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Growth and nutrition of peanut crop subjected to saline stress and organomineral fertilization[1]

Crescimento e nutrição da cultura do amendoim submetida ao estresse salino e adubação organomineral

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HIGHLIGHTS:

Irrigation of peanut with 5.0 dS m^{-1} water limited plant growth and the number of leaves.
Fertilization with 100% mineral and 100% bovine biofertilizer attenuated saline stress for foliar N and Ca concentrations.
Using 1.0 dS m^{-1} water and 100% mineral fertilization increased the foliar concentrations of K, P and Mg.

ABSTRACT: The peanut crop, owing to its microbiological and nutritional aspects, is of great economic importance for agriculture and the food industry. However, salt stress can negatively affect nutrient uptake and plant growth. The objective of this study was to evaluate the growth and foliar nutrient concentrations of peanut plants subjected to irrigation with saline water and different forms of organomineral fertilization. The experiment was conducted in a greenhouse in a completely randomized design (5 × 2 factorial scheme) with five forms of fertilization (F1 = 100% mineral; F2 = 100% bovine biofertilizer; F3 = 100% vegetal ash; F4 = 50% mineral + 50% bovine biofertilizer; and F5 = 50% mineral + 50% vegetal ash), two levels of electrical conductivity of the irrigation water (EC_w) (1.0 and 5.0 dS m^{-1}), and five replicates. Salt stress inhibited plant growth and the number of leaves, but increased the average stem diameter with the use of 100% bovine biofertilizer and higher salinity water. When EC_w of 5.0 dS m^{-1} was used along with the bovine biofertilizer (100%), the P concentration in plants increased. The K concentration was reduced in plants fertilized with bovine biofertilizer (100%) and vegetal ash (100%), while Mg concertation was reduced in plants fertilized with bovine biofertilizer (100%) or mineral fertilizer (50%) + bovine biofertilizer (50%) with irrigation water of 5.0 dS m^{-1}.

Key words: *Arachis hypogaea* L., salinity, plant nutrition

RESUMO: A cultura do amendoim em razão dos aspectos microbiológicos e nutricionais torna-se uma cultura de grande importância econômica para agricultura e indústria alimentícia. No entanto, o estresse salino pode causar efeitos negativos na absorção de nutrientes e no crescimento de plantas. Objetivou-se avaliar o crescimento e os teores foliares de nutrientes de plantas de amendoim submetidas a irrigação com água salina e formas de adubação organomineral. O experimento foi conduzido em casa de vegetação, em delineamento inteiramente casualizado, no esquema fatorial 5 × 2, referente a cinco formas de adubação (F1 = 100% mineral, F2 = 100% biofertilizante bovino, F3 = 100% cinza vegetal, F4 = 50% mineral + 50% biofertilizante bovino e F5 = 50% mineral + 50% cinza vegetal) e dois valores de condutividade elétrica da água de irrigação (1,0 e 5,0 dS m^{-1}), com cinco repetições. O estresse salino inibiu a altura da planta e o número de folhas, mas aumentou o diâmetro médio do caule com utilização de 100% de biofertilizante. As adubações com fertilizante 100% mineral, 100% biofertilizante bovino e 100% cinza vegetal mitigaram o estresse salino e aumentaram o teor de N e Ca foliar. O teor de K foi reduzido em plantas fertilizadas com 100% biofertilizante bovino e 100% cinza vegetal e de Mg em 100% biofertilizante bovino e 50% de fertilizante mineral + 50% biofertilizante bovino, quando exposto a maior salinidade da água de irrigação.

Palavras-chave: *Arachis hypogaea* L., salinidade; nutrição de plantas

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Introduction

Peanut (*Arachis hypogeae* L.), originating in South America, can be cultivated in almost all types of soil, and is a promising species for various purposes, from human food and animal fodder to the production of biofuels. However, regions with irregular rainfall and lower quality water, such as the northeast of Brazil, have low yields (Cruz et al., 2021).

Irrigation is the only way to guarantee agricultural production, especially in tropical regions with a hot dry climate, such as semi-arid regions of Northeast Brazil. These regions face several problems owing to water scarcity for plants at different phenological stages (Maniçoba et al., 2021). This problem is associated with the high water consumption of irrigation and has encouraged the use of lower quality resources, such as saline water, which is responsible for the decline in crop productivity worldwide (Costa & Medeiros, 2017; Silva et al., 2019; Bouras et al., 2021).

The use of saline water in agriculture reduces the osmotic and water potential of plants, which consequently decreases the availability of water, absorption, and transport of essential nutrients for plant growth. This, in turn, leads to nutritional imbalance, affecting the physiological functions and productive potential of cultivated plants (Lima et al., 2021; Sousa et al., 2021; Costa et al., 2021).

Practices to mitigate excess salts in irrigation water have been applied in various cropping systems, including mineral fertilization, which aims to nourish agricultural crops and maximize their cultivation (Sousa et al., 2022). The resources used to mitigate salt stress are biofertilizers, as organic sources; nitrogen (N), phosphorus (P), and potassium (K), as mineral sources; or a combination of both, which form organomineral fertilizers (Souza et al., 2018; Souza et al., 2019a).

The objective of this study was to evaluate the growth and foliar nutrient concentrations of peanut plants subjected to irrigation with saline water and different forms of organomineral fertilization.

Material and Methods

The experiment was carried out from June to September 2019 in the experimental area of the Auroras Seedling Production Unit (UPMA), which belongs to the Universidade da Integração Internacional da Lusofonia Afro-Brasileira (UNILAB), Redenção, Ceará, Brazil (4º13'33" S, 38º43'39" W; altitude of 88 m). The climate of the region is 'Aw', that is, rainy tropical, very warm, with a predominance of rain in the summer and autumn.

The meteorological data obtained during the experimental period are shown in Figure 1.

The experimental design used was completely randomized, in a 5 × 2 factorial arrangement, with five replicates and two plants per plot. The first factor corresponded to the different forms of fertilization: F1 = 100% mineral; F2 = 100% bovine biofertilizer; F3 = 100% vegetal ash; F4 = 50% mineral + 50% bovine biofertilizer; and F5 = 50% mineral + 50% vegetal ash) and two values of electrical conductivity of the irrigation water (EC_w) (1.0 and 5.0 dS m^{-1})

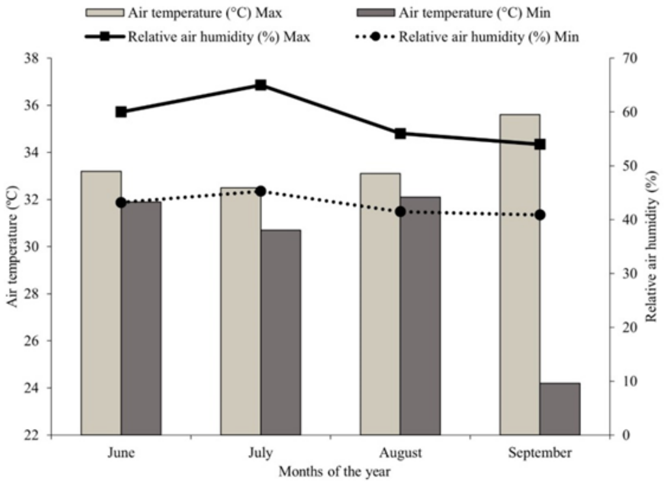


Figure 1. Mean values of temperature and relative air humidity during the experimental period

Six BR-1 peanut seeds were sown in 8 L plastic pots containing a material substrate obtained from a mixture of aloof, sand, and bovine manure at a ratio of 4:3:1.

To evaluate the chemical attributes of the soil, a sample was collected before treatment and sent to the Soil and Water Laboratory of the Soil Sciences Department at the Universidade Federal do Ceará (UFC). The results are presented in Table 1. Thinning was carried out 10 days after sowing (DAS), leaving only the most vigorous plants.

The biofertilizer used was composed of fresh bovine manure and water in a 1:1 ratio, stored in 100 L plastic pots, and maintained in aerobic fermentation for 20 d. The vegetal ash came from sugarcane burning in Fazenda Douradinha, Redenção, Ceará.

Plant fertilization was performed based on chemical analyses of the substrate, bovine biofertilizer, and vegetal ash (Tables 1 and 2), and mineral fertilization following the recommendations for chemical fertilization of Fernandes (1993), i.e., 15 kg ha^{-1} of N, 62.5 kg ha^{-1} of P_2O_5, and 50 kg ha^{-1} of K_2O. For the 10.000 plant stand, the maximum dose per plant in the cycle was 1.8 g N, 7.5 g P_2O_5, and 6.0 g K_2O.

To determine the fraction of nutrients present in the substrate, the density of the substrate (1.3 g dm^{-3}) was multiplied by the volume of the substrate in each pot (8 L). The value obtained (10.4 kg) was multiplied by the amounts of N, P, and K obtained in the substrate analysis (Table 3).

Table 1. Chemical attributes of the substrate used for growing peanuts before applying treatments

Chemical attributes									
OM	N	P	K	Ca	Mg	Na	pH	ESP	EC
(g kg^{-1})								(%)	(dS m^{-1})
4.34	0.26	0.065	0.25	0.24	0.15	0.08	6.2	7	1.19

OM - Organic matter; ESP - Exchangeable sodium percentage; EC - Electrical conductivity

Table 2. Chemical attributes of bovine biofertilizer and vegetal ash

Organic fertilizers	Chemical attributes								
	N	P	K	Ca	Mg	Fe	Cu	Zn	Cu
	(g L^{-1})					(mg L^{-1})			
Biofertilizer	0.82	1.4	1	2.5	0.75	141.6	1.92	68.2	14.72
	(g kg^{-1})								
Vegetal ash	0.4	1.13	54.4	28.7	13.9	7819.1	10.5	37.8	240.8

Table 3. Estimation of nutrient supply by the substrate and needs for mineral nutritional supplementation with cattle manure and vegetal ash

Fertilization strategies	Nutrients		
	N	P	K
Recommendation (g plant^{-1})	1.8	7.5	6.0
Substrate (g kg^{-1})	0.26	0.065	0.25
Total nutrient contribution per pot ##	2.70	0.67	2.6
Mineral complementation requirement (per plant)	0	6.83	3.4
Requirement for organic supplementation			
Biofertilizer (L plant^{-1})	0	5.0	0
Vegetal ash (g plant^{-1})	0	1.50	0

Substrate density (1.3 g dm^{-3}) multiplied by the volume of substrate per pot

Through nutrient supply strategies, split application of fertilizer 8 DAS was initiated. For 100% mineral fertilization (F1), 1.8 g per plant of N, 7.5 g per plant of P_2O_5, and 6.0 g per plant of K_2O were applied. In the organomineral treatments (F4 and F5), 50% in mineral form was used, in the amounts of 0.9 g per plant of N, 3.7 g P_2O_5, and 3.0 g per plant of K_2O, while the other half (50%) comprised biofertilizer and ash.

According to the demand for nutritional supplementation (Table 3) and the amount of NPK (Table 2), 5.0 L of bovine biofertilizer for the 100% dose (F1), and 2.5 L for the 50% dose (F4) were applied. For vegetal ash, 1.5 kg was used for the 100% dose (F3), and 0.75 kg for the 50% dose (F5).

The irrigation water was prepared by diluting soluble salts (NaCl, $CaCl_2.2H_2O$ and $MgCl_2.6H_2O$), following the methodology of Medeiros (1992), to obtain an equivalent ratio of 7:2:1 for Na:Ca:Mg. Irrigation was manually applied daily from 8 DAS, using 15% leaching. Calculations were performed according to the lysimeter principle of drainage (Bernardo et al., 2019), represented by two vessels of each treatment, maintaining the soil at field capacity. The water volume applied to the plants was determined using 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.

At 35 DAS, the following variables were analyzed: plant height (PH), the distance between the neck and the apex of the plant measured with a measuring tape (cm); number of leaves (NL), measured by directly counting green leaves; and stem diameter (SD), measured with the aid of a digital caliper, averaged over the basal stem diameter of plants at a height of approximately 2 cm from the soil surface.

At 85 DAS, plant material was collected from the aerial parts of peanut plants to determine the concentrations of mineral elements (N, P, K, Ca, Mg and Na). Samples were dried in an oven with forced air circulation at 65 °C until a constant weight was reached, then crushed in a mill. Furthermore, to determine total N, the milled material was subjected to nitric-perchloric digestion, followed by steam distillation and titration for NH_4 and quantified using the semimicro-Kjeldahl procedure (Miyazawa et al., 2009).

To determine the leaf concentrations of other macronutrients (P, K, Mg and Ca) and Na, the milled tissue samples were subjected to a dry digestion process, by incinerating in an electric muffle furnace at temperatures between 500 °C and 550 °C. The resulting ash was dissolved in dilute nitric acid solution (HNO_3). The concentrations were determined using a photoelectric flame photometer for K and Na, molybdenum blue spectrophotometry for P, and atomic absorption spectroscopy for Mg and Ca.

The variables analyzed in the study were subjected to the Kolmogorov-Smirnov test ($p \leq 0.05$) to assess normality. Data were then subjected to analysis of variance, and Tukey's test for comparison of means ($p \leq 0.05$) was performed using the program ASSISTAT 7.7 BETA (Silva & Azevedo, 2016).

Results and Discussion

The interaction between EC_w and organomineral fertilization significantly affected the stem diameter (SD) of peanut plants. Plant height (PH) was influenced by the two factors studied but was isolated. The number of leaves (NL) was affected only by the electrical conductivity of the irrigation water (Table 4).

The higher electrical conductivity of irrigation water (5.0 dS m^{-1}) negatively affected the height of peanut plants, which were 29% shorter on average than plants irrigated with water of 1.0 dS m^{-1} (Figure 2A). The greater amount of salt in the growth environment reduces the soil matric potential, creating resistance to water absorption by plants, limiting cell division and expansion, and consequently hindering growth (Souza et al., 2019a).

Freitas et al. (2021) obtained similar results when assessing the responses of peanut cultures grown in a greenhouse under different levels of salinity. Similarly, Pereira-Filho et al. (2017) also found a reduction in the height of cowpea plants under salt stress.

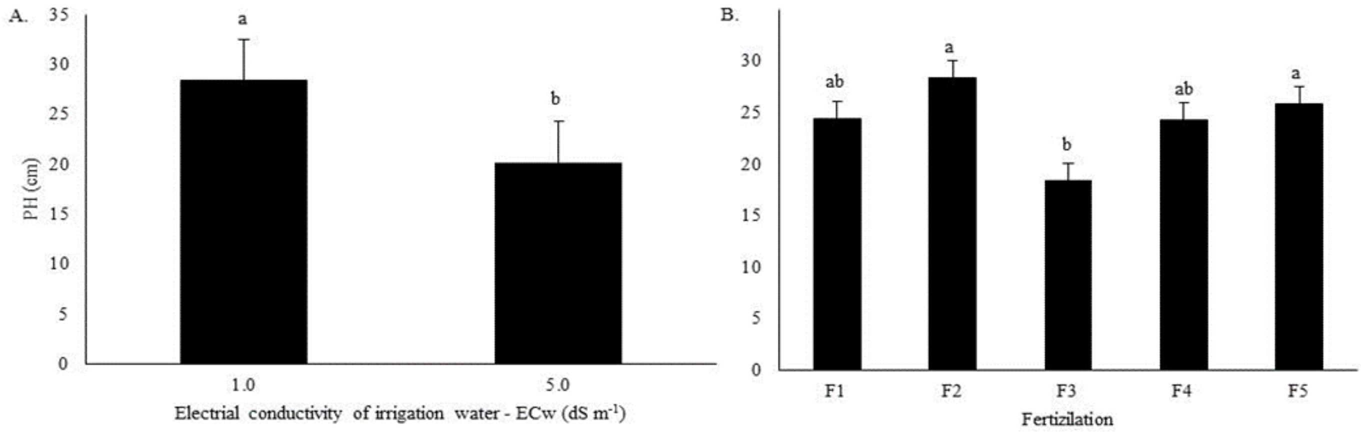
Except for plants fertilized with vegetal ash (F3), the other fertilizers resulted in statistically greater plant height (Figure 2B). Sales et al. (2020), evaluating the growth of okra cultures fertilized with bovine biofertilizer, observed similar results.

The highest EC_w negatively affected the number of leaves (NL) of peanut plants (Figure 3). Decreasing the number of

Table 4. Summary of the analysis of variance for the effects of electrical conductivity of irrigation water and different types of fertilization on plant height (PH), number of leaves (NL), and stem diameter (SD) of peanut plants subjected to irrigation

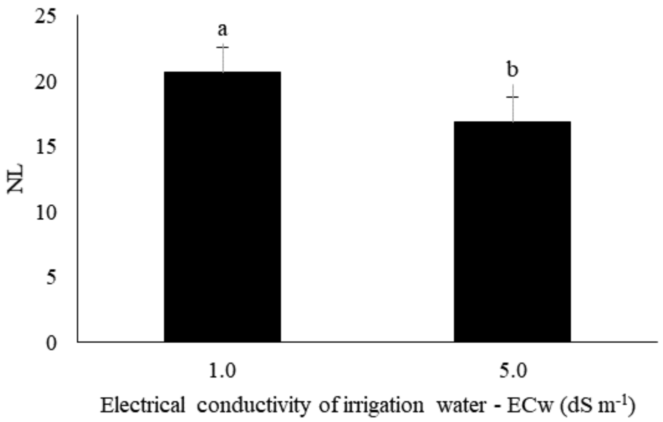
Sources of variation	DF	Mean square		
		PH	NL	SD
Type of fertilization (TF)	4	107.240**	8.067^{ns}	2.818**
Electrical conductivity of irrigation water (ECw)	1	676.753**	144.362**	19.782**
TF × ECw	4	35.167^{ns}	22.730^{ns}	4.846**
Residue	30	20.149	11.756	0.408
Total	39			
CV (%)		18.49	18.27	20.76

DF, degrees of freedom; CV, coefficient of variation; *, significant by the F test at $p \leq 0.05$; ** Significant by the F test at $p \leq 0.01$; ns, not significant



Lowercase letters compare the means by Tukey's test (p ≤ 0.05); vertical bars represent standard error (n = 4)

Figure 2. Plant height (PH) of peanut plants as a function of the electrical conductivity of irrigation water (EC_w) (A) and different types of fertilization (F1 - NPK 100%; F2 - biofertilizer 100%; F3 - vegetal ash 100%; F4 - NPK 50% +bio 50%; F5 - NPK 50% + ash 50%) (B)



Lowercase letters compare the means by Tukey's test (p ≤ 0.05); vertical bars represent standard error (n = 4)

Figure 3. Number of leaves (NL) of peanut plants as a function of the electrical conductivity of irrigation water (EC_w)

leaves in a saline medium is one of the adaptations that plants use to regulate water absorption, which is associated with other morphological and anatomical changes and decreased transpiration (Freitas et al., 2021).

These results are consistent with those of Goes et al. (2021), who found that an increase in the concentration of salts in irrigation water compromised the emission of lima bean leaves.

Table 5 presents the mean values for the stem diameter (SD) related to the interaction between the forms of fertilization and EC_w.

A decrease in SD was observed in plants irrigated with higher EC_w (5.0 dS m^{-1}), with the vegetal ash fertilization (F3) and organomineral treatments (F4 and F5) (Table 5). Melo Filho et al. (2016) evaluated the growth of peanuts irrigated with saline water and bovine biofertilizer and observed negative effects with increased EC_w, with a decrease in the relative SD in plants that did not receive bovine biofertilizer.

Freitas et al. (2021) analyzed the effects of irrigation water salinity on cultivar BR-1 peanuts, and found a greater peanut SD in plants grown in soil with mineral fertilizer and a K source than in plants grown without fertilizer.

Here, the interaction between the EC_w and type of fertilization showed a significant effect on the leaf concentrations of N, P, K, Ca and Na (Table 6).

With treatments F1, F2, and F3, plants irrigated with water with higher EC_w had a higher leaf N concentration than those irrigated with low salinity water (Table 7); however, it was below the range considered adequate (30 at 45 g kg^{-1}) for peanut culture (Ambrosano et al., 1996). Possibly, this increase in N under conditions of high salinity may be linked to metabolites, such as amino acids, amines, and betaines. These metabolites can be used for osmotic adjustment and protection from cytosolic oxidative stress (Annunziata et al., 2017).

Table 5. Average stem diameter (SD) values for peanut plants subjected to different fertilization and EC_w treatments

Fertilization	SD (cm)	
	1.0 dS m^{-1}	5.0 dS m^{-1}
F1 - NPK 100%	3.71 aA	3.65 aAB
F2 - Biofertilizer 100%	3.58 aA	3.83 aA
F3 - Vegetal ash 100%	3.60 aA	2.35 bB
F4 - NPK 50% + Bio 50%	4.04 aA	0.80 bB
F5 - NPK 50% + Ash 50%	3.99 aA	1.25 bB

Means followed by the same letter, uppercase in the column and lowercase in the row, did not differ significantly, based on Tukey's test (p ≥ 0.05)

Table 6. Summary of the analysis of variance results for the the effects of EC_w and fertilization type on nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sodium (Na) concentrations of the aerial part of peanut plants

Sources of variation	DF	Mean square					
		N	P	K	Ca	Mg	Na
Type of fertilization (TF)	4	19.20*	5.78**	42.22**	1.94^{ns}	3.93**	2.47*
Electrical conductivity of irrigation water (ECw)	1	107.91**	6.32*	162.49**	15.45**	0.03^{ns}	140.31**
TF × ECw	4	30.14**	5.51**	129.91**	9.00**	3.60**	6.81**
Residue	30	6.91	0.96	6.75	1.18	0.44	0.85
Total	39						
CV (%)		11.65	14.27	8.85	16.32	9.90	23.19

DF, degrees of freedom; CV, coefficient of variation; *, significant by F test at p ≤ 0.05; **, significant by F test at p ≤ 0.01; ns, not significant

Table 7. Average values of nitrogen (N), phosphorus (P), and potassium (K) concentrations of the dry leaf mass of peanut plants subjected to different fertilization and EC_w treatments

Fertilization	N (g kg^{-1})		P (g kg^{-1})		K (g kg^{-1})	
	1.0 dS m^{-1}	5.0 dS m^{-1}	1.0 dS m^{-1}	5.0 dS m^{-1}	1.0 dS m^{-1}	5.0 dS m^{-1}
F1 - NPK 100%	18.01 bB	24.59 aAB	7.44 aAB	4.64 bC	28.47 aB	31.26 aA
F2 - Biofertilizer 100%	23.08 bAB	27.16 aA	5.58 bB	7.30 aA	39.17 aA	25.64 bAB
F3 - Vegetal ash 100%	20.16 bAB	25.55 aAB	7.39 aAB	7.18 aAB	39.08 aA	23.59 bB
F4 - NPK 50% + Bio 50%	23.80 aA	20.44 aB	7.58 aAB	4.79 bBC	24.57 bB	29.18 aAB
F5 - NPK 50% + Ash 50%	19.60 aAB	23.33 aAB	8.65 aA	8.14 aA	27.26 aB	25.61 aAB

*Means followed by the same letter, uppercase in the column and lowercase in the row, are not significantly different by Tukey's test ($p \geq 0.05$)

Table 8. Average values of calcium (Ca), magnesium (Mg), and sodium (Na) concentrations of the dry leaf mass of peanut plants subjected to different fertilization and EC_w treatments

Fertilization	Ca (g kg^{-1})		Mg (g kg^{-1})		Na (g kg^{-1})	
	1.0 dS m^{-1}	5.0 dS m^{-1}	1.0 dS m^{-1}	5.0 dS m^{-1}	1.0 dS m^{-1}	5.0 dS m^{-1}
F1 - NPK 100%	6.07 bAB	8.11 aAB	5.21 bC	7.11 aAB	1.61 bA	7.41 aA
F2 - Biofertilizer 100%	4.34 bC	7.09 aAB	8.15 aA	6.21 bB	1.48 bA	6.79 aA
F3 - Vegetal ash 100%	4.54 bBC	9.04 aA	7.60 aA	8.14 aA	2.65 aA	3.50 aB
F4 - NPK 50% + Bio 50%	7.14 aAB	6.30 aB	7.10 aAB	5.78 bB	1.73 bA	5.45 aAB
F5 - NPK 50% + Ash 50%	7.74 aA	6.47 aAB	5.64 aBC	6.14 aB	1.63 bA	7.56 aA

* Means followed by the same letter, uppercase in the column and lowercase in the row, are not significantly different based on Tukey's test ($p \geq 0.05$)

Similar effects have been observed by Reges et al. (2017) in pepper plants, where the authors found an increase in shoot N with EC_w of 4.5 dS m^{-1}. Coelho et al. (2017) evaluated the effects of fertilization and mineral irrigation with saline water on sorghum and found reduced leaf N content with an EC_w of 7.5 dS m^{-1}.

The high EC_w reduced the foliar P concentration in peanut plants in treatments F1 and F4 and increased it in treatment F2 in relation to the low-salinity water (Table 7). The levels of P obtained in the two irrigation treatments did not reach the ideal range of 2 to 5 g kg^{-1} (Ambrosano et al., 1996).

Elevated phosphate adsorption and a decrease in the solubility of this mineral with an increase in the NaCl concentration of the soil reduces the P concentration in leaves (Souza et al., 2018). These results agree with those of Reges et al. (2017) in pepper cultures fertilized with bovine biofertilizer, and those of Coelho et al. (2017) in forage sorghum genotypes grown under saline and mineral fertilization conditions.

The potassium (K) concentration was reduced in plants fertilized with F2 and F3 when irrigated with high-salinity water (Table 7). This decrease in leaf K concentration reflects the antagonistic effects of K and Na, which compete for the same absorption sites in the plasma membrane of root cells (Rodrigues et al., 2021). Therefore, despite the large amount of K in the vegetal ash (Table 1), salt stress was not mitigated. In addition, the K content was much lower than the range considered adequate for the dry leaf mass of the crop, which ranges from 17 to 30 g kg^{-1} (Ambrosano et al., 1996). Similar results were obtained by Souza et al. (2019b) in noni plants irrigated with water with an EC of 4 dS m^{-1} and fertilized with organic compost.

There was an increase in the foliar Ca content with increasing EC_w in F1, F2, and F3 (Table 8). The use of organic biofertilizers can improve the chemical properties of the soil, such as increasing the Ca available to plants (Sales et al., 2020), and attenuating the harmful effects of salinity. For ash, Na^+ may have competed with K^+ (Table 8), providing a higher accumulation of Ca^{2+} in the aerial parts of peanut plants. Despite this, the values did not reach the Ca range considered ideal by Ambrosano et al. (1996), which is 12-20 g kg^{-1}.

Reges et al. (2017) also observed an increase in Ca concentration in the dry matter of pepper plants subjected to irrigation with saline water and fertilization with bovine biofertilizer.

The Mg concentration was lower in the aerial parts of plants irrigated with higher salinity water and F2 and F4 fertilization treatments (Table 8). However, the Mg concentrations were within the range considered adequate for this macronutrient, from 3 to 8 g kg^{-1} (Ambrosano et al., 1996).

The Na concentration was higher in plants irrigated with high EC_w for all forms of fertilization (Table 8). Increases in the Na concentration in the soil can induce a nutritional imbalance as a results of the high ionic concentration and inhibition of the absorption of other cations (Rodrigues et al., 2021). Ahmadi & Souri (2018) reported that high concentrations of NaCl can impair the biological function of the roots and interrupt the rate of absorption of nutrient elements, such as K, Ca, and Mg.

Similarly, Lima et al. (2015) found an increase in leaf Na concentration in castor bean under saline stress and N fertilization. However, Reges et al. (2017) found no effect of bovine biofertilizer and NPK fertilization on pepper leaves irrigated with saline water.

Conclusions

1. Salt stress inhibited plant growth and the number of leaves, but increased the average stem diameter with the use of 100% bovine biofertilizer and higher salinity water.

2. Fertilization with mineral fertilizer (100%), bovine biofertilizer (100%), and vegetal ash (100%) mitigated salt stress and increased the concentrations of N and Ca.

3. Irrigation with water of 5.0 dS m^{-1} and bovine biofertilizer application (100%) increased the P concentration in plants.

4. The K concentration was reduced in plants fertilized with bovine biofertilizer (100%) and vegetal ash (100%); the Mg concentration was reduced in plants fertilized with bovine biofertilizer (100%) and mineral fertilizer (50%) + bovine biofertilizer (50%), when irrigated with water of EC_w of 5.0 dS m^{-1}.

5. Irrigation with water of EC_w 5.0 dS m^{-1} increased the Na concentration under mineral fertilization with NPK (100%), bovine biofertilizer (100%), mineral fertilizer (50%) + bovine biofertilizer (50%), and mineral fertilizer (50%) + vegetal ash (50%).

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