Edição especial – VI Winotec

ISSN 1808-8546 (ONLINE) 1808-3765 (CD-ROM)

RESPOSTA DE MORINGA (*Moringa oleifera* L.) – (MORINGACEAE) A IRRIGAÇÃO COM ÁGUA SALINA FRENTE A GERMINAÇÃO

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1 RESUMO

A moringa (*Moringa oleifera* Lam.) é uma espécie de origem indiana que se adaptou bem às condições edafoclimáticas do semiárido do Nordeste brasileiro. É explorada tanto em condições irrigadas quanto de sequeiro, apresentando potencial em face de sua multiplicidade de usos alimentar, agrícola, medicinal e industrial. O objetivo do trabalho foi observar as respostas de *Moringa oleifera* à irrigação com água salina frente à germinação. O experimento foi realizado no Laboratório de Fitossanidade e Sementes, no Instituto Federal de Educação, Ciência e Tecnologia do Ceará – *campus* Sobral. Utilizou-se cinco níveis de salinidade da água de irrigação (0,27; 1,5; 3,0; 4,5 e 6,0 dS m^{-1}), com soluções salinas de água destilada e cloreto de sódio (NaCl); com quatro repetições de 20 sementes cada, representando a unidade experimental. Foram avaliadas primeira contagem de germinação (aos 7 DAS), e porcentagem final de germinação (aos 14 DAS), quando desta última, mensurou-se a altura da planta, número de folhas, comprimento da raiz, peso da matéria seca da parte aérea e peso da matéria seca do sistema radicular. De posse dos resultados analisados, verificou-se que a irrigação com água salina afetou negativamente a germinação e o crescimento inicial de plantas de moringa a partir de 3,0 dS m^{-1}.

Palavras-chave: *Moringa oleifera*, Salinidade, Semiárido, Irrigação.

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RESPONSE OF MORINGA (*Moringa oleifera* L.) – (MORINGACEAE) TO IRRIGATION WITH SALINE WATER IN RELATION TO GERMINATION

Recebido em 03/12/2024 e aprovado para publicação em 12/12/2024
DOI: http://dx.doi.org/10.15809/irriga.2024v29p112-119

2 ABSTRACT

Moringa (*Moringa oleifera* Lam.) is a species of Indian origin that has adapted well to the edaphoclimatic conditions of the semiarid region of northeastern Brazil. It has been explored under both irrigated and rainfed conditions and has great potential given its multiplicity of food, agricultural, medicinal and industrial uses. The objective of this work was to observe the response of *Moringa oleifera* to irrigation with saline water in relation to germination. The experiment was carried out at the Plant Health and Seeds Laboratory at the Federal Institute of Education, Science and Technology of Ceará – *campus* Sobral. Five salinity levels of irrigation water were used (0.27, 1.5, 3.0, 4.5 and 6.0 dS m^{-1}), with saline solutions of distilled water and sodium chloride (NaCl), with four replications of 20 seeds each, thus representing the experimental unit. The first germination count (at 7 DAS) and the final percentage of germination (at 14 DAS) were evaluated. The plant height, number of leaves, root length, and dry matter weight of each plant were also measured. aerial part and dry matter weight of the root system. The observed and analyzed results revealed that irrigation with saline water negatively affected the germination and initial growth of moringa plants from 3.0 dS m^{-1} onward.

Keywords: *Moringa oleifera*, Salinity, Semi-arid, Irrigation.

3 INTRODUCTION

The semiarid region of Brazil covers 80% of the Northeast Region and part of Southeast Brazil. The biome is characterized mainly by the Caatinga, which stands out because its vegetation adapts to conditions of water stress and irregular rainfall, with endemic vegetation that has physiological mechanisms that allow water retention, ensuring survival during long periods of drought (Santos *et al*., 2020). These extreme conditions make the semiarid region a region of great interest for studies regarding environmental resilience, consequently generating research for the development of sustainable management of natural resources.

Farmers in the backlands often face constant challenges due to the long periods of drought that are characteristic of semiarid regions, which leads them to seek viable alternatives that can guarantee the continuity of their agricultural activities. One of the strategies frequently adopted is the capture of groundwater by drilling artesian wells or wells, but finding water underground often does not constitute the definitive solution to these water challenges, since the crystalline water is saline in its origin, thus requiring the adoption of different complementary management techniques, in addition to the efficient use of water (Santos *et al*., 2020).

According to Granjeiro *et al*. (2023) estimated that there are approximately 160 thousand registered wells in Northeast Brazil; thus, Northeast China is an important alternative source of water for rural communities. However, the usefulness of these wells is quite limited due to the presence of water with brackish and saline characteristics, thus restricting their use, in addition to their limited flows, reducing their availability during periods of drought that occur in the region, considering that during this period, underground recharge becomes conditioned, reducing the available volume.

The moringa (*Moringa oleifera* Lam.) is a species of Indian origin that is cultivated in several countries in Asia, the Middle East and South Africa and has shown satisfactory adaptability to the edaphoclimatic conditions of the semiarid region in Northeast Brazil. In rural areas in

Northeast Brazil, the use of moringa seeds for the purification of water for residential supply has been a frequent practice, given the scarcity of drinking water, especially for the rural population in the region (Benedito; Ribeiro; Torres, 2008; Bezerra *et al*., 2004).

It can be explored under both irrigated and dryland conditions and has great potential because of its multiple uses in food, agriculture, medicine and industry (Lorenzi; Matos, 2002; Oliveira *et al*., 2013). Owing to its still incipient commercial exploitation, moringa is a species that has been little studied, especially regarding its growth under conditions of environmental stress.

The use of saline water for irrigation purposes results in a significant increase in the concentrations of salts in the soil solution, with an emphasis on the accumulation of sodium. This excess sodium has adverse effects on plants, manifesting itself through changes in ionic, osmotic, nutritional and hormonal natures. Such changes compromise the physiological and biochemical balance of plants, causing negative impacts at different stages of their development (Tavares Filho *et al. al*., 2020; Sá *et al*., 2017).

Among the main losses observed, the inhibition of seed germination processes stands out, compromising the stability of plants in the cultivation environment; the reduction in the seedling emergence rate, making it difficult to form a uniform stand; and the limitation of vegetative growth and the reduction in biomass accumulation, a fundamental factor for the good development of plants, directly affecting agronomic performance and compromising the economic viability of crops (Tavares Filho *et al.*, 2020; Sá *et al*., 2017).

High salt concentrations are a stress factor for plants, especially during the germination phase (Benedito; Ribeiro; Torres, 2008). According to Bewley and Black (1994), the first stage of germination occurs with the absorption of water by the seed through imbibition. This process occurs when, upon entering a humid environment, the seed begins to absorb water gradually, resulting in a chain reaction of biochemical processes essential for the activation of cellular functions.

Water absorption promotes the rehydration of macromolecules, enzymatic reactivation and the mobilization of energy reserves, consequently generating the intensification of respiration and all other metabolic activities, which culminate in the supply of energy and nutrients necessary for the resumption of growth by the necessary axis, marking the advance to the next phases of development (Benedito; Ribeiro; Torres, 2008; Carvalho; Nakagawa, 2012).

The inhibition of growth caused by salinity is due to both the osmotic effect and the toxic effect resulting from the concentration of ions in the protoplasm. One of the most widespread methods for determining plant tolerance to excess salts is the observation of the percentage of seed germination in saline substrates (Benedito; Ribeiro; Torres, 2008).

The objective of this work was to observe the response of *Moringa oleifera* L. (Moringaceae) to irrigation with saline water in relation to germination.

4 MATERIALS AND METHODS

The experiment was conducted at the Plant Health and Seed Laboratory at the Federal Institute of Education, Science and Technology of Ceará - Sobral *Campus*, from January to February 2024 in the city of Sobral-CE, which is located under geographic coordinates (03°40' S and 40°14' W). The climate is hot tropical semiarid, according to the Köppen climate classification, with an average temperature of 30 °C and an altitude of 70 meters. The average annual rainfall is 896.7 mm, with most of the rain concentrated between the months of January and May. The average annual temperature varies between a maximum of 34.1 °C, with an average of 27.2 °C, and a minimum of 22.4 °C. The relative humidity, in turn, has an annual average of 68.5%. The region also records an average sunshine duration of 2,648 hours per year (Brazil, 2018).

The seeds came from Alto do Cristo, a postcard of the city, and the trees are on the outskirts of the area, in the municipality of Sobral-CE, and were taken to the Phytosanitary and Seed Laboratory, at IFCE – Sobral *campus*, to carry out the test.

The different salinity levels were related to the relationship between the electrical conductivity of the solution (ECs) and the total dissolved salts in the desired proportions, with reference to the equation proposed by Richards (1954), presented in equation (1):

$$C = CEs \times 640 \quad (1)$$

Where C = salt concentration, mg L $^{-1}$; CEs = electrical conductivity of the solution, dS m $^{-1}$.

A randomized design (CRD) with five treatments composed of irrigation water salinity levels (0.0, 1.5; 3.0; 4.5 and 6.0 dS m $^{-1}$) was used, with four replicates of 20 seeds each, thus representing the experimental unit.

The seeds were allowed to germinate on germitest paper (3 sheets) and moistened with 3.5 times their weight in distilled water, according to the Rules for Seed Analysis (Brazil, 2009). Soon after, the rolls were made and placed in BOD at a constant temperature of 27 °C and a photoperiod of 8 hours/night and 16 hours/night.

Two evaluations were carried out, in which the first germination count (1st CG) was determined 7 days after sowing, and the final germination percentage was determined 14 days after sowing. The plant height, number of leaves, root length, dry matter weight of the aerial parts and dry matter weight of the root system were also measured. Measurements were made using a ruler graduated in centimeters; a digital caliper graduated in millimeters (Digimess© brand); the plant material was dried in an oven with forced air circulation at 105 °C for 24 hours; and weighing was performed on an analytical balance with a precision of 0.001 g.

® spreadsheet. With the means obtained, analysis of variance was performed via the F test via the statistical software Sisvar (Ferreira, 2011). When there was significance, the comparison of the means of the treatments, because they were quantitative, was performed via regression analysis. The results are expressed in graphs, with a significance level of 1.0%.

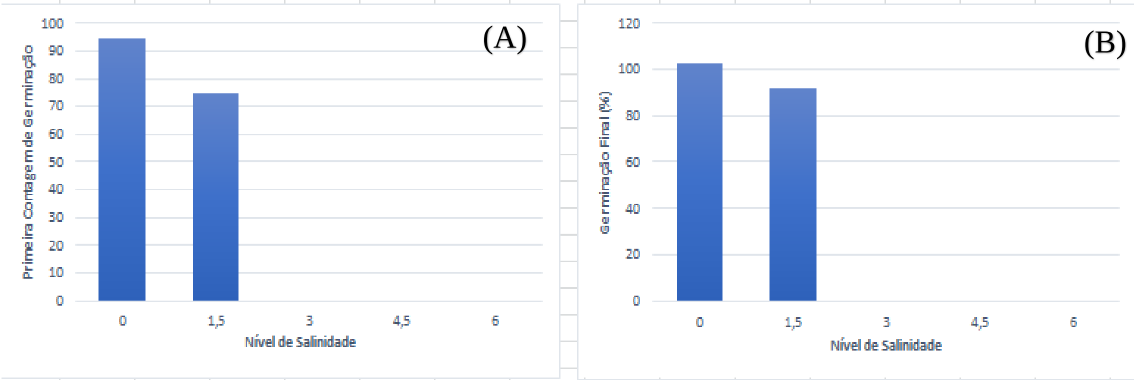
5 RESULTS AND DISCUSSION

The resulting weight of a thousand seeds was 27.861 g. The moisture content of this seed lot was 6.25%. The weight of a thousand seeds is an important piece of data that can provide an indication of seed quality and generate information to calculate the seeding density of a given crop (Amaro *et al*., 2006). However, it is considered a measurement that presents strong genetic control, according to the Rules for Seed Analysis - RAS, (Brazil, 2009), but it can be affected by temperature, light and humidity conditions during the maturation phase in the field. The moisture content of a seed lot is essential information, since, depending on this value, normally values above 10%, a low germination rate can occur, interrupting the entry of oxygen and reducing the resulting metabolic processes. Therefore, the moisture content of seeds is one of the factors that most influences germination.

The seeds of *M. oleifera* showed germination oscillation at different salinity levels, with germination observed at doses of zero (control) and 1.5 (dS m $^{-1}$). Seeds irrigated with doses of 3 dS m $^{-1}$, 4.5 dS m $^{-}$

^{1}, and 6.0 dS m $^{-1}$ did not germinate, which reflected the sensitivity of the seeds to irrigation with saltwater.

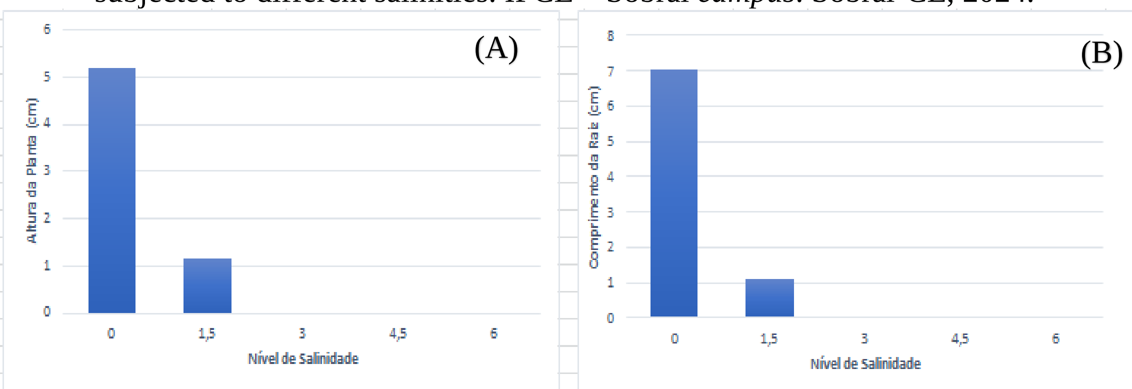
Figure 1. Results of the germination percentage in the first count (%1CTG) – (A) and final germination percentage (%GER) – (B) of *Moringa oleifera seeds* subjected to different levels of irrigation water salinity. IFCE – Sobral *campus*. Sobral-CE, 2024.



The graphs in Figure 1A and 1B show the differences in the development of seed germination in saline NaCl media. The seeds at salinity 0 were greater than 90%, and those at a salinity of 1.5 dS m $^{-1}$ were greater than 70%, indicating good development. The germination levels of 0 and 1.5 dS m $^{-1}$ were greater than 80% in the final evaluation, indicating that the plants were very resistant to the dose of 1.5 dS m $^{-1}$, whereas the salinity levels of 3 dS m $^{-1}$, 4.5 dS m $^{-1}$ and 6 dS m $^{-1}$ did not result in any germination.

As Tavares Filho *et al*. (2020) and Sá *et al*. Saline water can affect plant germination and development, such as biomass accumulation, and the dry weight of the aerial part of a plant can differ greatly between concentrations of 0 and 1.5 dS m $^{-1}$.

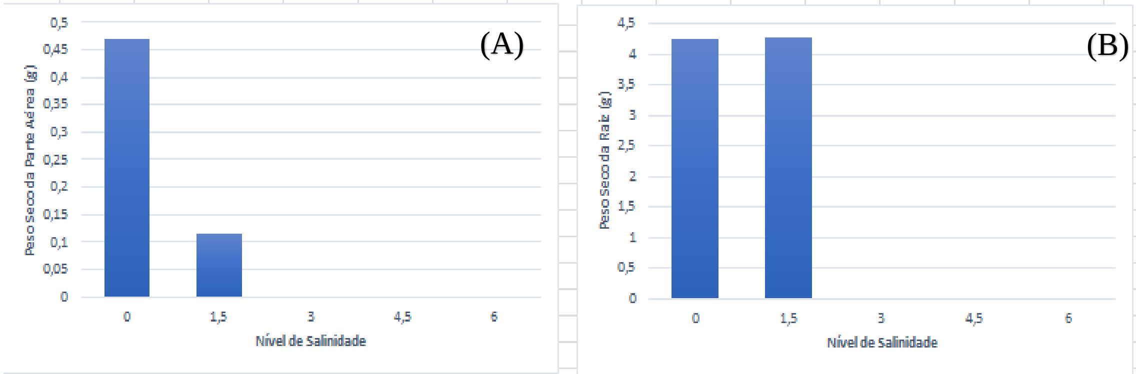
Figure 2. Results of the plant height (A) and root length (B) of *Moringa oleifera plants* subjected to different salinities. IFCE – Sobral *campus*. Sobral-CE, 2024.



The graphs in Figure 2A and 2B show the data on plant height and root length, in which the plants had different heights depending on the salinity level to which they were exposed; the plants at a salinity of 0.0 dS m $^{-1}$ had superior results to those at 1.5 dS m $^{-1}$. This variation in plant development occurs due to the toxins present in the salt, which affect plant development. The length of the roots at zero dosage was greater than that of the seeds that were in the medium at a salinity level of 1.5 dS m $^{-1}$.

According to Tavares Filho *et al*. (2020) and Alvarenga *et al*. (2019), the low development of plants at a relatively negative osmotic potential may be associated with increased absorption of Na+ and Cl^{-}, promoting nutritional imbalance and toxicity and modifying the absorption and distribution of nutrients. Compared with the data obtained, we confirmed that NaCl dosages can interfere with plant development.

Figure 3. Results of aerial part dry weight (APW) – (A) and root dry weight (RW) – (B) of *Moringa oleifera plants* subjected to different levels of irrigation water salinity. IFCE – Sobral *campus*. Sobral-CE, 2024.



As shown in the graph in Figure 3, the dry weights of the aerial parts were different, and the dry weights of the roots were similar and did not differ among the salinity levels (Figure 3A and 3B). Compared with the work of Benedito, Ribeiro and Torres (2008), where the lowest percentage of emergence of moringa seedlings was observed at 3.0 dS m $^{-1}$, we obtained very different values because the seeds germinated only at dosages of 0 and 1.5 dS m $^{-1}$; this difference may be related to the quality of the seeds, and further studies in this area are needed.

6 CONCLUSIONS

Irrigation with saline water negatively affected the germination and initial growth of moringa plants; however, with respect to the seed germination process, the tolerance limit response was better at salinities of 1.5 dS m $^{-1}$.

7 ACKNOWLEDGMENTS

The authors would like to thank the Institutional Scientific Initiation Scholarship Program (PIBIC) for granting innovation scholarships; the Ceará Foundation for Support of Scientific and Technological Development (FUNCAP); and the Federal Institute of Education, Science and Technology of Ceará, IFCE - Sobral *campus* and the Laboratory of Phytosanitary and Seeds for their logistical support in carrying out this work.

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