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Physiology and development of grafted dwarf cashew seedlings under different fertilization doses and irrigated with saline water

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Abstract

Salinity is one of the primary challenges faced by irrigated agriculture in semi-arid regions. This study aimed to investigate the effects of fertilization on the development of cashew seedlings irrigated with water of varying salinity levels. The research was conducted in a protected environment at Embrapa Agroindústria Tropical, Fortaleza, using grafted seedlings of the BRS 189 clone on CCP 06 rootstock. The treatments resulted from the combination of three levels of NPK fertilization (control - without fertilization, 50% less than conventional nutrition, and 100% of conventional nutrition used by the crop), which was incorporated into the substrate before sowing CCP 06, with four salinity levels (ECa of 0.8, 4.0, 7.0, and 10.0 dS m^{-1}) of the irrigation water for the seedlings. Gas exchange, assimilate accumulation, growth, and nutrient content in the leaves, stems, and roots of the seedlings were evaluated 90 days after grafting. The data were subjected to analysis of variance, and when a significant effect was observed, the Tukey test was performed, while quantitative data were subjected to regression analysis. Overall, fertilization levels did not influence seedling growth. Fertilization did not interfere with photosynthate production, which performed better when the seedlings were subjected to a salinity of 7.0 dS m^{-1}. The application of NPK to the substrate resulted in higher levels of nitrogen in the leaves, while phosphorus content decreased, and foliar potassium was not influenced by fertilization.

Keywords: *Anacardium occidentale*, salinity stress, photosynthesis, mineral nutrition

Introduction

Salinity is one of the main challenges faced by irrigated agriculture in the semi-arid regions, leading to consequences in plant growth and production. Generally, salinity inhibits plant growth due to the osmotic and toxic effects of ions (Munns, 2002). In the case of germination and seedling establishment, this effect is more pronounced, as seedlings are more susceptible to the salt's impact on biochemical and physiological processes during this phase (Ferreira-Silva et al., 2009).

The effects of salt on plants are manifested through toxicity symptoms such as leaf chlorosis or necrosis, resulting from the excessive accumulation of Na^+ or Cl^- ions in the tissues (Wahome et al., 2001; García Sánchez et al., 2002). The increased concentration of Na^+ in leaf tissues can affect physiological and biochemical processes dependent on K^+, such as stomatal opening, photosynthesis, respiration, and protein synthesis, due to the physicochemical similarity between these ions (Maathuis & Amtmann, 1999; Apse & Blumwald, 2007). The elevated concentration of Cl^- in the growth medium, on the other hand, can interfere with NO^{3-} absorption and osmoregulation (White & Broadley, 2001).

Nitrogen is the nutrient most heavily demanded by crops, followed by potassium. It is considered the essential nutrient for plant development (Epstein & Bloom, 2006), and its availability promotes greater growth and root system activity, with positive responses in the absorption of other nutrients and the amount of dry matter produced (Santi, 2003).

Nutrients such as K^+ and calcium (Ca^{2+}) positively interact during the development of plants from various species, and a beneficial effect of these ions occurs under saline stress conditions (Diniz Neto et al., 2014; Silva et al., 2017). Proper potassium nutrition results in several benefits for plants, such as: increased root growth,

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enhanced drought and cold resistance, resistance to pests and diseases, and improved nodulation in legumes (Meurer, 2006).

On the other hand, the use of phosphorus (P) in substrate formulation in combination with organic material is an excellent strategy for obtaining more vigorous seedlings, as they help in the formation of the root system (Crusciol et al., 2005; Sant'ana et al., 2003; Silva & Delatorre, 2009).

Research has been conducted to investigate the effects of using these nutrients to promote the production of more vigorous seedlings, impacting the overall performance of plants in the field, particularly under stressful conditions. In light of the above, the present study aimed to examine the effects of fertilization on the development of cashew tree seedlings irrigated with water of varying salinity levels.

Materials and Methods

The experiment was initially conducted in a shaded environment with shade netting on the sides and top, providing good ventilation and 50% radiation transmittance. This setup was located at the Experimental Field of Pacajus, Embrapa Agroindústria Tropical, Pacajus, Ceará, Brazil (4°11'12"S, 38°30'01"W, and 79 m altitude), during the months of January to May 2017.

The substrate used consisted of an equal parts mixture of carbonized rice husk, carnauba palm leaf fiber, and hydromorphic soil. This commercial mixture is commonly employed by Embrapa Agroindústria Tropical for cashew tree seedling production.

The substrate was fertilized with urea as a nitrogen (N) source, single superphosphate as a phosphorus (P) source, and potassium chloride as a potassium (K) source, following the prescribed treatments: control (no fertilization) (A1), and two levels of fertilization: 50% (A2) and 100% (A3) of the recommended mineral fertilizer application for the first year of the dwarf cashew tree (Crisóstomo et al., 2001) (**Table 1**).

Table 1- Recommended Mineral Fertilization for Dwarf Cashew Tree under Irrigation

Fertilizing		P soil (mg dm^{-3})			K soil ($mmol_c$ dm^{-3})		
		0 a 12	13 a 30	> 30	0 a 1.5	1.6 a 3.0	>3.0
	N (g $plant^{-1}$)	P_2O_5 (g $plant^{-1}$)			K_2O (g $plant^{-1}$)		
Planting	0	200	150	100	-	-	-
Training							
0 - 1 year	60	-	-	-	60	40	20
1 - 2 years	80	200	150	100	100	60	40
2 - 3 years	150	250	200	120	140	100	60
3 - 4 years	200	300	250	150	180	140	80

Source: Crisóstomo et al. (2001)

Seeding was carried out in tubes (288 cm^3) using seeds obtained from the clonal garden of the genotype at the Experimental Field of Pacajus, during the 2015 harvest. Throughout the production phase, the seedlings were manually irrigated daily.

At 30 days after grafting, the seedlings were transported to Fortaleza for the application of the experiment treatments. During this stage, the seedlings were placed in a shaded environment with shade cloth on the sides and transparent plastic on the top, providing good ventilation and radiation transmittance above 80%.

The saline treatments consisted of daily irrigations with saline solutions at electrical conductivities (ECa) of 0.8, 4.0, 7.0 and 10.0 dS m^{-1}. The treatments were arranged in a randomized complete block design in a 3 (fertilization levels) x 4 (salinity levels) factorial arrangement, with four replications. The saline solutions were prepared by mixing sodium chloride with water. These solutions were prepared and stored in 1000 L water tanks, and every day before irrigation, the conductivity was measured and adjusted according to the established treatments using a portable conductivity meter.

At 90 days, net photosynthesis (μmol CO_2 m^{-2} s^{-1}), transpiration (mmol m^{-2} s^{-1}), and stomatal conductance (mol m^{-2} s^{-1}) were measured at the end of the experiment in fully developed leaves, using an infrared gas analyzer (IRGA) (LCpro, ADC, Hoddesdon, UK). The measurements were taken from 9:00 AM to 12:00 PM, utilizing artificial radiation of 1200 μmol photons m^{-2} s^{-1}, ambient temperature, and CO_2 levels.

For the analysis of total soluble carbohydrates, only the leaves and roots extracted from the final collection were selected. The extraction and determination followed the same methodology described by Dubois (1956), in which the material, after being dried in an oven, was ground using an analytical mill to prepare the extract. The extract was prepared by mixing 0.5 grams of dried material with 25 ml of deionized water, under agitation for two hours using a shaker. Subsequently, the solution was filtered through filter paper to obtain the extract.

Afterwards, the quantification of total soluble carbohydrates was performed. For this purpose, a 50 μl aliquot of the extract was added to deionized water (final volume of 0.2 mL), along with 0.2 mL of 5% phenol and 1.0 mL of concentrated sulfuric acid. The mixture was vigorously shaken and allowed to cool. Then, the samples were subjected to quantification of soluble carbohydrates following the methodology of Dubois (1956). The standard curve was obtained using increasing concentrations of anhydrous D (+) glucose. Carbohydrate results were expressed in µg of glucose per gram of dry weight g^{-1} MS.

For the determination of nitrogen, phosphorus, and potassium contents, leaves, stems, and roots from the final assessment were used following the methodology of Embrapa (2009). With the extract, phosphorus and potassium contents were determined using inductively coupled plasma optical emission spectrometry (ICP-OES), Agilent 5100 model.

The nitrogen content in the leaves was determined following the methodology described by Baethgen & Alley (1989), where, after cooling the extract, the nitrogen present in the resulting acidic solution was determined through steam distillation, followed by titration with diluted acid. The macronutrient contents were expressed in g kg^{-1}MS.

An analysis of variance (ANOVA) was conducted on the obtained data. When a significant effect was observed in the ANOVA, qualitative data were subjected to the Tukey test, while quantitative data underwent regression analysis. The purpose of regression analysis was to determine the equation that best represents the relationship between the analyzed variables and the applied treatments. The statistical analyses were performed using the SISVAR statistical software (Ferreira, 2014).

Results and Discussion

Significant differences were observed in all analyzed variables of the photosynthetic metabolism among the saline levels ($p < 0.01$) by the F test. However, for fertilization, the seedlings did not show statistical differences, and there was also an interaction between the factors for stomatal conductance and photosynthesis (**Table 2**).

The transpiration rate (*E*) increased as the salinity levels increased, showing proportional increases up to a salinity of 7.0 dS m^{-1}. This indicates that the clone is quite tolerant to salinity during this developmental phase. However, when the seedlings were exposed to the highest applied salinity level (10.0 dS m^{-1}), their transpiration rate became similar to that of the control plants (**Figure 1**).

Authors such as Carneiro et al. (2002), who studied clones CCP76, observed that such seedlings already showed a reduction in transpiration rate when exposed to salinity levels of 0.7 dS m^{-1}. A modifying alteration occurs when leaves growing under water-

Table 2 - Summary of analysis of variance for gas exchange parameters: transpiration (*E*), stomatal conductance (*gs*), and photosynthesis (*A*) of dwarf cashew seedlings subjected to three levels of fertilization and four levels of salinity, analyzed 90 days after grafting (DAG)

Factor of Variation	DF	MS (Mean Square) E (mmol $m^{-2}s^{-1}$)	gs (mol m^{-2} s^{-1})	A (µmol m^{-2} s^{-1})
Fertilizing	2	0.4376 ^{ns}	0.0029 ^{ns}	5.2595 ^{ns}
Salinity	3	1.6205**	0.0137**	44.3118**
Interaction	6	0.0989 ^{ns}	0.0060**	25.5895**
Blocks	3	0.1778 ^{ns}	0.0028 ^{ns}	8.2735 ^{ns}
Residue	33	0.2462	0.0010	3.1319
CV (%)		28.69	31.77	18.80
Overall Mean		1.73	0.09	9.41

** Significant at 1% probability level by the F test. *Significant at 5% probability level by the F test. C.V. %: Coefficient of Variation. DF: Degrees of freedom

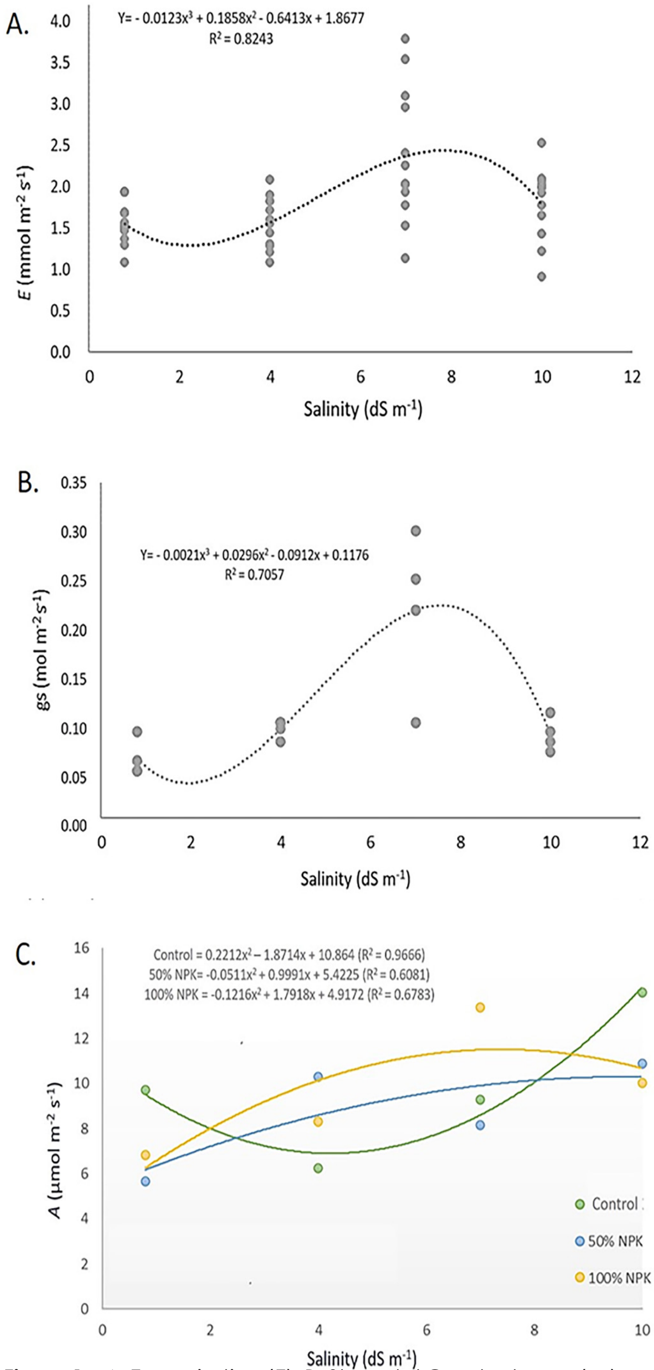

Figure 1 – A. Transpiration (*E*), B. Stomatal Conductance (*gs*) and C. Photosynthesis (*A*) of dwarf cashew seedlings, clone BRS 189 on CCP 06, subjected to different levels of salinity, analyzed 90 days after grafting (DAG). Source: AUTHOR.

deficient conditions exhibit smaller stomata but a higher stomatal density. This modification provides conditions for a faster reduction in transpiration through stomatal closure regulation (Larcher, 2006).

Stomatal conductance (*gs*) showed the same quadratic polynomial behavior for the three fertilization levels across the salinity levels (Figure 1B). However, the plants that received 100% of the recommended dose of fertilizer exhibited the highest stomatal conductance values. It can be observed that as salinity levels increased, stomatal conductance values also increased, with the seedlings showing the highest *gs* values when subjected to irrigation with a salinity of 7.0 dS m^{-1}, followed by a decrease at the highest level (Figure 1B).

A similar effect to that of transpiration was observed for stomatal conductance, where the seedlings had the highest values when subjected to a salinity of 7.0 dS m^{-1}(Figure 1A and B). Regardless of the salinity level, the seedlings exhibited high stomatal conductance values. This may have occurred because these seedlings consistently received water (through irrigation and misting), ensuring an adequate water supply throughout the experiment.

Regarding photosynthesis, a quadratic polynomial behavior was observed for all fertilizer levels as the salinity level increased. This indicates that when the plants were exposed to the highest salinity level (10 dS m^{-1}), they exhibited the highest photosynthetic rate on average across all treatments (Figure 1C).

The reductions in gas exchange activity observed in this study are possibly related to the osmotic effect. The osmotic effect influences plant water relations, reducing cellular content and causing contractions and relaxation of the cell membrane (Taiz & Zeiger, 2016). In this way, the osmotic effect acts on stomatal activity, promoting stomatal closure and consequently reducing transpiration rates, internal CO_2 concentration through reduced CO_2 influx into the cell, thereby compromising photosynthetic activity.

Salinity can reduce transpiration rates because it is associated with partial closure of stomata due to the reduced hydraulic conductivity of the root system caused by salinity, resulting in reduced flow of water through the plants. Lima et al., (2020), observed that these reductions can be mediated by specific toxic effect, nutritional imbalance, such as reduced absorption of K, as well as reduced absorption of water (osmotic effect) evidenced by the reduction of gas exchanges and efficiency in water use. However, in this study, it was observed that fertilization had a mitigating effect on salt stress.

The analysis of variance for total soluble sugars (TSS) based on fertilization showed a significant effect ($p < 0.05$) in leaves and roots, whereas for salinity, the effect was observed only in leaves, with no interaction between the factors for both organs (**Table 3**).

Table 3 - Summary of analysis of variance for total soluble sugars in leaves of dwarf cashew seedlings subjected to three levels of fertilization and four levels of salinity, analyzed 90 days after grafting (DAG).

Factor of Variation	DF	MS (Mean Square)	
		Leaf	Root
Fertilizing	2	1652.0428*	757.1415*
Salinity	3	1384.6962*	147.8958 ns
Interaction	6	783.3378 ns	276.4291 ns
Blocks	3	4609.6934 **	195.9773 ns
Residue	33	402.8547	195.136
CV (%)		15.82	32.95
Overall Mean		126.8300	42.38

**Significant at 1% probability level by the F test. *Significant at 5% probability level by the F test. C.V. %: Coefficient of Variation. DF: Degrees of freedom

The increase in salinity levels linearly reduced the content of soluble carbohydrates in the leaves, with seedlings irrigated with the lowest salinity (0.8 dS m^{-1}) showing the highest values (132.4 mg glucose g^{-1} MS) (**Figure 2**A). There was a 14.0% reduction in leaf carbohydrates for seedlings irrigated with the highest EC (10 dS m^{-1}) compared to the control plants.

Regarding fertilization, seedlings that received 50% of the recommended dose exhibited the highest amounts of total soluble carbohydrates in the leaves, with no difference between the other two treatments (Figure 2B).

Regarding the roots, the different levels of salinity did not affect the TSS concentration among the seedlings. However, similar to the leaves, seedlings that received 50% of the recommended fertilization dose exhibited the highest amounts of TSS (**Figure 3**). Proportionally, the seedlings showed reductions of 25% and 21% in carbohydrate concentrations in the roots of the control treatment (no fertilization) and 100% of the recommended fertilization, respectively.

The accumulation of inorganic and organic compounds, such as certain ions and soluble carbohydrates, is well evidenced under saline stress conditions, as these are some of the solutes that contribute the most to cellular osmotic potential (Azevedo Neto et al., 2004). Regarding soluble carbohydrate levels, Kerbauy (2004) states that the increase in total soluble carbohydrate levels in leaves is linked to the purpose of maintaining leaf water content and inducing osmotic adjustment in the plant, aiming for cellular osmotic balance. However, authors like Kerepesi & Galiba (2000) and Singh et al. (2000) observed that increased salt

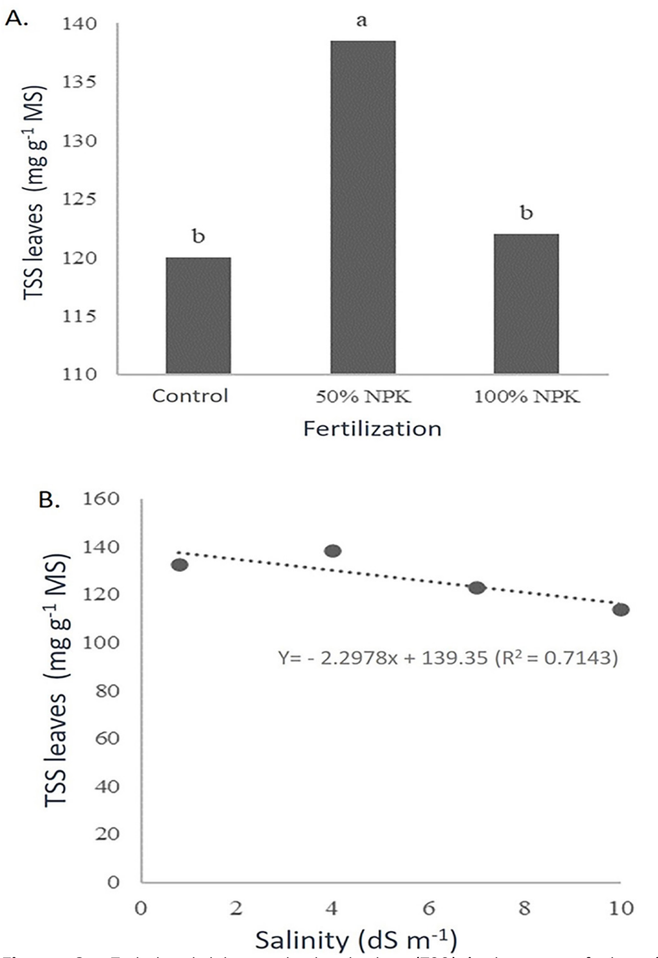

Figure 2 - Total soluble carbohydrates (TSS) in leaves of dwarf cashew seedlings, clone BRS 189 on CCP 06, subjected to different levels of fertilization and salinity, analyzed 90 days after grafting (DAG). Source: AUTHOR.

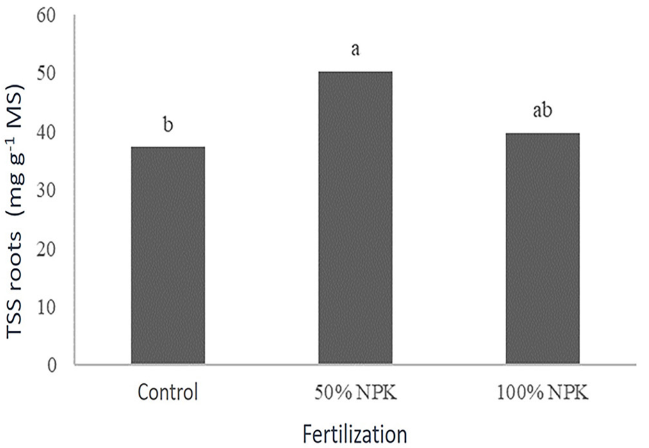

Figure 3 - Total soluble carbohydrates (TSS) in roots of dwarf cashew seedlings, clone BRS 189 on CCP 06, subjected to different levels of fertilization and salinity, analyzed 90 days after grafting (DAG). Source: AUTHOR.

stress reduces concentrations of sugars such as glucose, fructose, and sucrose in a wide range of plants.

When the salinity level was increased, there was a decrease in both shoot dry weight and root dry weight, by 22% and 2% respectively, compared to the control treatment, indicating that leaves were more affected by salinity regardless of fertilization. In general, it has been suggested that this trend of smaller decreases in root dry weight compared to shoot dry weight under saline conditions is largely explained by increased carbohydrate export from the shoot to the roots (Viégas et al., 2004), allowing for preferential root growth despite the restrictive cultivation conditions (Silveira et al., 2003). In the present study, there was a decrease in total soluble carbohydrates (TSS) in the leaves without a corresponding increase in the roots.

The analysis of variance showed a significant effect ($p<0.05$) for nitrogen content in the leaves only for the fertilization treatments, without a significant effect of salinity. Nitrogen content in the stem was not affected by either factor, while in the roots, there was an effect of fertilization and an interaction between the factors (**Table 4**).

Table 4 - Summary of analysis of variance for nitrogen (N) content in leaves, stems, and roots of dwarf cashew seedlings subjected to three levels of fertilization and four levels of salinity, analyzed 90 days after grafting (DAG).

Factor of Variation	DF	MS (Mean Square)		
		N in leaf	N in stems	N in roots
		g Kg^{-1} MS		
Fertilizing	2	9.5982*	0.1921 ^{ns}	4.2376*
Salinity	3	4.3855 ^{ns}	2.8603 ^{ns}	2.1374 ^{ns}
Interaction	6	3.3050 ^{ns}	3.1885 ^{ns}	7.2593**
Blocks	3	2.5968 ^{ns}	1.2136 ^{ns}	4.9028*
Residue	33	2.0988	1.0712	1.2100
CV(%)		8.24	17.35	13.42
Overall Mean		17.57	5.96	8.19

**Significant at 1% probability level by the F test. *Significant at 5% probability level by the F test. C.V. %: Coefficient of Variation. DF: Degrees of freedom.

Leaf nitrogen content increased gradually as the seedlings were subjected to higher NPK fertilization, with the highest values observed in seedlings fertilized with 100% of the recommended dose, showing a 10.0% increase compared to the control treatment (without fertilization) (**Figure 4**A).

Stem nitrogen content was not influenced by the applied salinity levels in irrigation or by the fertilization doses. In the roots, nitrogen content was not affected by salinity. Regarding the effect of fertilization, only at the salinity level of 4.0 dS m^{-1}, there was a difference among the applied treatments, with the highest nitrogen content found in plants that were not fertilized (control) (Figure 4B).

As expected in the behavior of seedlings, the highest nitrogen levels were found in the leaves, followed by the roots, and lastly in the stems, indicating that the

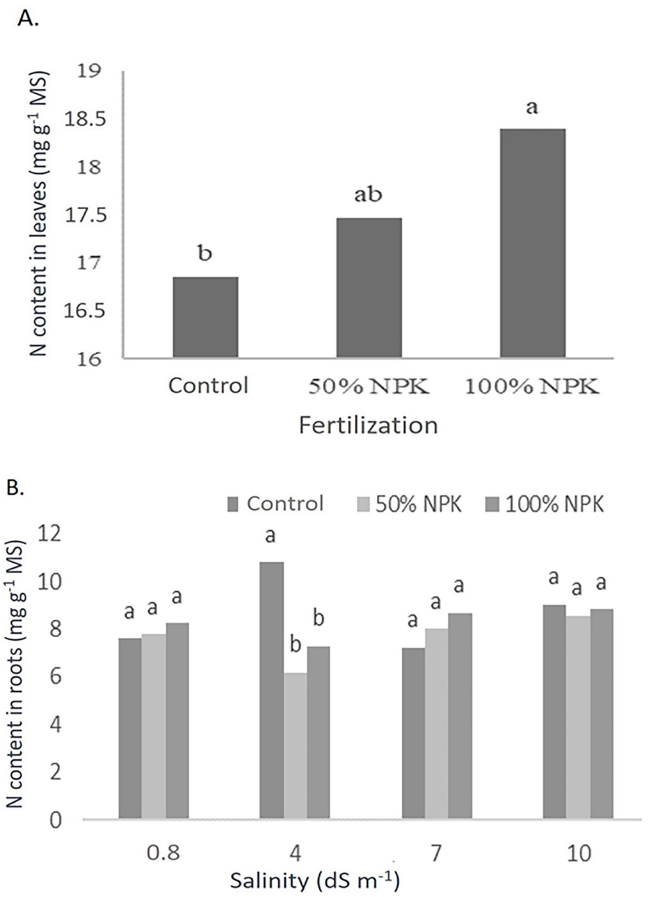

Figure 4 – Nitrogen (N) content in leaves (A) and roots (B) of dwarf cashew seedlings, clone BRS 189 on CCP 06, subjected to different levels of fertilization and salinity, analyzed 90 days after grafting (DAG). Source: AUTHOR.

leaves were in a phase of active growth and expansion, acting as a sink in the plant. In this organ, as well as in the others, nitrogen serves a structural role in the plant, being a part of various molecules. Additionally, it aids in the synthesis of carbohydrates, proteins, and other metabolites.

In contrast to the findings of the present study, Oliveira et al. (2009), while working with CCP 76 cashew seedlings irrigated with electrical conductivity (ECa) levels of 0.8, 1.6, 2.4, 3.2, and 4.0 dS m^{-1}, observed that all parts of the seedlings showed significant effects ($p<0.01$) in response to salinity. In their study, roots, leaves, and stems exhibited higher nitrogen values with increasing salinity levels.

The analysis of variance revealed that fertilization influenced phosphorus levels in both leaves and stems, as well as in the roots. In turn, salinity influenced phosphorus levels in leaves and roots, without interaction between the factors in the three organs (**Table 5**).

It was observed that as the ECa of irrigation water increased, the leaves of the seedlings accumulated more phosphorus, showing two distinct levels (lower levels at 0.8

Table 5 - Summary of analysis of variance for phosphorus (P) levels in leaves, stems, and roots of dwarf cashew seedlings subjected to three levels of fertilization and four levels of salinity, analyzed 90 days after grafting (DAG).

Factor of Variation	DF	MS (Mean Square)		
		P in leaf	P in stems	P in roots
		g Kg^{-1} MS		
Fertilizing	2	0.5705^{**}	5.6924^{**}	42.9755^{**}
Salinity	3	0.1544^{*}	0.0369^{ns}	1.7619^{**}
Interaction	6	0.0355^{ns}	0.1799^{ns}	0.6826^{ns}
Blocks	3	0.0305^{ns}	0.1491^{ns}	0.3146^{ns}
Residue	33	0.0400	0.1350	0.3113
CV (%)		15.63	22.25	18.83
Overall Mean		1.28	1.65	2.96

**Significant at 1% probability level by the F test. *Significant at 5% probability level by the F test. C.V. %: Coefficient of Variation. DF: Degrees of freedom.

and 4.0 dS m^{-1}, and higher levels at 7.0 and 10.0 dS m^{-1}) (**Figure 5**A). However, regarding fertilization, the seedlings showed lower phosphorus concentrations in the leaves of those that received NPK in the substrate (Figure 5B).

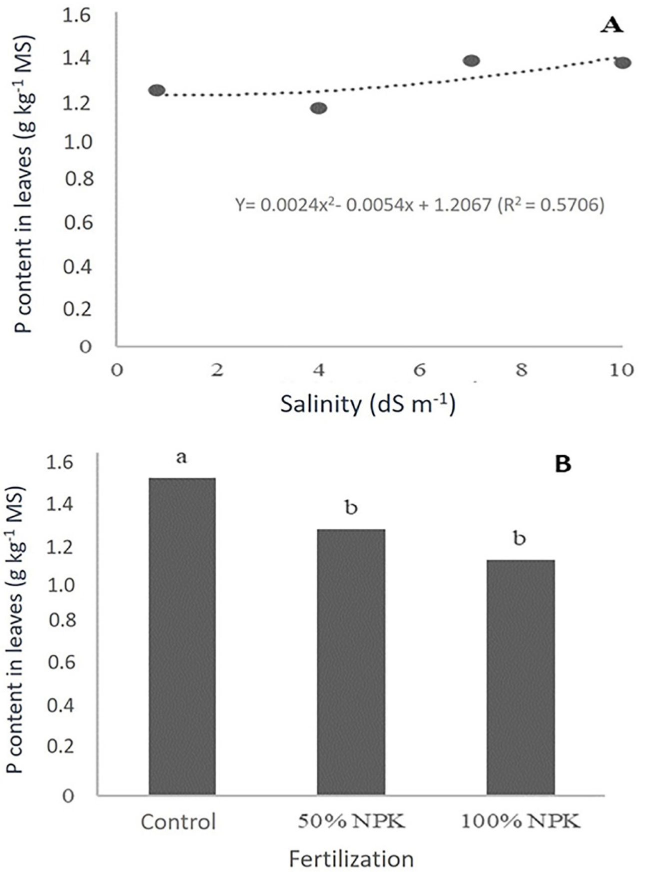

Figure 5 – Phosphorus (P) content in leaves of dwarf cashew seedlings, clone BRS 189 on CCP 06, subjected to different levels of salinity (A) and different levels of fertilization (B), analyzed 90 days after grafting (DAG).

The phosphorus content in the stem was influenced only by the NPK doses applied to the seedling substrate. Seedlings exhibited higher concentrations of phosphorus in the stem when not fertilized and when fertilized with 50% of the recommended dose, however, there was a 44% reduction when subjected to the maximum fertilizer dose (**Figure 6**).

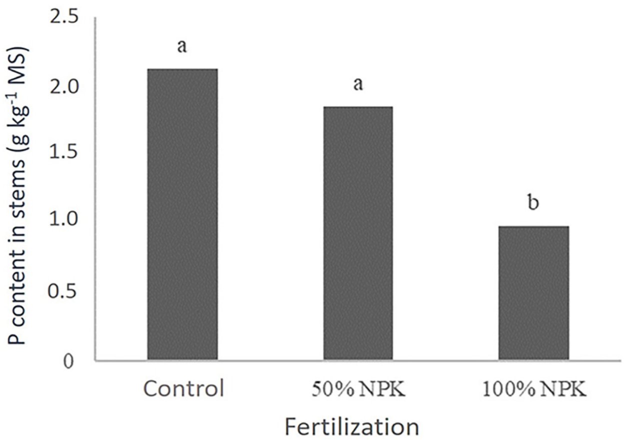

Figure 6 – Phosphorus (P) levels in stems of dwarf cashew seedlings, clone BRS 189 on CCP 06, subjected to different levels of fertilization, analyzed 90 days after grafting (DAG).

Finally, root phosphorus levels were influenced separately by fertilization and salinity. As the salinity level of the irrigation water for the seedlings increased, phosphorus levels in the roots decreased at intermediate salt levels, with an elevation at the highest salinity level (10.0 dS m^{-1}) (**Figure 7**A). Regarding the NPK dosage treatment, the roots exhibited the same pattern observed in leaves and stems, with substrate-applied fertilization negatively affecting phosphorus content (Figure 7B).

Oliveira et al. (2009), working with CCP 76 cashew seedlings irrigated with electrical conductivity (ECa) levels of 0.8, 1.6, 2.4, 3.2, and 4.0 dS m^{-1}, obtained slightly different results from those obtained in this study, with roots, leaves, and stems showing higher phosphorus values with increasing salinity. It is known that the presence of excessive ions can hinder the absorption of essential elements for plant growth, leading to nutritional imbalance (Tester & Davenport, 2003).

In contrast to nitrogen, the highest phosphorus averages in the plant organs were found in the roots, followed by the stems, and then the leaves.

Possibly, the reduction in P concentration in the analyzed organs of the seedlings may have been due to the effects of ionic strength, which reduce the activity of phosphate in the soil solution, the high adsorption of phosphate, and the decreased solubility of this mineral, due to the increase in Na and Cl levels in the soil as a result of the irrigation water used (Do Carmo et al., 2011).

For potassium content, the analysis of variance showed a significant effect at a 1% probability level ($p<0.01$) for the salinity treatments and fertilizer doses in the stem. In the roots, only the fertilizer dose treatment showed a significant effect at a 5% probability level ($p<0.05$), while the leaves did not show a significant effect for the applied treatments (**Table 6**).

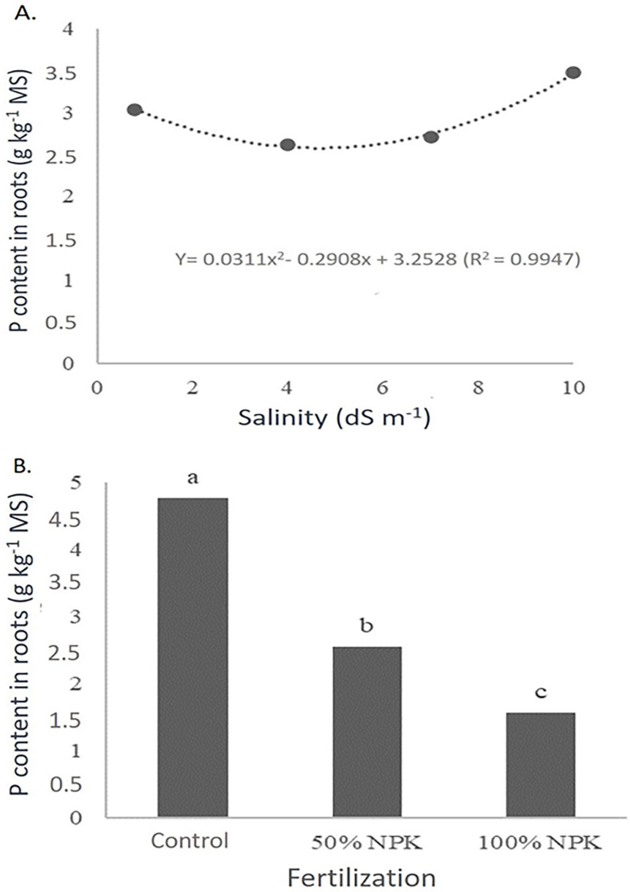

Figure 7 – Phosphorus (P) content in the roots of dwarf cashew seedlings, clone BRS 189 on CCP 06, subjected to different levels of salinity (A) and different levels of fertilization (B), analyzed 90 days after grafting (DAG). Source: AUTHOR.

Table 6 - Summary of analysis of variance for potassium (K) content in leaves, stems, and roots of dwarf cashew seedlings subjected to three levels of fertilization and four levels of salinity, analyzed 90 days after grafting (DAG)

Factor of Variation	DF	MS (Mean Square)		
		K in leaf	K in stems	K in roots
		g Kg^{-1} MS		
Fertilizing	2	0.2870 ^{ns}	6.2357**	2.0792*
Salinity	3	0.7100 ^{ns}	3.4211**	1.4020 ^{ns}
Interaction	6	0.2973 ^{ns}	0.3256 ^{ns}	0.1920 ^{ns}
Blocks	3	0.1238 ^{ns}	0.4818 ^{ns}	0.5674 ^{ns}
Residue	33	1.6080	0.6015	0.5446
CV (%)		16.31	10.81	16.64
Overall Mean		7.77	7.17	4.43

**Significant at 1% probability level by the F test. *Significant at 5% probability level by the F test. C.V. %: Coefficient of Variation. DF: Degrees of freedom.

It was observed that as the ECa of irrigation water increased, the potassium levels in the stems of the seedlings decreased, except for the seedlings irrigated with an ECa of 4.0 dS m^{-1}, which showed the highest observed means (**Figure 8**A). When comparing the seedlings irrigated with lower salinity water to the higher salinity levels, the latter showed a reduction of 13% and 15% in the potassium content in the stems for ECa of 7.0 and 10.0 dS m^{-1}, respectively (**Figure 8**A).

Regarding fertilization, the optimal response for the stem occurred when the seedlings were fertilized with 50% of the recommended NPK dose (Figure 8B). For the roots, the highest potassium levels were found in the seedlings without fertilization and with 50% of the recommended NPK dose (Figure 8C).

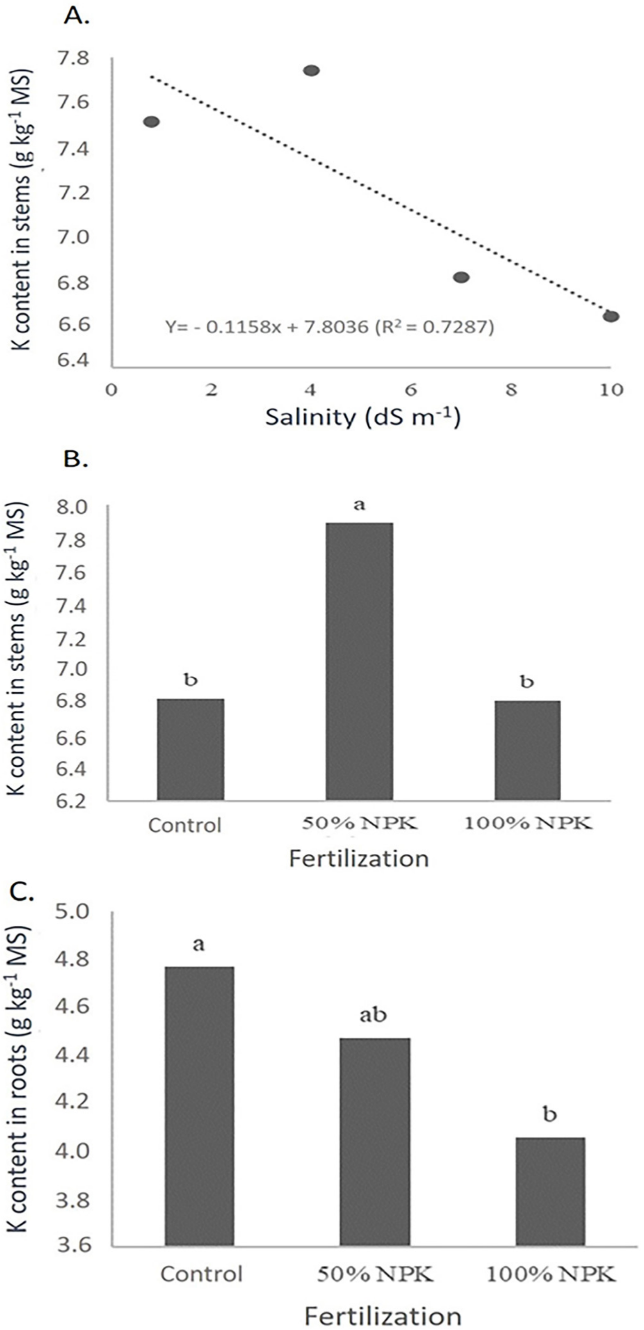

Figure 8 – Potassium (K) levels in the stems of dwarf cashew seedlings, clone BRS 189 on CCP 06, subjected to different levels of salinity (A) and different levels of fertilization (B), and in the

The application of potassium in the substrate mixture before sowing did not lead to higher levels of this nutrient in the seedlings' organs, indicating a wastage of fertilizers and unnecessary cost increase for dwarf cashew seedling production. Similar results were also observed by Ribeiro et al. (2016), and Santos et al. (2004). These authors concluded that elevated soil K levels did not necessarily lead to increased absorption by plants.

Conclusions

Fertilization did not interfere with photosynthetic activity, which showed improved performance when the seedlings were exposed to a salinity of 7.0 dS m^{-1}.

The application of NPK to the substrate resulted in higher levels of nitrogen in the leaves, while phosphorus content decreased, and foliar potassium was not influenced by fertilization.

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