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Strategies for the management of irrigation with saline water and nitrogen fertilization in millet crop

Estratégias de irrigação com água salina e adubação nitrogenada na cultura do milheto

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ABSTRACT - It is believed that nitrogen fertilization will attenuate the salt stress on pearl millet plants. Thus, the objective was to evaluate the agronomic performance of the millet crop under different saline water irrigation strategies and nitrogen fertilization. The experimental design adopted was completely randomized (CRD), in a 4 x 2 factorial scheme, with 4 replicates, with the first factor being four irrigation strategies: S1 = low-salinity water (W1) = 0.3 dS m^{-1} throughout the cycle; S2 = saline water (W2) = 4.0 dS m^{-1} from 30 days after sowing - DAS; S3 = W2 from 45 DAS; and S4 = W2 from 65 DAS; and the second factor being two nitrogen doses (60 and 120 kg ha^{-1} of N). At the end of the experiment, the following variables were evaluated: photosynthesis, transpiration, stomatal conductance, instantaneous water use efficiency, internal CO_2 concentration, leaf temperature, plant height, stem diameter, root length, panicle length, leaf dry mass, stem dry mass and root dry mass. Fertilization with 60 and 120 kg ha^{-1} promotes greater photosynthesis, transpiration, stomatal conductance and internal CO_2 concentration in millet plants under the strategies S1, S2 and S3. The strategies S1 and S4 were more efficient to increase the efficient use of water and reduce leaf temperature.

Keywords: *Pennisetum glaucum* L.. Physiology. Salinity.

RESUMO - Acredita-se que a adubação nitrogenada atenuará o estresse salino sobre as plantas de milheto. Dessa forma, objetivou-se avaliar o desempenho agronômico da cultura do milheto sob diferentes estratégias de irrigação com água salina e adubação nitrogenada. O delineamento experimental adotado foi inteiramente casualizado (DIC), em esquema fatorial 4 x 2, com 4 repetições, sendo o primeiro fator, quatro estratégias de irrigação: S1 = água de baixa salinidade (W1) = 0,3 dS m^{-1} durante todo o ciclo; S2 = água salina (W2) = 4,0 dS m^{-1} utilizada a partir dos 30 dias após a semeadura – DAS; S3 = W2 a partir dos 45 DAS e S4 = W2 a partir dos 65 DAS; e o segundo fator, duas doses de nitrogênio (60 e 120 kg ha^{-1} de N). Ao final do experimento foram avaliadas: fotossíntese, transpiração, condutância estomática, eficiência instantânea no uso da água, concentração interna de CO_2, temperatura foliar, altura de planta, diâmetro do colmo, comprimento da raiz, comprimento da panícula, massas secas da das folhas, do colmo e da raiz. Adubações com 60 e 120 kg ha^{-1} proporcionam maior fotossíntese, transpiração, condutância estomática e concentração interna de CO_2 em plantas de milheto nas estratégias S1, S2 e S3. As estratégias S1 e S4 foram mais eficientes para aumentar o uso eficiente de água e reduzir a temperatura foliar.

Palavras-Chave: *Pennisetum glaucum* L.. Fisiologia. Salinidade.

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INTRODUCTION

Irrigation is one of the techniques that allow crops to reach maximum production, but the amount of good quality water in semi-arid and arid regions may not be sufficient to maintain irrigated agriculture, because these regions have areas with high evapotranspiration rates, higher than the rainfall, which favors the accumulation of salts in the waters that are available for irrigation (LIMA et al., 2017; MINHAS et al., 2020).

The use of saline water compromises physiological processes, causing partial closure of stomata, limiting the internal concentration of CO_2, reducing the photosynthesis and transpiration rates and reducing the absorption of water and nutrients by plants, in addition to reducing growth and yield (LIMA et al., 2020a; BRAZ et al., 2019; SOUSA et al., 2021).

Like the quality of irrigation water, nitrogen fertilization is crucial for agricultural crops, increasing cell expansion, development of the entire shoots and biomass accumulation, essential characteristics in forage crops, besides acting as a component of organic solutes, such as amino acids and proline, which can increase osmotic adjustment in plants under conditions of salt stress (TAIZ et al., 2017; MASOULEH; ALDINE; SASSINE, 2019).

Millet (*Pennisetum glaucum* L), an annual crop belonging to the Poaceae family, is a forage species that can be used in the production of straw, silage or grains (FERREIRA et al., 2020), demonstrating great production potential, since the species has low requirement in terms of soil fertility and resistance to low water availability (JACOVETTI et al., 2018), characteristics typical of the northeastern region of Brazil, considered moderately sensitive to salinity (MAAS, 1986).

In view of the above, the objective of this study was to evaluate the agronomic performance of millet crop under different saline water irrigation strategies and nitrogen fertilization.

MATERIAL AND METHODS

The experiment was carried out in full sun, in an area belonging to the Auroras Seedling Production Unit (*Unidade de Produção de Mudas dos Auroras* - UPMA), belonging to the University of International Integration of Afro-Brazilian Lusophony (UNILAB), Redenção, Ceará (4°13'5.97" S, 38° 42'46.65" W and altitude of 88.8 m). The predominant climate in the region is Aw, with average annual temperature and rainfall of 27 °C and 1062.0 mm, respectively.

The experimental design adopted was completely randomized (CRD) in a 4 x 2 factorial scheme, with 4 replicates, with the first factor referring to four irrigation strategies: S1 = low-salinity water (W1)= 0.3 dS m^{-1} throughout the cycle; S2 = saline water (W2) = 4.0 dS m^{-1} from 30 days after sowing - DAS; S3 = W2 from 45 DAS; and S4 = W2 from 65 DAS; and the second factor referring to two doses of nitrogen (60 and 120 kg ha^{-1} of N, equivalent to 50 and 100% of the recommendation, respectively).

The experimental units were composed of pots with volumetric capacity of 25 liters (L), and the substrate used was obtained from the mixture of *arisco* (light-textured sandy material normally used in constructions in Northeast Brazil), sand and bovine manure at a ratio of 4:3:1, respectively. A sample of the substrate used was collected and taken to the Soil and Water Laboratory of the Soil Sciences Department of UFC to perform the chemical analysis (Table 1).

Table 1. Chemical characterization of the substrate.

OM	N	P	K^+	Ca^{2+}	Mg^{2+}	Na^+	H^++Al^{3+}	Al^{3+}	C/N	pH	V
(g dm^{-3})		(mg dm^{-3})	------------------------(cmol$_c$ dm^{-3}) --------------------------							(in H_2O)	(%)
11.90	0.41	16.00	0.14	4.50	1.90	0.26	1.98	0.20	9.00	6.60	77.00

OM = Organic Matter; V% = Base saturation.

The crop used was millet, cultivar BRS-1501, sown in rows (five per pot), using an average of 45 seeds to guarantee the minimum plant stand in each experimental unit, at 1 cm depth. Thinning was performed at 15 days after emergence, leaving three plants per pot.

The waters used for irrigation consisted of local-supply water (0.5 dS m^{-1}) and saline solution (4.0 dS m^{-1}), applied according to the strategies adopted. The saline solution was prepared using NaCl, $CaCl_2.2H_2O$ and $MgCl_2.6H_2O$ salts, at a ratio of 7:2:1, respectively, from the local-supply water, following the relationship between ECw and its concentration (mmol$_c$ L^{-1} = EC x 10) (RHOADES; KANDIAH; MASHALI, 2000). Irrigation was manually applied, with a leaching fraction of 15% according to Ayers and Westcot (1999), using a daily frequency, calculated based on the drainage lysimeter principle (BERNARDO et al., 2019). The volume of water to be applied to plants was determined by Equation 1:

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

where: VI = Volume of water to be applied in irrigation (mL); Vp = volume of water applied in the previous irrigation (mL); Vd = Volume of water drained (mL) and LF = leaching fraction of 0.15.

The N, P and K doses were defined considering the recommendations of Pereira Filho et al. (2003), based on the use of millet for grazing or silage purposes, being applied via fertigation and adopting an initial stand of 10000 plants ha^{-1}. The nitrogen doses (60 and 120 kg ha^{-1}, 50 and 100% of the recommendation, respectively) were split into 6 applications throughout the experiment using urea (45% N) as source. P and K fertilizations were also performed, adopting doses of 30 kg ha^{-1} and 40 kg ha^{-1}, respectively, using single superphosphate (18% P) and potassium chloride (60% K).

At the end of the experiment, at 85 DAS, readings of the following physiological variables were performed: net photosynthesis rate (A), transpiration (E), stomatal conductance (gs), instantaneous water use efficiency (WUE), internal CO_2 concentration (Ci) and leaf temperature (LT), using an infrared gas analyzer - IRGA (LI 6400 XT from LIQUOR), in an open system, with airflow of 300 mL min^{-1}, with measurements made between 9h00min and 11h00min, in fully expanded leaves.

After the physiological readings, evaluations were carried out regarding crop growth in plant height (PH, in cm), measured with a measuring tape, from the base of the stem to the end of the last leaf; stem diameter (SD, in mm), measured with a digital caliper, at 2 cm from the ground to standardize the measurements; and root length (RL, in cm) and panicle length (PL, in cm), measured with a ruler graduated in centimeters. Then, the plants were collected and separated into leaves, stem and root, placed in paper bags and taken to a forced air circulation oven at 65 °C, where they were kept for 72 hours for drying and subsequent determination of the dry masses of leaves (LDM), stem (SDM) and root (RDM), which were weighed on a digital scale with precision of 0.0001 g.

The data referring to the strategies and nitrogen doses were subjected to analysis of variance (ANOVA) by the F test and, when significant, they were subjected to Tukey test at 1% and 5% significance level through the computer program ASSISTAT 7.7beta (SILVA; AZEVEDO, 2016).

RESULTS AND DISCUSSION

According to the analysis of variance (Table 2), the strategies factor had significant effects on SD and RDM ($p < 0.01$), whereas the N doses factor caused significant effect only on the PH ($p < 0.05$) and RL ($p < 0.01$) of millet crop. There was also an effect of the interaction between the factors for RDM at 1% significance level. For SDM and LDM, there was no statistically significant effect ($p > 0.05$).

Table 2. Analysis of variance for plant height (PH), stem diameter (SD), root length (RL), stem dry mass (SDM), leaf dry mass (LDM), root dry mass (RDM) and panicle length (PL) of millet plants under different saline water irrigation strategies and nitrogen fertilization.

SV	DF	Mean square						
		PH	SD	RL	SDM	LDM	RDM	PL
Strategies (S)	3	85.23^{ns}	8.40**	13.89ns	6.35ns	0.42ns	68.44**	126.42**
N doses (D)	1	232.66*	0.08ns	129.12**	0.18ns	2.71ns	52.89**	26.85*
S x D	3	80.07^{ns}	4.05ns	8.78ns	4.14ns	1.36ns	27.51**	19.04**
Treatments	7	104.08^{ns}	5.34**	28.16*	4.52ns	1.15ns	48.68**	66.18**
Residual	24	43.26	1.39	9.26	2.67	1.43	2.86	4.01
CV (%)	-	10.87	12.00	14.59	42.88	32.65	39.29	12.44

SV = source of variation; DF = degrees of freedom; ** = significant at 1% probability level; * = significant at 5% probability level; ns = not significant.

Figure 1 shows the results for plant height (A) and root length (B) of millet plants as a function of nitrogen doses.

The dose of 120 kg ha^{-1} was statistically superior (Figure 1A), leading to a height of 63.21 cm, 8.54% higher than that obtained with the dose of 60 kg ha^{-1} (57.81 cm). Nitrogen stimulates plant growth in height, contributing to the expansion of plant tissues. That is, the splitting of fertilizer applications may have affected its better use by the plant due to the reduction in the urea hydrolysis rate, allowing a better absorption rate. A similar trend was reported by Rocha et al. (2017) when fertilizing millet crop with increasing N doses.

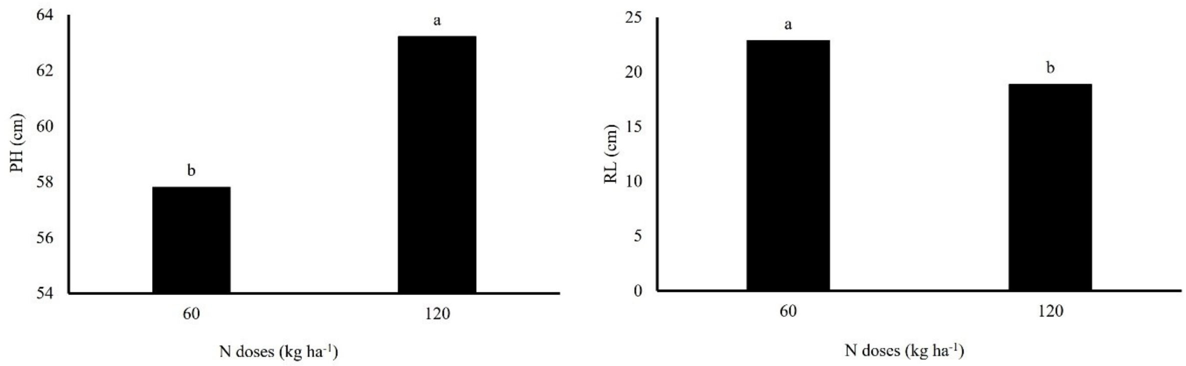

Figure 1. Plant height (A) and root length (B) of millet plants under different doses of nitrogen fertilization. Columns followed by the same lowercase letters do not differ significantly from each other by Tukey test ($P \leq 0.05$). Means followed by the same letter do not differ statistically from each other by Tukey test at 5% probability level.

Figure 1B shows that the lowest dose of urea promoted longer root length, 22.87 cm, which is 17.58% higher than the value obtained with the dose of 120 kg ha^{-1} of N (8.54 cm). Fertilizers usually have a saline character and, when remaining for a long period in contact with the roots of crops, they can cause effects similar to that of salt stress caused by water or soil (LIMA et al., 2020b). These results are in agreement with Albuquerque et al. (2020), who studied the cycle of N sources in millet cultivation.

The stem diameter of millet plants was directly influenced by the saline water irrigation strategies (Figure 2). When plants received saline water for a longer period of time, as in S2 (from 30 DAS), this influence was negative, reducing stem diameter to 8.38 mm, whereas saline water irrigations started at 45 and 65 DAS (S3 and S4) did not differ statistically from the control treatment (S1).

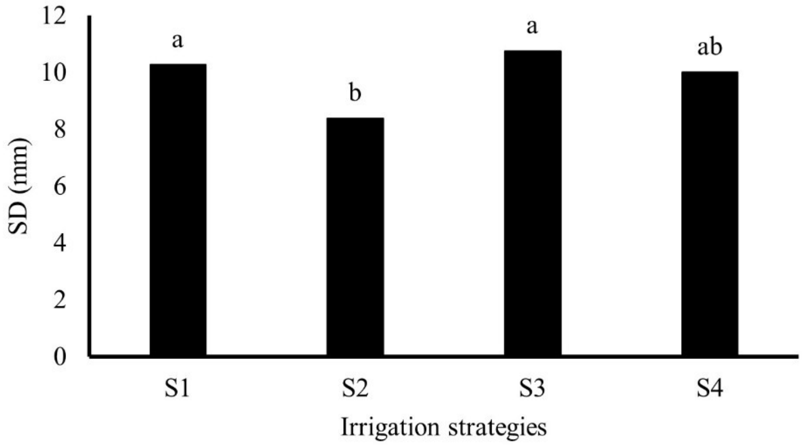

Figure 2. Stem diameter of millet plants under different saline water irrigation strategies. Columns followed by the same lowercase letters do not differ significantly from each other by Tukey test ($P \leq 0.05$).

When inducing osmotic stress, salts can cause reduction in water absorption by plants, limiting the processes of cell division and expansion and, consequently, shoot development (TAIZ et al., 2017). Deleterious effects of salinity on stem diameter in millet plants were also verified by Lima et al. (2020a).

Figure 3 shows the results for panicle length (A) and root dry mass (B) of millet plants as a function of different saline water irrigation strategies and nitrogen doses.

Figure 3A shows that the strategies that promoted longer panicle length were S1 and S4, regardless of the N dose applied (19.79 and 20.90 cm for S1 and 19.98 and 18.67 cm for S4, at N doses of 60 and 120 kg ha^{-1}, respectively), not differing statistically from each other, whereas S2 and S3 caused reduction in PL (8.35 and 14.65 cm; 14.66 and 13.89 cm at N doses of 60 and 120 kg ha^{-1}, respectively), and this reduction was more significant in S2 and under a dose of 60 kg ha^{-1} of the N recommendation (8.35 cm).

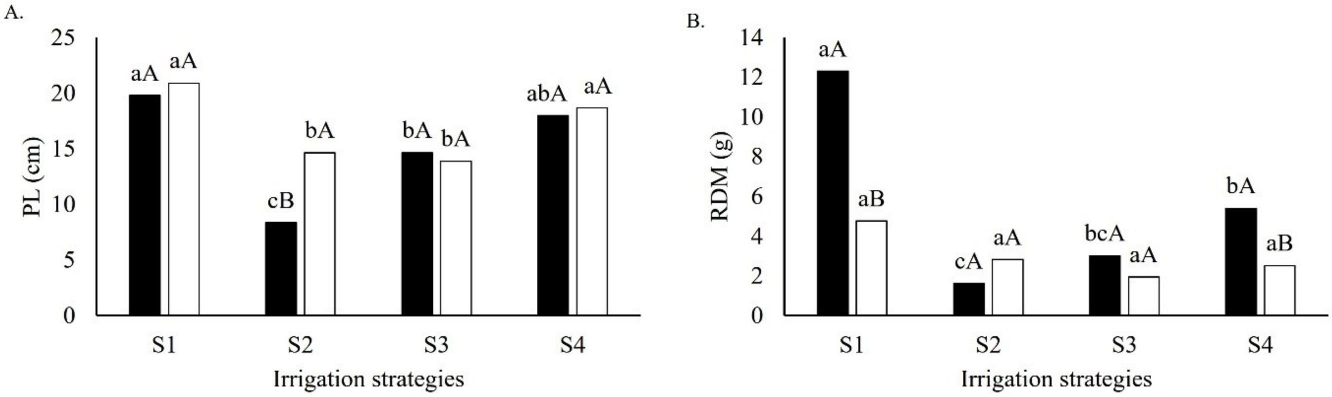

Figure 3. Panicle length (A) and root dry mass (B) of millet plants under different saline water irrigation strategies and nitrogen fertilization of 50% (■) and 100% (□) of the recommendation. Lowercase letters compare strategies and uppercase letters compare within strategies. Means followed by the same letter do not differ statistically from each other by Tukey test at 5% probability level.

The cultivar BRS 1501 has a definite cycle, in which panicle formation begins at 36 DAS, a period that coincides with the strategies in which the lowest means for panicle length were obtained (S2 and S3), revealing the deleterious effect of salts on the reproductive stage of the millet, occasionally caused by the water restriction generated from the reduction in the osmotic potential of the soil solution (ANDRADE et al., 2018).

The values obtained for root dry mass of millet plants (Figure 3B) were reduced with the use of saline water in strategies S2, S3 and S4 (2.83, 1.95 and 2.52 g), not differing statistically from each other at the dose of 100% of the recommendation, while at the dose of 50% of the recommendation, strategies S1 and S4 led to better results, with 12.31 and 5.41 g, respectively, compared to the 100% dose, and S1 stood out for promoting the highest root dry mass.

A shorter root length may have induced lower root dry mass, given the negative influence and the combined effects of irrigation water salinity and exposure of roots to a higher N dose and hydrolysis of the fertilizer. Sousa et al. (2018) also found reductions in the root dry mass of maize under salt stress. However, contrary to the present study, Bianchet et al. (2015) obtained an increase in the root dry mass of rice plants with the increase in N fertilizer doses, demonstrating the beneficial effect of N fertilization on the gains of root mass in rice crop.

As presented in the analysis of variance for the gas exchange of millet (Table 3), the strategies and N doses factors had significant simple effects on the variables WUE and LT ($p < 0.01$), with interaction between the factors for A, E, gs and Ci ($p < 0.01$).

Table 3. Analysis of variance for net photosynthesis rate (A), transpiration (E), stomatal conductance (gs), instantaneous water use efficiency (WUE), internal CO_2 concentration (Ci) and leaf temperature (LT) of millet plants under different saline water irrigation strategies and nitrogen fertilization.

SV	DF	Mean square					
		A	E	gs	WUE	Ci	LT
Strategies (S)	3	44.32**	0.12ns	0.012**	4.69**	3588.81**	4.61**
N doses (D)	1	88.11**	0.03ns	0.016**	9.40**	3336.62**	17.50**
S x D	3	56.02**	3.15**	0.028**	1.14ns	2962.87**	0.99ns
Treatments	7	55.59**	1.40**	0.019**	3.84**	3284.52**	4.90**
Residual	24	4.51	0.29	0.001	0.64	180.73	0.50
CV (%)	-	9.35	13.41	13.58	13.94	9.14	1.97

SV = source of variation; DF = degrees of freedom; ** = significant at 1% probability level; * = significant at 5% probability level; ns = not significant.

Figure 4 shows the results for photosynthesis (A), transpiration (B), stomatal conductance (C) and internal CO_2 concentration (D) of millet plants as a function of different saline water irrigation strategies and nitrogen doses.

The use of the N dose of 60 kg ha^{-1} associated with strategy 2 caused reductions in the photosynthesis of millet plants, differing statistically from the other treatments, leading to a value of 15.36 μmol m^{-2} s^{-1}, a reduction of 34.7% compared to the same dose in S1, while for S3 a similar behavior was observed at the N dose of 100 kg ha^{-1}, reaching 20.11 μmol m^{-2} s^{-1}, representing a reduction of 27.4% compared to the same dose in S1 (Figure 4A).

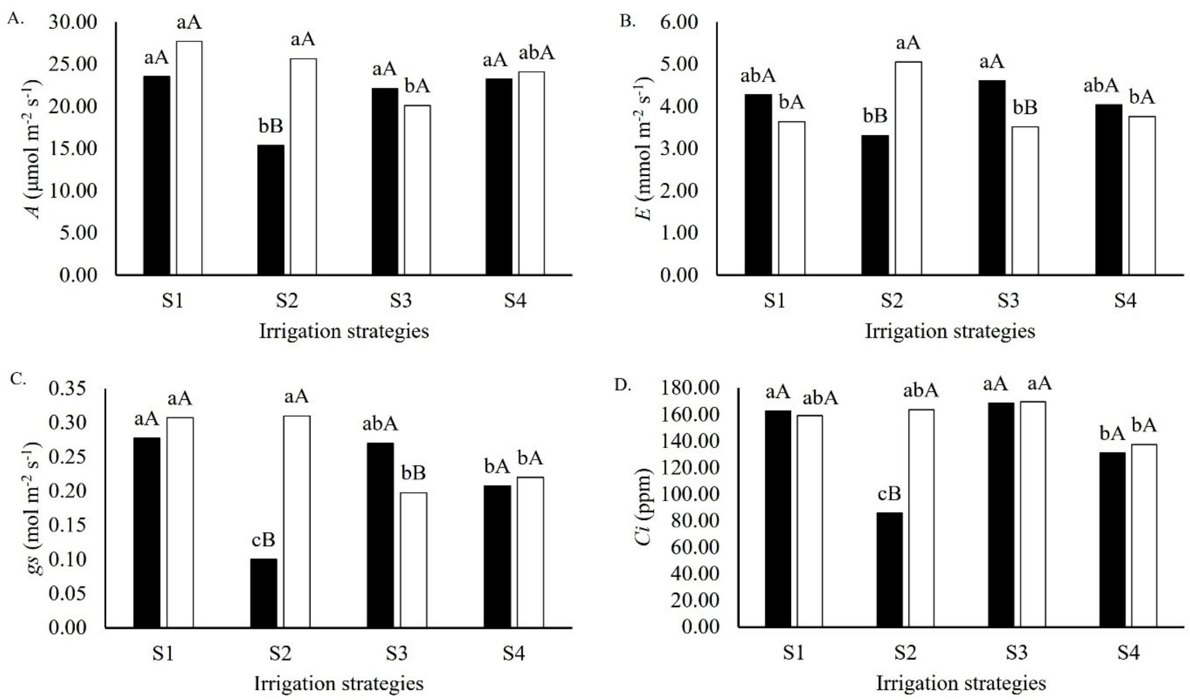

Figure 4. Photosynthesis (A), transpiration (B), stomatal conductance (C) and internal CO_2 concentration (D) of millet plants under different saline water irrigation strategies and nitrogen fertilization of 50% (■) and 100% (□) of the recommendation. Lowercase letters compare strategies and uppercase letters compare within strategies. Means followed by the same letter do not differ statistically from each other by Tukey test at 5% probability level.

A smaller amount of N results in a smaller amount of NO_3^- and NH_4^+ ions in solution, promoting a lower concentration close to the roots, causing an ionic competition with Na^+ and Cl^- ions of the salts, which are possibly at higher concentrations due to a greater input from the irrigation water, reducing the entry of N into plants, the main component of the photosynthesizing pigment, chlorophyll, which results in deleterious effects on photosynthesis, as observed in S2 (TAIZ et al., 2017; SOUSA et al., 2021). In similar studies combining irrigation water salinity and N fertilization, Braz et al. (2019) and Dias et al. (2018) found no significant relationships between these two factors for photosynthesis in maize and sesame plants, respectively.

Transpiration in millet plants (Figure 4B) was affected by the strategies applied and the N doses. Plants under strategies S1 and S4 did not differ statistically from each other or as a function of the N doses applied, with lower means, while in S2, plants that received 100% of the recommended dose transpired more, about 5.05 mmol m^{-2} s^{-1}, as well as plants that received 50% of the dose in S3, 4.61 mmol m^{-2} s^{-1}. Urea, when hydrolyzed, generates ammonium, which is absorbed by crops. When in excess, it can change the pH inside the cells and increase the content of reactive oxygen species, an effect that is accentuated by salinity, causing physiological imbalance (BITTSÁNSZKY et al., 2015). Refuting this study, Dias et al. (2020) and Braz et al. (2019) evaluated the influence of salinity and N fertilization on cotton and maize crops, respectively, and found no joint actions of salts and N on transpiration.

The stomatal conductance of millet plants was influenced by both strategies and N doses (Figure 4C). Lower values of stomatal conductance were observed under the strategies S3 and S4 with 100% N (0.20 and 0.22 mol m^{-2} s^{-1}, respectively), which did not differ statistically from each other, and under S2 with 50% N (0.10 mol m^{-2} s^{-1}), this latter being the lowest conductance obtained among the treatments and statistically different from the others, following a similar trend to that of transpiration.

Stomatal conductance is the mechanism that regulates water exchanges between the plant and the atmosphere; thus, under some type of stress, whether salt or oxidative stress, the stomata tend to reduce their opening. Under the correct supply of N, for example, the plant may end up synthesizing compounds that help the plant to adjust osmotically and overcome this stress, such as the production of proline and glycine-betaine, causing reduction in the stomatal resistance generated by stress (TAIZ et al., 2017), which probably occurred in S2 with 100% of the N dose; however, there is also the possibility that stressed plants with high ammonium contents reduce the hydraulic conductivity of their roots, also causing stomatal closure, as probably occurred in S3.

Sousa et al. (2021), when investigating gas exchange in maize crop under irrigation with saline water and N fertilization, also verified interaction between the factors studied for stomatal conductance. Contrary to this study, Dias et al. (2020) also found no relationship between N doses and irrigation water salinity for the stomatal conductance of cotton.

Among all the strategies adopted, the lowest internal CO_2 concentrations were obtained under the strategies S2 associated with 50% of the N recommendation (85.66 g kg^{-1}) and S4 associated with 100% of the N recommendation (137.33 g kg^{-1}) (Figure 4D).

The stomatal opening also regulates the capture of CO_2, so a similar behavior is noted between these two variables (Figure 4C and 4D), which explains the low concentrations of this gas in similar treatments in terms of stomatal conductance. However, when analyzing the rate of CO_2 assimilation by photosynthesis (Figure 4A), it can be verified that this captured CO_2 is not being fully converted into sugars in the photosynthetic process for some non-stomatal reason, causing the accumulation of this gas (NAJAR et al., 2019).

Braz et al. (2019) found no interaction between salinity and N doses applied for the internal CO_2 concentration in maize crop. Similarly, Sousa et al. (2016) evaluated salinity and N fertilization in citrus and also found no interaction between the factors for this variable, which contradicts the results obtained in the present study.

Figure 5 shows the results for water use efficiency and leaf temperature as a function of saline water irrigation strategies (A and B, respectively) and as a function of N doses (C and D, respectively).

There was lower water use efficiency in millet plants that received the application of S2, followed by S3 (Figure 5A). Millet plants reached WUE of 4.89 mmol m^{-2} s^{-1} under S2 and 5.36 mmol m^{-2} s^{-1} under S3, which are 26.0 and 18.9% lower when compared to the value found in the control treatment (S1 = 6.61 mmol m^{-2} s^{-1}), respectively.

Plants exposed to salt stress for longer tend to have a low water absorption caused by the reduction in the osmotic potential of the soil solution due to salts and, in addition, reduce their uptake and assimilation of CO_2 due to an increase in stomatal resistance as mechanisms of escape from salt stress and excessive water loss by transpiration, which can reduce the efficiency in water use by crops, especially in periods of increasing requirements, such as the end of vegetative stage and beginning of reproductive stage (TAIZ et al., 2017).

Similar effects were found by Soares et al. (2018), who evaluated gas exchange in cotton crop irrigated with saline water at different phenological stages and also observed greater reductions in water use efficiency.

Figure 5B shows the comparison of means for leaf temperature of millet plants under irrigation strategies, and it can be observed that plants subjected to S2 reached the highest temperatures, followed by S3, differing statistically from those under the strategies S1 and S4, which did not differ statistically from each other. When subjected to S2, the plants reached a leaf temperature of 36.85 °C, about 5% higher than the value found in plants of S1, which reached a temperature of 35.05 °C.

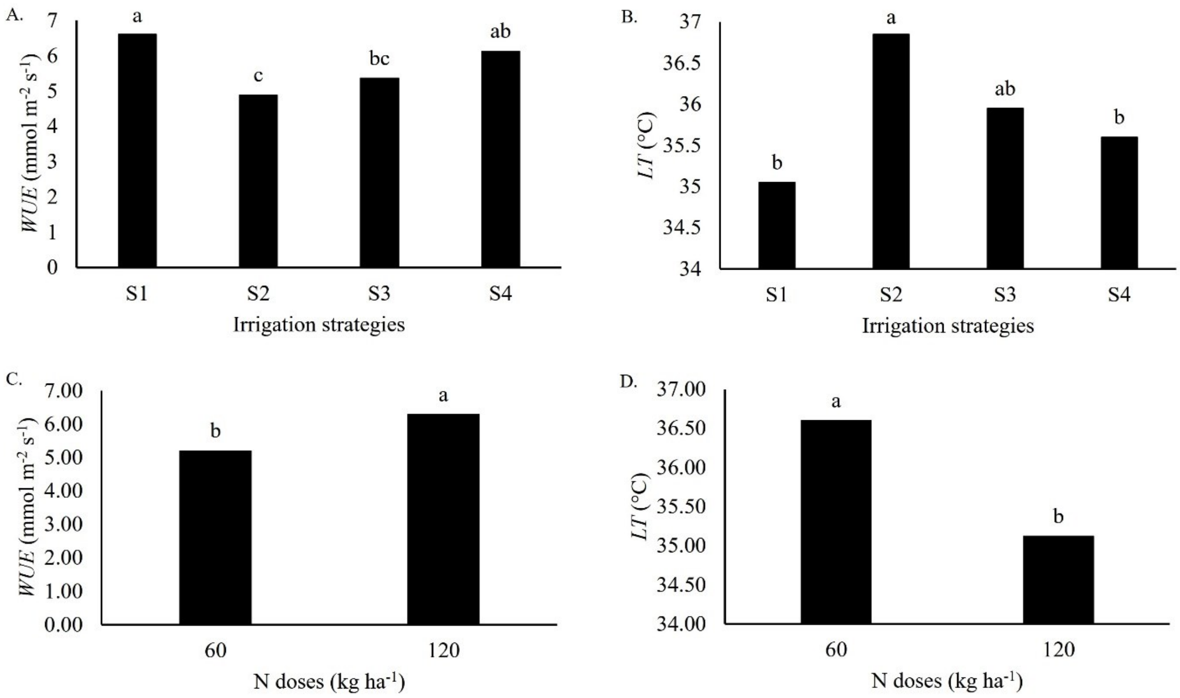

Figure 5. Water use efficiency and leaf temperature of millet plants under different saline water irrigation strategies (A and B) and doses of nitrogen fertilization (C and D). Means followed by the same letter do not differ statistically from each other by Tukey test at 5% probability level.

Transpiration acts as a major leaf temperature-regulating mechanism, so plants that transpire less tend to accumulate heat and raise their temperature (SOARES et al., 2018). Hessini et al. (2019), in studies with maize plants, also found that salinity caused an increase in leaf temperature, which reached 36.7 °C.

Higher water use efficiency was obtained in millet plants (6.29 mmol m^{-2} s^{-1}) under the N dose of 120 kg ha^{-1}, when compared with the dose of 60 kg ha^{-1} (Figure 5C) (5.20 mmol m^{-2} s^{-1}), whose value was 17.3% lower.

An adequate supply of N favors higher photosynthetic rates in plants due to the increase in the photosynthesizing pigment, ensuring that water is more efficiently used for physiological processes (TAIZ et al., 2017). Similarly, Souza et al. (2016) obtained maximization of WUE with a N dose of 168.4 kg ha^{-1}.

In relation to the leaf temperature of millet plants as a function of N doses (Figure 5D), it was observed that plants fertilized with 60 kg ha^{-1} of N had an increase of 4% in their temperature (36.6 °C) when compared to the temperature obtained at the N dose of 120 kg ha^{-1} (35.1 °C).

Higher water flows in the soil-plant-atmosphere system favor N absorption as it is absorbed by mass flow, generating a high transpiration and consequently a lower leaf temperature (TAIZ et al., 2017), which was not observed in this study. Similarly, Elli et al. (2013) also obtained an increase in leaf temperature with the increase of N fertilizer doses in the Surinam cherry crop.

CONCLUSIONS

Nitrogen fertilization favors growth in height, root length, efficient water use and leaf temperature in millet plants.

Water of higher salinity from 30 DAS and 65 DAS associated with the N dose of 120 kg ha^{-1} promotes greater panicle length and root dry mass in millet plants.

Fertilization with 60 and 120 kg ha^{-1} promotes greater photosynthesis, transpiration, stomatal conductance and internal CO_2 concentration in millet plants with the use of water of lower salinity throughout the cycle and with the water of higher salinity from 30 and 45 DAS.

The strategy of using water of lower salinity throughout the cycle and water of higher salinity from 65 DAS increases water use efficiency and reduces leaf temperature.

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