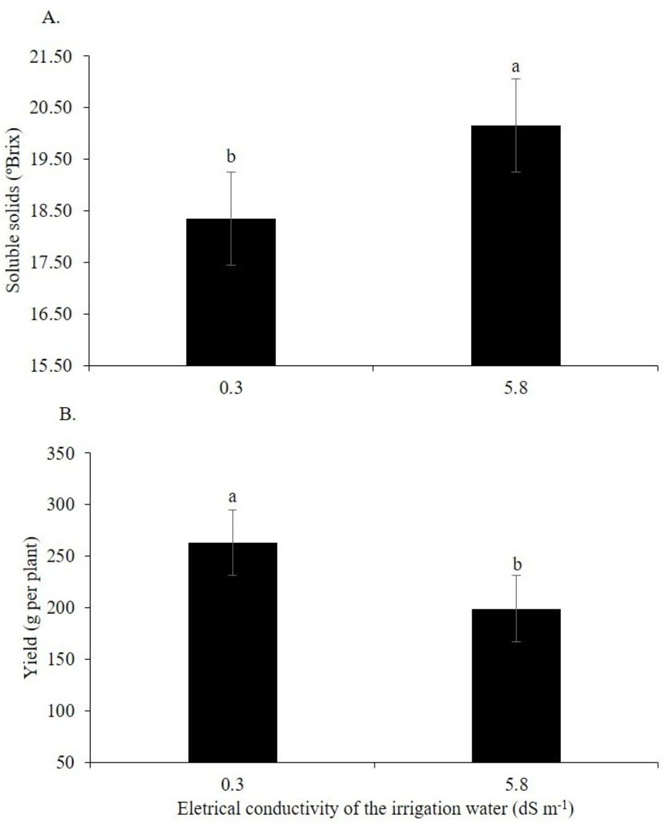
Working in field conditions, Santos et al. (2016) also found reductions in length of the tuberous root of beet plants of the same cultivar in increasing electrical conductivity levels of irrigation water. Putti et al. (2018) reported reductions in the values of the length of roots of zucchini plants when irrigated with water up to 5.0 dS m^{-1}.

The soluble solids content was about 9.8% higher in tuber roots of plants irrigated with high salinity water (ECw = 5.8 dS m^{-1}), obtaining a value of 20.15 °Brix. In contrast, in roots of plants irrigated with water of low salinity (ECw = 0.3 dS m^{-1}), this value was 18.35 °Brix (Figure 4A). The decline in the osmotic potential of the soil solution provoked by the dissolved salts results in low water absorption by the plants, reducing their internal content, causing a higher concentration of solutes in the cellular juice, leaving them less dissolved and, consequently, increasing the soluble solids (Silva et al., 2019).

Corroborating the present study, Lima et al. (2020) found that West Indian cherry also increased the soluble solids when irrigated with saline water concerning non-saline water. Likewise, Zhang et al. (2016) found higher levels of soluble solids in tomato fruits in plants irrigated with saline water concerning low salinity water.

The beet production (Figure 4B), when irrigated with high salinity water, revealed a negative influence, reaching values of 198.8 g per plant, a reduction of 24.3% obtained compared to plants irrigated with low water salinity (262.8 g per plant).

It is important to highlight that yield is directly influenced by the accumulation of photoassimilates in the storage organs, which, for beet, is the tuberous root. The decrease in the number of leaves due to salinity caused by morphological adjustments (leaf abscission) may have induced a decline in the plant's photosynthetic capacity and, consequently, in the



Lowercase letters compare the means by the Tukey test ($p \leq 0.05$); Vertical bars represent standard error (n = 5)

Figure 4. Soluble solids (A) and yield (B) of beet plants under electrical conductivity of the irrigation water

production and translocation of carbohydrates, thus reducing yield (Melo Filho et al., 2020).

Similar results regarding the negative effect of increasing salt concentration in irrigation water on yield were reported by Silva et al. (2019) in the beet crop grown under field conditions. Similarly, Sousa et al. (2016), irrigating radish with saline water in pots, also found reduced yield.

Conclusions

1. The use of vegetal mulching (rice hulls, carnauba bagana and crop residues) mitigated the effects of irrigation water salinity for plant height, leaf area, stem diameter, and tuberous root.

2. An increase in the concentration of salts in irrigation water negatively affected the number of leaves, length of the tuberous root, and production.

3. Irrigation with saline water increases the soluble solids in the beet crop.

Literature Cited

Almeida, A. V. R. de; Silva, A. O. da; Costa, R. N. T.; Santos, J. da S. G.; Silva, G. F. da. Use of carnauba palm bagana to reduce water consumption in the production of irrigated radish. Revista Caatinga, v.33, p.1071-1081, 2020. https://doi.org/10.1590/1983-21252020v33n422rc

Ayers, R. S., Westcot, D. W. A qualidade da água na agricultura. 2.ed. Campina Grande: UFPB, 1999. 153p.

Bartlett, M. S. Properties of sufficiency and statistical tests. Proceedings of the Royal Society of London, v.160, p.268-282, 1937. https://doi.org/10.1098/rspa.1937.0109

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

IPECE - Instituto de Pesquisa e Estratégia Econômica do Ceará, 2017. Perfil básico municipal de Redenção, CE: Governo do Estado do Ceará, 2017. Available on: https://www.ipece.ce.gov.br/wpcontent/uploads/sites/45/2018/09/Redencao_2017.pdf. Accessed on: Dez. 2020.

Lessa, C. I. N.; Oliveira, A. C. N. de; Magalhães, C. L.; Sousa, J. T. M. de; Sousa, G. G. de. Estresse salino, cobertura morta e turno de rega na cultura do sorgo. Revista Brasileira de Agricultura Irrigada, v.13, p.3637-3645, 2019. https://doi.org/10.7127/RBAI.V13N5001122

Lima, A. F. da S.; Santos, M. F. dos; Oliveira, M. L.; Sousa, G. G. de; Mendes Filho, P. F.; Luz, L. N. da. Physiological responses of inoculated and uninoculated peanuts under saline stress. Revista Ambiente e Água, v.16 p.e2643, 2021. https://doi.org/10.4136/ambi-agua.2643

Lima, G. S. de; Silva, A. R. P. da; Sá, F. V. da S.; Gheyi, H. R.; Soares, L. A. dos A. Physicochemical quality of fruits of West Indian cherry under saline water irrigation and phosphate fertilization. Revista Caatinga, v.33, p.217-225, 2020. https://doi.org/10.1590/1983-21252020v33n123rc

Lima Neto, A. J. de; Dantas, T. A. G.; Cavalcante, L. F.; Dias, T. J.; Diniz, A. A. Biofertilizante bovino, cobertura morta e revestimento lateral dos sulcos na produção de pimentão. Revista Caatinga, v.26, p.1-8, 2013.

Malik, A.; Shakir, A. S.; Khan, M. J.; Naveedullah.; Latif, M.; Ajmal, M.; Ahmad, S.; Effects of different mulching techniques on sugar beet performance under semi-arid subtropical climatic conditions. Pakistan Journal of Botany, v.50, p.1219-1224, 2018.

Marrocos, S. de T. P.; Dantas, M. S. M.; Dombroski, J. L. D.; Lucena, R. R. M. de; Batista, T. M. de V. Análise comparativa de métodos de estimativa de área foliar em beterraba, Revista Verde de Agroecologia e Desenvolvimento Sustentável, v.5, p.140-146, 2010.

Melo Filho, J. S. de; Silva, T. I. da; Gonçalves, A. C. de M.; Sousa, L. V. de; Véras, M. L. M.; Dias, T. J. Physiological responses of beet plants irrigated with saline water and silicon application. Comunicata Scientiae, v.11, p.e3113, 2020. https://doi.org/10.14295/cs.v11i0.3113

Pereira Filho, J. V.; Viana, T. V. de A.; Sousa, G. G. de; Chagas, K. L.; Azevedo, B. M. de; Pereira, C. C. M. de S. Physiological responses of lima bean subjected to salt and water stresses. Revista Brasileira de Engenharia Agrícola e Ambiental, v.23, p.959-965, 2019. https://doi.org/10.1590/1807-1929/agriambi.v23n12p959-965

Prado, R. de M. Nutrição de plantas. São Paulo: Editora UNESP, 2008. 407p.

Putti, F. F.; Silva, A. O. da; Silva Júnior, J. F.; Gabriel Filho, L. R. A.; Klar, A. E. Crescimento e produção da abobrinha sob irrigação com água salobra. Irriga, v.23, p.713-726, 2018. https://doi.org/10.15809/irriga.2018v23n4p713-726

Resende, G. M. de; Cordeiro, G. G. Uso de água salina e condicionador do solo na produtividade de beterraba e cenoura no semi-árido do Submédio São Francisco. Petrolina: Embrapa Semi-Árido, 2007. 4p.

Richards, L. A. Diagnosis and improvement of saline and alkali soils. Washington: US Department of Agriculture, 1954. 160 p. USDA Agricultural Handbook, 60.

Rodrigues, V. dos S.; Bezerra, F. M. L.; Sousa, G. G.; Fiusa, J. N.; Leite, K. N.; Viana, T. V de. A. Produtividade da cultura do milho irrigado com águas salinas. Revista Brasileira de Engenharia Agrícola e Ambiental, v.24, p.101-105, 2020. https://doi.org/10.1590/1807-1929/agriambi.v24n2p101-105

Santos, D. P. dos; Santos, C. S. dos; Silva, P. F. da; Pinheiro, M. P. M. A.; Santos, J. C. dos. Crescimento e fitomassa da beterraba sob irrigação suplementar com água de diferentes concentrações salinas. Revista Ceres, v.63, p.509-516, 2016. https://doi.org/10.1590/0034-737X201663040011

Santos, J. R. C. dos; Fernandes, C. N. V.; Oliveira Filho, J. N.; Silva, A. R. A. da; Fernandes, J. N. V.; Saraiva, K. R. Adubação nitrogenada e cobertura do solo no cultivo da alface irrigada. Revista Brasileira de Agricultura Irrigada, v.12, p.2327-2337, 2018. https://doi.org/10.7127/rbai.v12n100702

Silva, A. O. da; Silva, Ê. F. F.; Klar, A. E. Manejo da fertirrigação e salinidade do solo no crescimento da cultura da beterraba. Engenharia Agrícola, v.35, p.230-241, 2015. https://doi.org/10.1590/1809-4430-Eng.Agric.v35n2p230-241/2015

Silva, C. B. da; Silva, J. C. da; Santos, D. P. dos; Silva, P. F. da; Barbosa, M. de S.; Santos, M. A. L. dos. Manejo da irrigação na cultura da beterraba de mesa sob condições salinas em Alagoas. Revista Brasileira de Agricultura Irrigada, v.13, p.3285-3296, 2019. https://doi.org/10.7127/RBAI.V13N200880

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

Sousa, G. G. de; Rodrigues, V. dos S.; Sales, J. R. da S.; Cavalcante, F. Silva, G. L. da; Leite, K. N. Estresse salino e cobertura vegetal morta na cultura do milho. Revista Brasileira de Agricultura Irrigada, v.12, p.3078-3089, 2018. https://doi.org/10.7127/RBAI.V12N700889

Sousa, G. G. de; Rodrigues, V. dos S.; Viana, T. V. de A.; Silva, G. L. da; Rebouças Neto, M. de O.; Azevedo, B. M. de. Irrigação com água salobra na cultura do rabanete em solo com fertilizantes orgânicos. Revista Brasileira de Agricultura Irrigada, v.10, p.1065-1074, 2016. https://doi.org/10.7127/rbai.v10n600514

Sousa, H. C.; Sousa, G. G.; Lessa, C. I. N.; Lima, A. F. da S.; Ribeiro, R. M. R.; Rodrigues, F. H. da C. Growth and gas exchange of corn under salt stress and nitrogen doses. Revista Brasileira de Engenharia Agrícola e Ambiental, v. 25, p.174-181, 2021. https://doi.org/10.1590/1807-1929/agriambi.v25n3p174-181

Teixeira, P. C., Donagemma, G. K., Fontana, A., Teixeira W. G. Manual de métodos de análise de solo. 3.ed. Brasília: Embrapa, 2017. 573p.

Veras, P. V.; Valnir Júnior, M.; Lima, L. S. de S.; Rocha, J. P. A.; Demontiezo, F. L. L.; Aragão, M. F. Avaliação de crescimento de cultivares de beterraba de mesa sob diferentes lâminas de irrigação. Revista Brasileira de Agricultura Irrigada, v.11, p.1271-1277, 2017. https://doi.org/10.7127/rbai.v11n200597

Zhang, P.; Senge, M.; Dai, Y. Effects of salinity stress on growth, yield, fruit quality and water use efficiency of tomato under hydroponics system. Reviews in Agricultural Science, v.4, p.46-55, 2016. https://doi.org/10.7831/ras.4.46