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Semi-hydroponic cultivation of fertigated curly lettuce with calcium nitrate-enriched saline solutions[1]

Cultivo semi-hidropônico de alface crespa fertirrigada com soluções salinas enriquecidas com nitrato de cálcio

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HIGHLIGHTS:

Salinity negatively affects the growth characteristics of lettuce.
Nutrition with calcium at 11.43 mm L^{-1} potentiates the deleterious effect of salinity on lettuce.
Calcium fertilization at 11.43 mmol L^{-1} increases the levels of vitamin C and titratable acidity of lettuce under saline conditions.

ABSTRACT: Lettuce is a leafy vegetable sensitive to salinity, and under saline stress conditions it presents nutritional imbalance, mainly in calcium absorption. Thus, the objective was to evaluate the effect of enriching the nutrient solution with calcium nitrate in solutions prepared with saline water in the lettuce crop. A completely randomized design was used, with five treatments and four replicates. The treatments were represented by five nutrient solutions [S1 - standard nutrient solution (SNP); S2 - SNP + NaCl (3.5 dS m^{-1}); S3 - S2 + Ca $(NO_3)_2$ (50% = 6.86 mmol L^{-1}); S4 - S2 + $Ca(NO_3)_2$ (100% = 9.15 mmol L^{-1}); S5 - S2 + $Ca(NO_3)_2$ (150% = 11.43 mmol L^{-1})] in lettuce from the curly group, cv. Elba. After preparing the nutrient solutions, the solutions had the following electrical conductivities: 1.8 (S1); 4.8 (S2); 5.4 (S3); 6.0 (S4); 6.6 (S5) dS m^{-1}. Variables of growth, nutrition and postharvest quality of lettuce were evaluated. With the exception of stem diameter, number of total leaves, plant pH and vitamin C content, the other variables were affected by the extra addition of $Ca(NO_3)_2$ in the nutrient solutions. The lettuce cv Elba grown in coconut fiber is tolerant to the salinity of 4.8 dS m^{-1} (S2). In conditions where the use of saline water with 3.5 dS m^{-1} for the preparation of the nutrient solution is unavoidable, the use of extra doses of $Ca(NO_3)_2$ in the lettuce crop is not recommended.

Key words: *Lactuca sativa* L., salinity, hydroponics, leafy vegetables

RESUMO: A alface é uma hortaliça folhosa sensível à salinidade, e em condições de estresse salino apresenta crescimento reduzido e desequilíbrio nutricional, principalmente na absorção de cálcio. Assim, objetivou-se avaliar o efeito do enriquecimento da solução nutritiva com nitrato de cálcio em soluções preparadas com água salina na cultura da alface. Utilizou-se o delineamento inteiramente casualizado, com cinco tratamentos e quatro repetições. Os tratamentos foram representados por cinco soluções nutritivas [S1 - solução nutritiva padrão (SNP); S2 - SNP + NaCl (3,5 dS m^{-1}); S3 - S2 + $Ca(NO_3)_2$ (50% = 6,86 mmol L^{-1}); S4 – S2 + $Ca(NO_3)_2$ (100% = 9,15 mmol L^{-1}); S5 - S2 + Ca $(NO_3)_2$ (150% = 11,43 mmol L^{-1})] em alface do grupo crespa, cv. Elba. Após o preparo das soluções nutritivas, as soluções apresentaram as seguintes condutividades elétricas: 1,8 (S1); 4,8 (S2); 5,4 (S3); 6,0 (S4); 6,6 (S5) dS m^{-1}. Foram avaliadas variáveis de crescimento, nutrição e qualidade pós-colheita da alface. Com exceção do diâmetro do caule, número de folhas totais, pH da planta e teor de vitamina C, as demais variáveis foram afetadas pela adição extra de $Ca(NO_3)_2$ nas soluções nutritivas. A alface cv. Elba cultivada em fibra de coco é tolerante à salinidade de 4,8 dS m^{-1} (S2). Em condições onde o uso de água salina com 3,5 dS m^{-1} para o preparo da solução nutritiva é inevitável, não é recomendado o uso de doses extras de $Ca(NO_3)_2$ na cultura da alface.

Palavras-chave: *Lactuca sativa* L., salinidade, hidroponia, vegetais folhosos

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Introduction

The consumption of vegetables has increased not only due to population growth, but also the changing trend in eating habits, thereby necessitating higher production. Among vegetables, lettuce is the most consumed vegetable in Brazil (Silva et al., 2015). In 2020, the total area harvested with this crop, globally, was estimated to be greater than 1.22 million hectares, with a total production of approximately 27.66 million tons (FAOSTAT, 2022).

Hydroponic cultivation is one of the main lettuce production systems, as it allows greater quality and production of plants year-round (Silva et al., 2015). The nutrient film technique (NFT) is the one of the most widely used techniques in lettuce cultivation, one of the advantages being that it facilitated greater tolerance to salinity (Promwee & Intana, 2022).

Lettuce is sensitive to salinity (Nezamdoost et al., 2022). Situations in which plants are subjected to high-salinity conditions can cause physiological and productivity disturbances (Ahmed et al., 2019), in addition to reduced nutrient absorption. Among nutrients, calcium is considered to be one of the main factors responsible for the mechanical strength of plant structures (Taiz et al., 2017).

Few studies have been conducted on the effect of salt stress in mineral nutrition in lettuce, and because calcium is an important nutrient, calcium nutrition in lettuce subjected to salt stress must be evaluated. Therefore, this study evaluated how enriching a nutrient solution in saline water with calcium nitrate could affect lettuce.

Material and Methods

The experiment was conducted in a greenhouse located in the experimental sector of the Department of Agronomic and Forestry Sciences (DCAF), Federal Rural University of the Semi-Arid (UFERSA), Mossoró, RN, Brazil (5° 11' 31" S, 37° 20' 40" W, 18 m altitude).

A completely randomized design was used with five treatments and four replicates. Each experimental unit comprised six plants. The treatments were represented by five nutrient solutions (S1 – standard nutrient solution; S2 – standard nutrient solution + NaCl (3.5 dS m^{-1}); S3 – standard nutrient solution + NaCl (3.5 dS m^{-1}) + $Ca(NO_3)_2$ (50% = 6.86 mmol L^{-1}); S4 - standard nutrient solution + NaCl (3.5 dS m^{-1}) + $Ca(NO_3)_2$ (100% = 9.15 mmol L^{-1}); S5 - standard nutrient solution + NaCl (3.5 dS m^{-1}) + $Ca(NO_3)_2$ (150% = 11.43 mmol L^{-1})). The salinity level of irrigation water and the definition of percentages of calcium fertilization were based on the work of Guimarães et al. (2017) and Oliveira et al. (2018), who also worked with lettuce.

The culture was established using lettuce seedlings from the curly group cv. Elba. Seedlings produced in expanded polystyrene trays were used, and seeds were sown on a commercial substrate based on coconut fibers. When the seedlings had approximately four to five definitive leaves (15 days after sowing), they were transplanted into plastic bags with a capacity of 3 L using coconut fiber as a substrate, where a plant was placed in each bag.

The solution S1 corresponded to the standard solution (Furlani et al., 1999), containing the following doses of fertilizers: 4.57 mmol L^{-1} of calcium nitrate, 4.95 mmol L^{-1} of potassium nitrate, 1.30 mmol L^{-1} of phosphate of monoammonium, and 3.32 mmol L^{-1} of magnesium sulfate. For the micronutrients, the fertilizer Rexolin® was used (11.6% potassium oxide (K_2O), 1.28% sulfur (S), 0.86% magnesium (Mg), 2.1% boron (B), 2.66% iron (Fe), 0.36% copper (Cu), 2.48% manganese (Mn), 0.036% molybdenum (Mo), and 3.38% zinc (Zn). The same concentrations were used for the other treatments, except for calcium nitrate in solutions S3, S4, and S5. Nutrient solutions were prepared using water collected from the university's supply network. Table 1 lists the characteristics of the water used in this study.

To maintain the pH of the solution in the range 6.0 and 6.5, solutions of 0.1 mol L^{-1} of KOH or HCl were employed. After preparing the nutrient solutions, their electrical conductivities were determined using a benchtop conductivity meter, and the following values were obtained:1.8, 4.8, 5.4, 6.0, and 6.6 dS m^{-1} for solutions S1, S2, S3, S4, and S5, respectively.

Irrigation was performed using a drip irrigation system independent of the nutrient solution. Altogether, the irrigation system consisted of five PVC reservoirs (60 L), pump motor, lateral lines with a diameter of 16 mm, and microtube emitters with an internal diameter and length of 0.8 mm and 25 cm, respectively, with an average flow of 2.5 L h^{-1}, using one emitter per plant.

Six irrigations were performed daily at intervals of 2 hours, starting at 7 am and ending at 5 pm. During the experiment, the irrigation period increased with plant development (Table 2).

All analyses were performed 30 days after transplantation. The growth variables analyzed were canopy diameter (cm), total leaf number, leaf area (cm^2), stem diameter (cm), total fresh mass (g per plant), total dry mass (g per plant), leaf succulence (g H_2O cm^{-2} leaf), and specific leaf area (cm^2 g^{-1} leaf dry mass). The relative chlorophyll index was verified for nutritional analysis of the plant. For the variables leaf area and total fresh mass, the transformation was carried out in $\sqrt{x}$.

The canopy diameter was determined using a graduated ruler by measuring the aerial part of the plant from one end

Table 2. Details of irrigation management

Irrigation management	Crop stages (days after transplant)	
	0-15	16-30
Time/event	30 s	1 min
Daily watering time (min)	3	6

Table 1. Analysis of the water used in the preparation of nutrient solutions

pH	EC (dS m^{-1})	K^+	Na^+	Ca^{++}	Mg^{++}	Cl^-	CO_3^{-2}	HCO_3^-
		(mmol$_c$ L^{-1})						
8.3	0.5	0.3	2.3	3.1	1.1	1.8	0.2	3.0

EC - Electrical conductivity

to the other. The number of total leaves were counted on the day of harvest, considering only those with a size greater than 3 cm, presented more than 70% of green color, and without the presence of physical damage and/or dryness.

Leaf area was determined via the leaf disc method using a volumetric ring with an internal diameter of 5 cm and collecting 10 leaf discs per plant. The leaf discs were placed in paper bags and dried in an oven with forced air circulation at a temperature of 65 °C until constant weight was achieved. From the values of the area of the discs, the dry mass of the discs and leaves, and the leaf area of the plant were determined using Eq. 1 (Benincasa, 2003):

$$LA = \frac{AD \times DML}{\frac{LDM}{N}} \quad (1)$$

where:

LA - leaf area, cm^2 per plant;
AD - leaf area of the disc, cm^2;
DML - dry mass of leaves, g per plant;
LDM - leaf disc dry mass, g per plant; and,
N - number of disks used in the plot.

Stem diameter was determined using a digital caliper, measuring 1.0 cm from the cut region of the plant. The total fresh mass of the plants was determined immediately after harvesting using a digital precision scale. For total dry mass, the plants were placed in previously identified paper bags and dried in an oven with forced air circulation, at a temperature of 65 °C (±1); the plants were kept in the oven until constant weight was achieved. They were then weighed using a digital precision scale (0.01 g).

Leaf succulence was determined by evaluating the relationship between the mass of water contained in the leaf and leaf area, according to Eq. 2:

$$LS = \frac{(FLM - DML)}{LA} \quad (2)$$

where:

LS - leaf succulence, mg H_2O cm^{-2};
FLM - fresh leaf mass, g per plant;
DML - dry mass of leaves, g per plant; and,
LA - leaf area, cm^2.

The specific leaf area was determined as the ratio of the leaf area to its respective dry mass, according to Eq. 3:

$$ELA = \frac{LA}{DML} \quad (3)$$

where:

ELA - specific leaf area, cm^2 g^{-1};
LA - leaf area, cm^2; and,
DML - dry mass of leaves, g per plant.

In addition, post-harvest quality analysis was carried out, with the following variables being analyzed: pH, titratable acidity (%), soluble solids (Brix), and vitamin C (mg 100 mL), where the samples were ground in a domestic blender, following which the quantities required for each analysis were withdrawn.

To determine pH, 100 mL of distilled water was added to samples containing 10 g of lettuce pulp, and the pH was determined using a benchtop pH meter. The soluble solid content was determined using a digital refractometer (model PR – 100, Palette, Atago Co., Ltd., Japan), and the results were expressed in Brix (IAL, 2008).

The titratable acidity was determined using the titration method with 10 g of pulp diluted in 100 mL of distilled water. Volumetric procedure: the burette was filled with 0.02 N sodium hydroxide (NaOH), and 3–4 drops of phenolphthalein were added to the sample and titrated with NaOH until the color turned slightly pink (IAL, 2008).

The vitamin C content was determined using 10 g sample of the ground material diluted in 100 mL of oxalic acid; then, a 5 mL aliquot was taken and 45 mL of water was added. Titration was performed with DFI (0.094 mg mL^{-1}) until the solution turned pink (IAL, 2008).

The data obtained were subjected to analysis of variance (ANOVA), and if the results were found to be significant using the F-test, the means were analysed using the Tukey test ($p \leq 0.05$). Statistical analyses were performed using the statistical program SISVAR 5.0 (Ferreira, 2019).

Results and Discussion

Nutrient solutions significantly affected canopy diameter and leaf succulence ($p \leq 0.05$), and total fresh mass, total dry mass, number of total leaves, relative chlorophyll index, leaf area, and specific leaf area ($p \leq 0.01$) (Table 3).

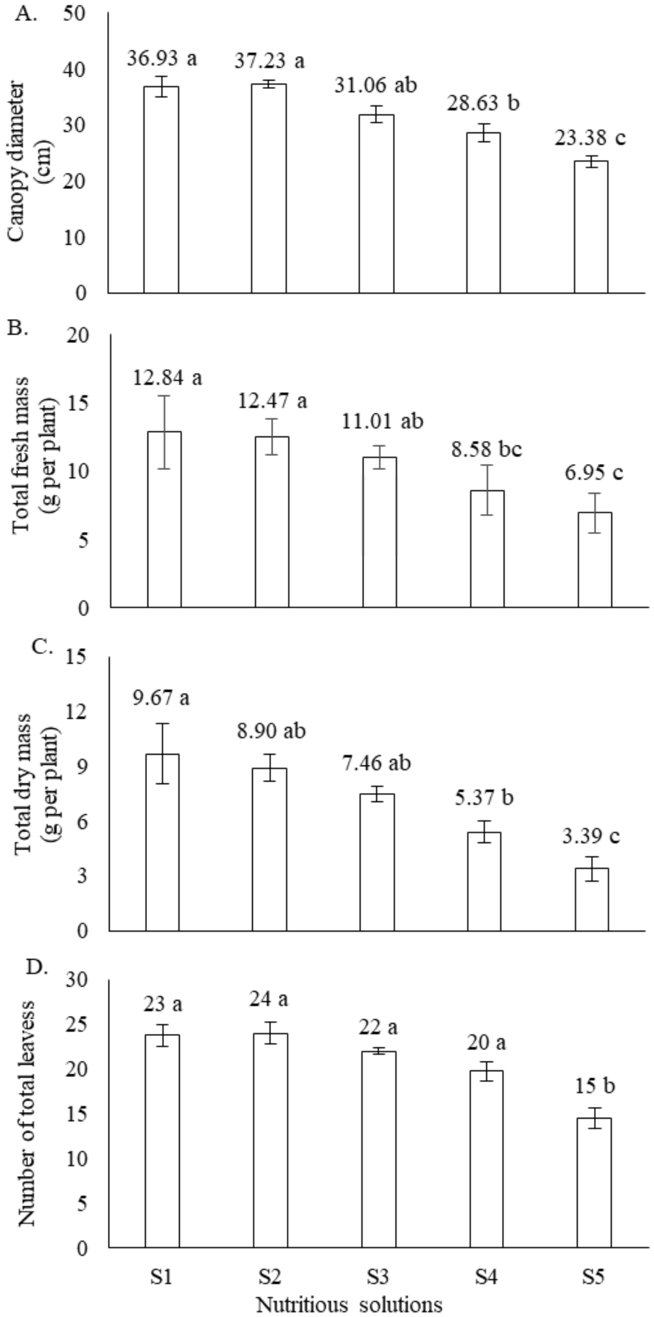
However, the nutrient solution did not significantly influence stem diameter, resulting in an average diameter of 9.36 mm (Table 3). Most vegetables subjected to saline stress tend to have unfavorably altered morphological characteristics, including stem diameter (Vetrano et al., 2020). However, the lack of change in stem diameter may be related to the accumulation of reserves in this region of the plant owing to the stress caused by high salinity (Ferreira et al., 2012).

Table 3. Summary of analysis of variance for canopy diameter, stem diameter, total fresh mass, total dry mass, number of total leaves, relative chlorophyll index, leaf area, specific leaf area and leaf succulence in lettuce submitted to different nutrient solutions

Variables	Treatments Nutritive solution	Residue	CV (%)	P value
Canopy diameter	136.66^{*}	6.25	7.95	0.0000
Stem diameter	3.03^{ns}	1.71	14.0	0.1885
Total fresh mass#	26.86^{**}	2.54	15.43	0.0003
Total dry mass	26.63^{**}	3.39	26.49	0.0013
Number of total leaves	61.17^{**}	4.7	10.42	0.0001
Relative chlorophyll index	5.19^{**}	5.09	24.55	0.0137
Leaf área#	$1,045.84^{**}$	89.46	17.16	0.0002
Specific leaf area	$53,076.72^{**}$	12,053.62	25.39	0.0149
Leaf succulence	47.40^{*}	14.78	12.50	0.0432

*, **, ns - Significant at $p \leq 0.05$ and $p \leq 0.01$ and not significant, respectively; # data transformed into √x

Adding sodium chloride did not affect the canopy diameter variable (Figure 1A); however, adding calcium nitrate reduced the canopy diameter, mainly from the addition of 100%, with the greatest loss (36.7%) in the nutrient solution with an extra dose of 150%. For crown diameter, divergent results were found from the quadratic response with increasing salinity in the NFT hydroponic system (Fernandes et al., 2018), and favorable responses for some cultivars (Valença et al., 2018). This component is of fundamental importance for the producer, considering that the consumer market prefers to purchase lettuces with larger heads (Queiroz et al., 2017).



S1, S2, S3, S4 and S5 - Standard nutrient solution, standard nutrient solution + NaCl (3.5 dS m^{-1}), standard nutrient solution + NaCl (3.5 dS m^{-1}) + $Ca(NO_3)_2$ (50% = 6.86 mmol L^{-1}), standard nutrient solution + NaCl (3.5 dS m^{-1}) + $Ca(NO_3)_2$ (100% = 9.15 mmol L^{-1}), standard nutrient solution + NaCl (3.5 dS m^{-1}) + $Ca(NO_3)_2$ (150% = 11.43 mmol L^{-1}), respectively. Different lowercase letters indicate significant differences between solutions, according to Tukey's test ($p \leq 0.05$ and $p \leq 0.01$). Vertical bars represent the standard error of the mean (n = 6)

Figure 1. Canopy diameter (A), total fresh mass (B), total dry mass (C) and number of total leaves (D) of curly lettuce grown in coconut fiber and with different nutrient solutions

For the total fresh mass and total dry mass (Figures 1B and C, respectively), it was observed no difference between the standard nutrient solution and saline solution with NaCl; however, when the levels of calcium nitrate were increased, it was noticed a significant reduction in mass. Losses of 45.87% and 64.94% were recorded in the total fresh and dry masses in solutions without NaCl (S1) and with 150% Ca (S5), respectively. A possible explanation for the lack of favorable effects to extra calcium supplementation could be that the high concentration of fertilizers increased the electrical conductivity of the nutrient solution, preventing the plants from overcoming the osmotic effects due to increasing salt concentration (Guimarães et al., 2012).

Tzortzakis (2009) observed unfavorable results in the fresh and dry mass of plants when working with calcium nitrate in lettuce and endives in salinized water, as it was observed in the present study. According to the authors, this factor may be related to the plant species and/or its adaptation to salt concentration.

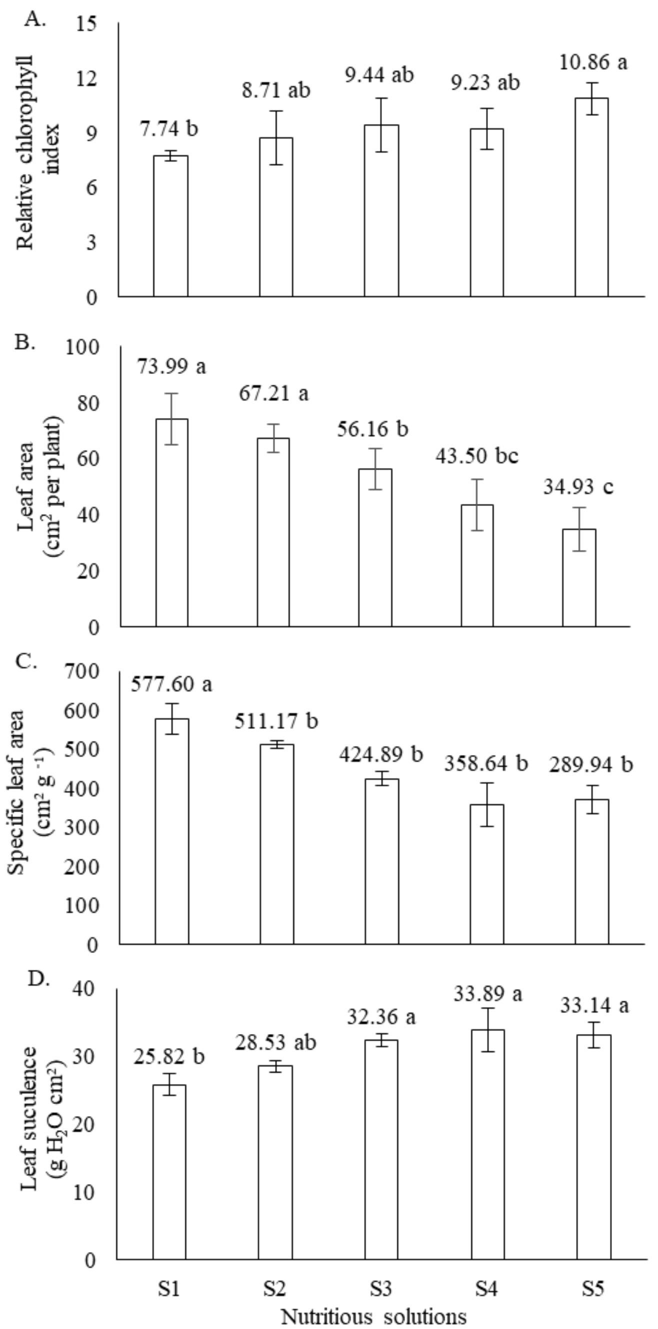
The reduction in dry and fresh mass in lettuce plants, even when the calcium content was increased in the treatments, occurred because of the probable toxicity acquired by the excessive absorption of ions such as Na^+ and Cl^-, and consequently, by the nutritional imbalance in the nutritional value of nutrients essential to metabolic processes (Munns, 2005).

The total number of leaves (Figure 1D) was not affected by the salinity of the nutrient solution when NaCl was added; however, it was significantly reduced when the salinized nutrient solution was enriched with 150% extra calcium nitrate (S5), causing a loss of 34.78% compared to the standard nutrient solution (S1). The results for the total number of leaves corroborated those presented by Kurunc (2021), who observed that salinity did not significantly affect the number of lettuce leaves.

The relative chlorophyll index was favorably affected upon adding sodium chloride and calcium nitrate, with the highest value obtained in plants fertigated with a saline solution enriched with the highest concentration of calcium nitrate (S5–150% Ca), in which an increase of 40.30% was obtained in comparison with the chlorophyll index obtained in the standard nutrient solution (Figure 2A).

An increase in chlorophyll content as a function of the increase in electrical conductivity was also observed by Borghesi et al. (2013), who attributed this increase to the presence of calcium attenuating the deleterious effect of salinity on chlorophyll. In addition, the increase in chlorophyll content could be attributed to the size of the lettuce; in the S5 solution, the plants showed less development.

The addition of calcium nitrate at concentrations of 50% and 150% (S3 and S5) potentiated the effect of salinity on leaf area (Figure 2B), with losses of 24.10 and 52.79% in these calcium concentrations, respectively, compared to the values obtained from plants grown in the standard nutrient solution (S1).



S1, S2, S3, S4 and S5 - Standard nutrient solution, standard nutrient solution + NaCl (3.5 dS m^{-1}), standard nutrient solution + NaCl (3.5 dS m^{-1}) + $Ca(NO_3)_2$ (50% = 6.86 mmol L^{-1}), standard nutrient solution + NaCl (3.5 dS m^{-1}) + $Ca(NO_3)_2$ (100% = 9.15 mmol L^{-1}), standard nutrient solution + NaCl (3.5 dS m^{-1}) + $Ca(NO_3)_2$ (150% = 11.43 mmol L^{-1}), respectively. Different lowercase letters indicate significant differences between solutions, according to Tukey's test ($p \leq 0.05$ and $p \leq 0.01$). Vertical bars represent the standard error of the mean (n = 6)

Figure 2. Relative chlorophyll index (A), leaf area (B), specific leaf area (C) and leaf succulence (D) of curly lettuce grown in coconut fiber and with different nutrient solutions

The reduction in leaf area under saline stress occurs due to a decrease in cell volume and helps the culture adapt to salinity, as it allows the conservation of water owing to the smaller transpiration area of the plants (Taiz et al., 2017). Considering that the leaf area is a function of the number and unit size of leaves, the effect of salinity was more evident on the expansion of the leaf blade, which is in agreement with the results presented by Fernandes et al. (2018).

The specific leaf area was reduced by the salinity of the nutrient solution when NaCl (S2) was added, with a loss of 11.50% compared to that observed in the standard nutrient solution (S1) (Figure 2C). However, no significant difference was observed between the solutions containing NaCl (S2) and those containing calcium nitrate (S3, S4, and S5). An absolute loss of 49.80% was observed in solution S5 compared to that observed in solution S1.

Specific leaf area is related to the relationship between leaf size and mass and is reflected in leaf blade thickness (Targino et al., 2019). The rates of cell elongation and division depend directly on the cell wall extensibility process; therefore, the immediate response of plants to salinity is a reduction in cell expansion (Parida & Das, 2005). According to Parida et al. (2004), the thickness of leaf mesophyll increases with an increase in the number and length of cells.

The addition of NaCl did not significantly affect leaf succulence (S2) (Figure 2D); however, when salinized nutrient solutions were enriched with calcium nitrate, succulence increased, with a maximum increase of 31.25% in the S4 solution compared to that observed in the standard nutrient solution (S1).

According to Martínez et al. (2004), plants subjected to NaCl-induced saline stress may exhibit increased leaf succulence, which is indicative of effective osmotic adjustment. In addition, succulence allows the regulation of salt concentration in leaf tissues, allowing hydration of the leaves under conditions of low water availability, and depends directly on the absorption, transport, and accumulation of ions in the leaf tissues, which may contribute to reducing the effect of salts on plant growth (Matos et al., 2013).

Nutrient solutions significantly affected soluble solids ($p \leq 0.05$) and titratable acidity ($p \leq 0.01$). However, no significant response to hydrogen potential (pH) and vitamin C was observed (Table 4).

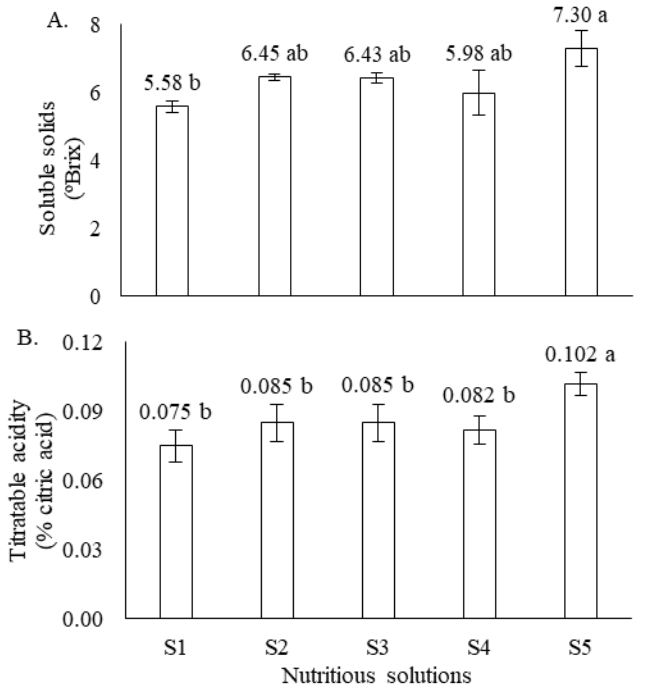
The soluble solid content did not differ significantly upon adding NaCl to the nutrient solution (S2) when compared to the standard nutrient solution (S1); however, it was observed a significant increase of 23.5% when the plants were enriched with calcium nitrate at 150% (S5) compared to that observed in the standard nutrient solution (S1) (Figure 3A).

The increase in the soluble solid content in lettuce under saline conditions of S5, which was observed in the present study (Figure 3A), was also observed by Freire et al. (2009) and can be attributed to the calcium concentration. In more saline nutrient solutions, plants showed lower development, resulting in a higher concentration of sugars, probably due to the osmotic adjustment by the plant, in an attempt to reach equilibrium in relation to the osmotic potential of the solution (Freire et al., 2009).

Table 4. Summary of analysis of variance for soluble solids, titratable acidity, hydrogen potential and vitamin C in lettuce submitted to different nutrient solutions

Variables	Treatments	Residue	CV (%)	P value
	Nutrient Solution			
Soluble solids	1.66*	0.38	9.74	0.0382
Titratable acidity	0.00039**	0.000051	8.36	0.0130
Hydrogen potential (pH)	0.040ns	0.025	2.70	0.0831
Vitamin C	0.078ns	0.069	9.05	0.0922

*, **, ns - Significant at $p \leq 0.05$ and $p \leq 0.01$ and not significant, respectively



S1, S2, S3, S4 and S5 - Standard nutrient solution, standard nutrient solution + NaCl (3.5 dS m^{-1}), standard nutrient solution + NaCl (3.5 dS m^{-1}) + $Ca(NO_3)_2$ (50% = 6.86 mmol L^{-1}), standard nutrient solution + NaCl (3.5 dS m^{-1}) + $Ca(NO_3)_2$ (100% = 9.15 mmol L^{-1}), standard nutrient solution + NaCl (3.5 dS m^{-1}) + $Ca(NO_3)_2$ (150% = 11.43 mmol L^{-1}), respectively. Different lowercase letters indicate significant differences between solutions, according to Tukey's test ($p \leq 0.05$). Vertical bars represent the standard error of the mean (n = 6)

Figure 3. Soluble solids (A) and titratable acidity (B) of curly lettuce grown in coconut fiber with different nutrient solutions

Titratable acidity did not significantly increase on adding NaCl or calcium nitrate in nutrient solutions S2, S3, and S4; however, when the plants were fertigated with a nutrient solution salinized with NaCl and enriched with calcium nitrate at 150% (S5), an increase of 36.00% was observed compared with that of the plants in the standard nutrient solution (S1) (Figure 3B).

When working with the tomato crop in saline waters, Paiva et al. (2018) observed a significant effect of adding calcium on titratable acidity. They observed that the nutrient solution with the highest Ca concentration reduced this variable. Thus, changes in titratable acidity due to the concentration of nutrients are due to electrical conductivity, in addition to other factors, such as genetic material and culture systems.

The hydrogen potential (pH) was not affected by the nutrient solutions, either by the addition of NaCl or increase in calcium nitrate, resulting in an average pH of 5.80. These results show that the pH of lettuce plants was slightly affected by the Ca^+ concentration in the nutrient solution and by the salinity of the irrigation water. Paiva et al. (2018) conducted a study on the effect of water salinity and calcium fertilization on tomato crops, and observed no effects of Ca^+ concentration on the pH of the fruits.

As was observed for the pH, it was observed no differences between the standard nutrient solution (S1) and nutrient solutions with NaCl, and an average vitamin C content of 25.58 mg was obtained per 100 g increase in the calcium nitrate content.

Vitamin C values were close to those observed by Vicentini-Polette et al. (2018), who was working with crispy curly lettuce (SVR-2005) and Vanda lettuce (TE112), and obtained ascorbic acid contents of 6.1 and 6.5 mg 100g^{-1}, respectively. When comparing the levels of vitamin C found in the present study with those recommended by the Tabela Brasileira de Composição dos Alimentos (TBCA, 2011), it was observed that the average value found was higher than that of TBCA, given that every 100 g of lettuce from the curly group contains 15.6 mg of vitamin C.

Conclusions

1. Calcium nitrate supplementation did not reduce the effect of salinity on lettuce production.

2. The enrichment of the nutrient solution with calcium nitrate at doses of 6.86, 9.15, and 11.43 mmol L^{-1} potentiated the deleterious effect of salinity on lettuce grown on coconut fiber.

3. In conditions where saline water must be used at 3.5 dS m^{-1} for preparing the nutrient solution, extra doses of $Ca(NO_3)_2$ in lettuce crops is not recommended.

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