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Accumulation of cations in lettuce cultivars under low-cost hydroponic system with brackish waters¹

Acúmulo de cátions em cultivares de alface sob sistema hidropônico de baixo custo com águas salobras

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HIGHLIGHTS:

Lettuce plants of the cvs. Betty and Mimosa in hydroponic system with brackish water reduce Na accumulation after 4.5 dS m⁻¹. There is a greater impact on Mg absorption compared to K and Ca due to the increase of Na accumulation in lettuce. In hydroponic lettuce the salinity increase causes greater reductions in the accumulation of K compared to Ca and Mg.

ABSTRACT: The use of brackish water to cultivate lettuce can cause nutritional imbalances, impairing production. In this context, the objective of the present study was to evaluate the effect of salinity on the accumulation of dry matter of the aerial part and macronutrients K, Ca and Mg and their relations with Na in lettuce cultivars grown in a low-cost hydroponic system. The experiment was conducted in a randomized block design, in a 6 × 2 factorial scheme, with four replicates. The treatments consisted of six electrical conductivities of the nutrient solution (1.5, 2.5, 3.5, 4.5, 5.5 and 6.5 dS m⁻¹) and two lettuce cultivars, Betty [iceberg] and Mimosa [green-leaf]. Regardless of the evaluated cultivar, the increase in the electrical conductivity of the nutrient solution reduced the accumulation of dry matter in the aerial part. In both cultivars, the increase in the electrical conductivity of the nutrient solution reduced the accumulations of K and Mg and increased Na/K, Na/Ca and Na/Mg ratios. The green-leaf cv. Mimosa showed Ca and Mg accumulations higher than that in the iceberg cv. Betty, regardless of electrical conductivity. The increase in electrical conductivity reduced the accumulation of K, in both cultivars evaluated. The decreasing order in the accumulation of macronutrients and sodium in both cultivars was: K > Na > Ca > Mg.

Key words: *Lactuca sativa*, plant nutrition, nutrient solution, salinity

RESUMO: A utilização de águas salobras para cultivo da cultura da alface pode causar desequilíbrios nutricionais, prejudicando a produção. Neste sentido, objetivou-se avaliar o efeito da salinidade sobre o acúmulo de matéria seca da parte aérea e dos macronutrientes K, Ca e Mg e suas relações com o Na em cultivares de alface cultivadas em um sistema hidropônico de baixo custo. O experimento foi conduzido no delineamento experimental de blocos casualizados, em esquema fatorial 6 × 2, com quatro repetições. Os tratamentos foram constituídos por seis valores de condutividade elétrica da solução nutritiva (1,5; 2,5; 3,5; 4,5; 5,5 e 6,5 dS m⁻¹) e por duas cultivares de alface Betty [Americana] e Mimosa [Crespa]. Independentemente da cultivar avaliada, o aumento da condutividade elétrica da solução nutritiva reduziu o acúmulo de matéria seca da parte aérea. Em ambas as cultivares, o aumento da condutividade elétrica da solução nutritiva reduziu os acúmulos de K e de Mg e elevou as relações de Na/K, Na/Ca e Na/Mg. A cv. Mimosa apresentou acúmulos de Ca e Mg superiores aos acúmulos da cv. Betty, independentemente da condutividade elétrica. O aumento da condutividade elétrica reduziu o acúmulo de K, nas duas cultivares. A ordem decrescente no acúmulo dos macronutrientes e sódio em ambas as cultivares foi: K > Na > Ca > Mg.

Palavras-chave: *Lactuca sativa* L., nutrição de plantas, solução nutritiva, salinidade

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INTRODUCTION

The Brazilian semiarid region is plagued by water scarcity and irregular distribution of meteorological factors, which harms agricultural production (Souza et al., 2015). Alternatively, many farmers use brackish waters from natural water reservoirs in the region. However, Silva et al. (2018) report that these resources acquire high contents of salts due to the geology and regional climate. As an alternative to minimize the effects of salinity on plants and also to financially benefit the rural producer, low-cost hydroponic systems have emerged (Santos Júnior et al., 2013).

The increase in electrical conductivity through the use of brackish water can restrict the growth of the photosynthetically active area of the plant, minimizing carbon fixation and consequently biomass production (Negrão et al., 2016), causing direct consequences on the absorption and accumulation of nutrients by plants. However, compared to conventional cultivation, an insignificance of the matric potential reduces the difficulty of water absorption by plants (Soares et al., 2007).

Lettuce (*Lactuca sativa* L.) stands out nationally as an important hydroponic crop (Cometti et al., 2019), due to its high yield, earliness and market acceptance. It is rich in nutrients that are important for human health, being the leafy vegetable most consumed in Brazil (Moura et al., 2020).

Morphogenic variability between lettuce cultivars should be expected for yield characteristics, and local studies allow the recommendation of adaptable and stable cultivars in the region in which they were evaluated (Blind & Silva Filho, 2015). In Brazil, the most produced cultivars are the green-leaf (70%) and iceberg (15%) (Sala & Costa, 2005).

In this context, the objective of the present study was to evaluate the effect of salinity on the accumulation of dry matter in the aerial part and macronutrients K, Ca and Mg and their relations with Na in lettuce cultivars grown in a low-cost hydroponic system.

MATERIAL AND METHODS

The study was conducted from June 20 to August 2, 2019, in a greenhouse-type protected environment, in the Departamento de Engenharia Agrícola of Universidade Federal Rural de Pernambuco, Recife, PE, Brazil (8° 01' 07" South latitude and 34° 56' 53" West longitude, and average altitude of 6.5 m).

The experimental site is characterized as a plastic greenhouse-type protected environment and has the following dimensions: 6.0 m wide, 18.0 m long, 4.0 m ceiling height and 5.5 m at the highest part of the covering. The covering is arched, made of 0.10-mm-thick transparent low-density polyethylene film, treated against the action of ultraviolet rays. The sides are made with screen.

The region has a megathermal climate (As'), according to Köppen's climate classification. During the experimental period, the average minimum, mean and maximum temperatures were 23, 27 and 34 °C, respectively. The average relative air humidity was 78%. These data were monitored by means of a portable weather station (Digitech model XC0348).

The experimental structure used consisted of a low-cost hydroponic module (Santos Júnior et al., 2013), composed of a pyramidal wooden support, waterproofed with oil paint, with dimensions of 0.45 m top width, 1.4 m base width, 1.5 m length and 1.8 m height, which supports twelve 100-mm-diameter PVC pipes, which are level. Circular openings were made in the PVC pipes, 60 mm in diameter, equidistantly spaced at every 0.20 m, considering the central axis of each circle.

The experimental design used was randomized blocks, in a 6 x 2 factorial scheme, with four replicates, corresponding to six values of electrical conductivity of the nutrient solution (1.5, 2.5, 3.5, 4.5, 5.5 and 6.5 dS m⁻¹) and two lettuce cultivars, Betty [Iceberg] and Mimosa [Green-leaf]. Each plot was composed of seven plants.

The respective amounts of NaCl to be solubilized in order to attain the desired electrical conductivity were quantified as proposed by Richards (1954). The electrical conductivity of 1.5 dS m⁻¹ corresponded only to water with fertilizer salts, being the control treatment, following the recommendations for nutrient solution of Furlani et al. (1999), as shown in Table 1.

The seedlings were produced in 200-cell polystyrene trays. Sowing was performed on June 8, 2019 and, 12 days after sowing (DAS), when the seedlings had four to six true leaves, they were transplanted to the respective experimental plots and began to receive treatments with nutrient solution prepared in brackish water.

Nutrient solution circulation was performed twice a day, at nine hours and at 15 hours, circulating 10 L of nutrient solution per experimental plot (pipe). However, as the hydroponic system used was of the closed type, the surplus of nutrient solution in relation to the level inside the pipe, returned to the solution reservoir through a tube and the process was repeated daily.

Table 1. Amounts of fertilizers and the respective concentrations (mg L⁻¹) of nutrients to prepare 1000 L of nutrient solution for hydroponic cultivation of leafy crops (Furlani et al., 1999)

Fertilizer	(g m ⁻³)	NH ₄	NO ₃	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Mo	Zn
Calcium nitrate	750.0	7.5	108.8			142.5								
Potassium nitrate	500.0		65		182.5									
MAP	150.0	16.5		39										
Magnesium sulfate	400.0						40	52						
Copper sulfate	0.20									0.02				
Zinc sulfate	0.3													0.07
Manganese sulfate	1.5											0.39		
Boric acid	1.8								0.31					
Sodium molybdate	0.20												0.06	
Fe-EDTA- 13% Fe	16.0										2.08			
Recommendation		24	173.8	39	182.5	142.5	40	52	0.31	0.02	2.08	0.39	0.06	0.07

The plants were harvested at 55 DAS, when they were already developed. At the time of harvest, their aerial part was separated from the roots and dried in an air circulation oven at temperature of 65 °C until reaching constant weight. After this procedure, the oven-dried material was weighed, processed in a Wiley-type mill and stored in properly labeled plastic container for subsequent quantification of K, Ca, Mg and Na concentrations.

The cationic macronutrients K, Ca and Mg and the Na ion in dry matter were extracted by wet extraction, using nitric digestion, based on the methodology proposed by Silva (2009). K and Na concentrations were determined by the flame photometry method and Ca and Mg concentrations by the atomic absorption spectrophotometry method, following the methodological procedures recommended by Bezerra Neto & Barreto (2011).

To quantify the accumulation of macronutrients (K, Ca and Mg) and sodium (Na) by the crop, the concentration of each of the macronutrients evaluated and was multiplied by the value of dry mass of the plants. The relations between the ions (Na/K, Na/Ca and Na/Mg) were estimated by the ratio between the values of their accumulation in the plants.

The results obtained were subjected to analysis of variance. The electrical conductivity of the nutrient solution was submitted to polynomial regression analysis ($p \leq 0.05$).

RESULTS AND DISCUSSION

There was no significant effect ($p \leq 0.05$) of the interaction between the electrical conductivity of the nutrient solution (EC_{ns}) and the cultivars (Table 2) on the accumulations of dry matter of the aerial part (DMAP), sodium (Na), potassium (K), magnesium (Mg) and calcium (Ca).

Accumulations of dry matter of the aerial part (DMAP), Na, K, Mg and Ca were significantly influenced ($p \leq 0.05$) by the electrical conductivity of the nutrient solution, and the accumulations of Mg and Ca were significantly influenced ($p \leq 0.05$) by the cultivars.

The individual effects of nutrient solution electrical conductivity on the accumulations of dry matter of the aerial part (DMAP), Na, K, Mg and Ca can be observed in Figures 1A, B, C, D and E, respectively.

The dry matter of the aerial part (DMAP) decreased by 0.56 g plant⁻¹ per unit increase in the electrical conductivity of the nutrient solution (Figure 1A). The highest estimated value for this variable was 6.83 g plant⁻¹, which was obtained at the lowest electrical conductivity of the nutrient solution

(1.5 dS m⁻¹), and the lowest value obtained was 4.02 g plant⁻¹, at the electrical conductivity of 6.5 dS m⁻¹, thus representing a reduction of 41.14%.

The reduction in DMAP verified in the present study is due to the osmotic effect of the electrical conductivity of the nutrient solution on plants caused by the excess of Na⁺ and Cl⁻ ions in the waters used to prepare such a solution.

According to Tester & Davenport (2003), the Na⁺ and Cl⁻ ions when in excess in the nutrient solution can cause imbalance in the absorption and accumulation of essential nutrients to plants, such as K, Mg, Ca and N. In the present study, it was found that the excess of these ions in the nutrient solution and, specifically, Na⁺, caused antagonistic effect on the accumulations of K⁺ (Figure 1C) and Mg⁺ (1D) in the aerial part of the crop.

The results of DMAP due to the increase in the electrical conductivity of the nutrient solution obtained in this study are consistent with those found in the literature. Evaluating the effects of saline waters of up to 3.93 dS m⁻¹ on the production of curly lettuce (*Lactuca sativa* L.) in hydroponic conditions, Soares et al. (2007) found that DMAP was reduced by 0.32 g per unit increment of nutrient solution salinity.

Furthermore, Cova et al. (2017), evaluating the growth and accumulation of ions in lettuce grown in different hydroponic systems and recirculation frequencies, also found a reduction in DMAP due to the increase in the conductivity of the water used to prepare the nutrient solution.

The EC_{ns} that promoted the highest Na accumulation (Figure 1B) was 4.21 dS m⁻¹ (0.131 g plant⁻¹). The value found is 60.7% higher than the Na accumulation observed at the EC_{ns} of 1.5 dS m⁻¹ (0.0815 g plant⁻¹). Several studies have reported increase in the accumulation of Na ions in plants subjected to the addition of NaCl in the nutrient solution (Bartha et al., 2015; Cova et al., 2017). According to Bartha et al. (2015), the accumulation of Na in lettuce leaves leads to a better osmotic adjustment of the plants to salt stress.

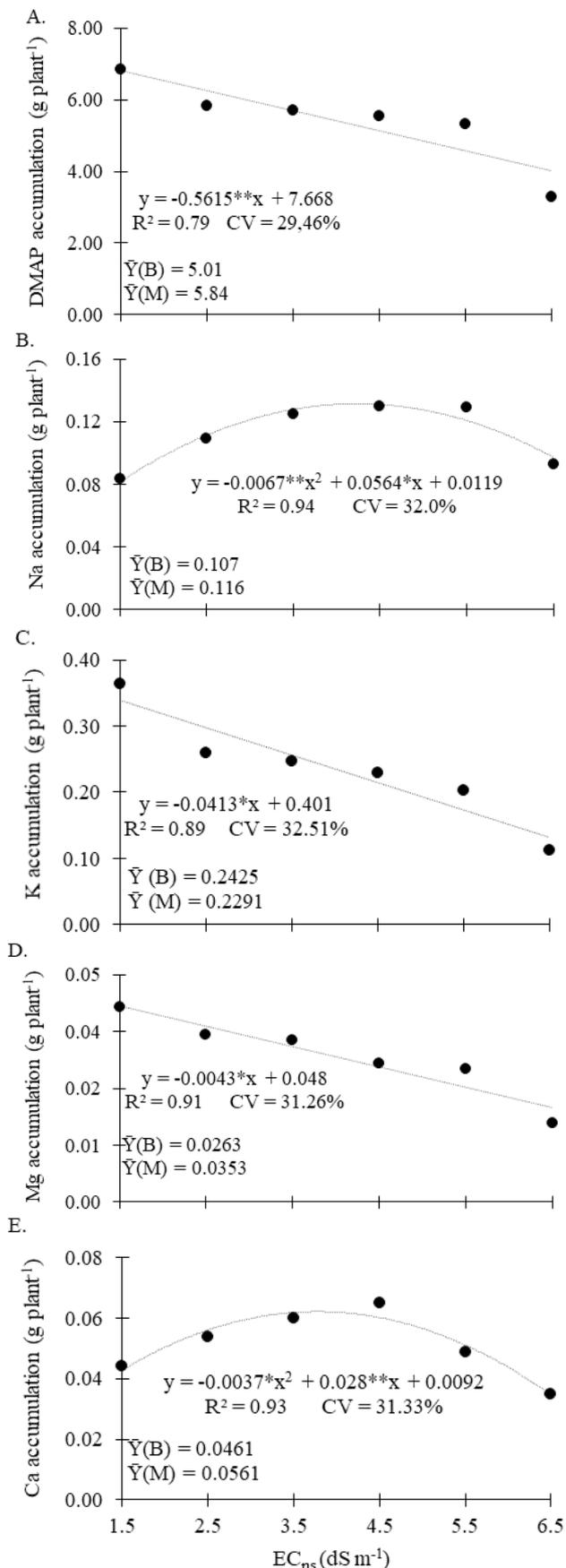
This increase in Na accumulation up to EC_{ns} of 4.21 dS m⁻¹ in the aerial part of the plants, regardless of the cultivar evaluated, occurred because the source of salt used to obtain the electrical conductivity of the water in the experiment was sodium chloride, which increases the concentration of this salt in the nutrient solution and this possibly influenced the absorption and accumulation of the ion in the aerial part of the crop.

According to Furlani (1999), the highest absorption of ions by plants in hydroponic cultivation occurs in the presence of high concentrations of these ions in the nutrient solution.

Table 2. Summary of the analysis of variance for the accumulations of dry matter of the aerial part (DMAP), sodium (Na), potassium (K), magnesium (Mg), calcium (Ca) and the cationic ratios sodium/potassium (Na/K), sodium/magnesium (Na/Mg) and sodium/calcium (Na/Ca) in lettuce crop, as a function of cultivars and electrical conductivity of the nutrient solution

SV	DF	MS							
		DMAP	Na	K	Mg	Ca	Na/K	Na/Mg	Na/Ca
Cultivars (C)	1	8.301 ^{ns}	0.001 ^{ns}	0.002 ^{ns}	0.001 ^{**}	0.001 [*]	0.0257 ^{**}	18.158 ^{**}	0.478 ^{**}
Salinity (S)	5	11.12 ^{**}	0.003 [*]	0.053 ^{**}	0.001 ^{**}	0.001 ^{**}	0.338 ^{**}	15.376 ^{**}	0.955 ^{**}
C x S	5	1.073 ^{ns}	0.001 ^{ns}	0.001 ^{ns}	0.0001 ^{ns}	0.0001 ^{ns}	0.0204 ^{**}	3.201 ^{**}	0.476 ^{**}
Blocks	3	3.493 ^{ns}	0.001 ^{ns}	0.011 ^{ns}	0.0001 ^{ns}	0.0001 ^{ns}	0.0023 ^{ns}	0.335 ^{ns}	0.069 ^{ns}
Error	33	2.551	0.001	0.006	0.0001	0.0002	0.0018	0.123	0.0521
CV (%)	%	29.46	32.00	32.51	31.26	31.33	7.92	8.62	10.19

CV - Coefficient of variation; **, *, ns - Significant at $p \leq 0.01$ and $p \leq 0.05$, and not significant by the F test, respectively



* and ** - Significant at $p \leq 0.05$ and $p \leq 0.01$ by F test, respectively; B - Betty; M - Mimosa

Figure 1. Accumulation of dry matter of the aerial part (DMAP), sodium (Na), potassium (K), magnesium (Mg) and calcium (Ca) in lettuce crop, as a function of the electrical conductivity of the nutrient solution (EC_{ns}) and the cultivars (A, B, C, D and E, respectively)

Corroborating the results obtained in the present study, Santos et al. (2017) evaluating Na accumulation in cherry tomatoes and Souza et al. (2020) assessing Na accumulation in chives also observed that there was an increase in Na accumulation by these crops with the increase in nutrient solution salinity.

Such increase in Na accumulation in lettuce plants can become harmful because Na, at high concentrations, penetrates through the ionic channels, depolarizes the plasma membrane, of low selectivity, and thus reduces the absorption of other metal cations (Santos et al., 2009).

According to Modesto et al. (2019), excessive Na accumulation leads to symptoms that hamper plant metabolism, such as oxidative stress of proteins, nucleic acids and lipids, thus resulting in reductions in nutrient assimilation and in plant growth and development, causing premature senescence.

On the other hand, the reduction in Na accumulation by the crop at electrical conductivity higher than 4.21 dS m⁻¹ may be associated with the mechanism or capacity that some plants have to control the concentration of the salt in the aerial part by accumulating it in the roots or also by reducing its absorption, which hence confer an important adaptation mechanism to enable their survival and growth under conditions of salt stress (Souza et al., 2020).

In the case of K (Figure 1C), it can be observed that the increase in electrical conductivity of the nutrient solution caused a 10.3% reduction in its accumulation per unit increase in EC_{ns}. The highest K accumulation (0.339 g plant⁻¹) was obtained with EC_{ns} of 1.5 dS m⁻¹, which is 154.9% higher than the accumulation obtained at the highest level of salinity applied (6.5 dS m⁻¹), equal to 0.133 g plant⁻¹.

Similar results were found by Soares et al. (2016), evaluating the mineral nutrition of Iceberg lettuce produced using brackish water with EC_{ns} of up to 5.2 dS m⁻¹, also found reduction in K accumulation with increasing electrical conductivity of the nutrient solution. Similarly, Souza et al. (2020) evaluated the accumulation of nutrients and inorganic solutes in green chives, produced with brackish water, concluded that the increase in nutrient solution salinity reduced K accumulation by plants, corroborating the results obtained in leafy vegetables in the present study.

Among the nutrients evaluated, K was the most accumulated by both lettuce cultivars studied. Grangeiro et al. (2006) studying lettuce cultivars grown under semi-arid conditions also had K as a nutrient accumulated in greater quantity, being 0.45, 0.35 and 0.33 g plant⁻¹, for the cultivars Babá de Verão, Tainá and Verônica. Marschner (2012) explains that this result is due to the fact that this nutrient is required in the activation of several enzymes that are essential for the synthesis of organic compounds, including starch.

Regarding the accumulation of Mg by the cultivars evaluated (Figure 1D), its highest value was observed for the cv. Mimosa (0.0353 g plant⁻¹), which had an accumulation 34.2% higher than that observed for the cv. Betty (0.0263 g plant⁻¹). Also, according to Figure 1D, it is observed that the increase in electrical conductivity of the nutrient solution led to 8.9% reduction in Mg accumulation per unit increase in EC_{ns}. Despite the importance of magnesium for plant

physiology, studies on the accumulation of this nutrient under salt stress are quite limited. However, as this ion is required in the chlorophyll molecule and acts as a cofactor in almost all enzymes of energy metabolism (Taiz & Zeiger, 1991), it is likely that the growth of plants has been affected, causing less accumulation of this macronutrient.

Almeida et al. (2011) obtained the highest Mg accumulation in the aerial part of lettuce plants, equivalent to 39.2 mg plant⁻¹, which is within the range of values found for the factors analyzed in this study. However, studying lettuce cv. Verônica in hydroponic cultivation, Beninni et al. (2005) obtained maximum accumulation of 0.071 g plant⁻¹, at electrical conductivity varying from 1.8 to 2.0 dS m⁻¹.

In relation to Ca (Figure 1E), the cv. Mimosa accumulated higher amount of Ca (0.0562 g plant⁻¹) when compared to the cv. Betty (0.0461 g plant⁻¹). Contrary to this result, Grangeiro et al. (2006) obtained higher Ca and Mg accumulations in iceberg cv. Tainá lettuce than in green-leaf cv. Verônica, being 0.063 and 0.046 g plant⁻¹, respectively.

The higher accumulations of Ca and Mg by the cv. Mimosa in comparison to the cv. Betty can express a better adaptation of this cultivar to saline conditions. Therefore, tolerance to salt stress varies between cultivars and development stages, with more than one tolerance-controlling gene in each of these stages, in addition to being highly influenced by environmental aspects (Munns, 2005).

Ca is one of the main nutrients in the control of selective absorption of Na and is fundamental for plant growth and development, as well as for maintaining osmotic adjustment and cell turgor, which is essential to maintain the selectivity and integrity of membranes, directly affecting the response of plants under saline conditions (Souza et al., 2020).

For the electrical conductivity of the nutrient solution evaluated, it was verified that the highest accumulation of Ca (0.0622 g plant⁻¹) was obtained at 3.78 dS m⁻¹ (Figure 1D).

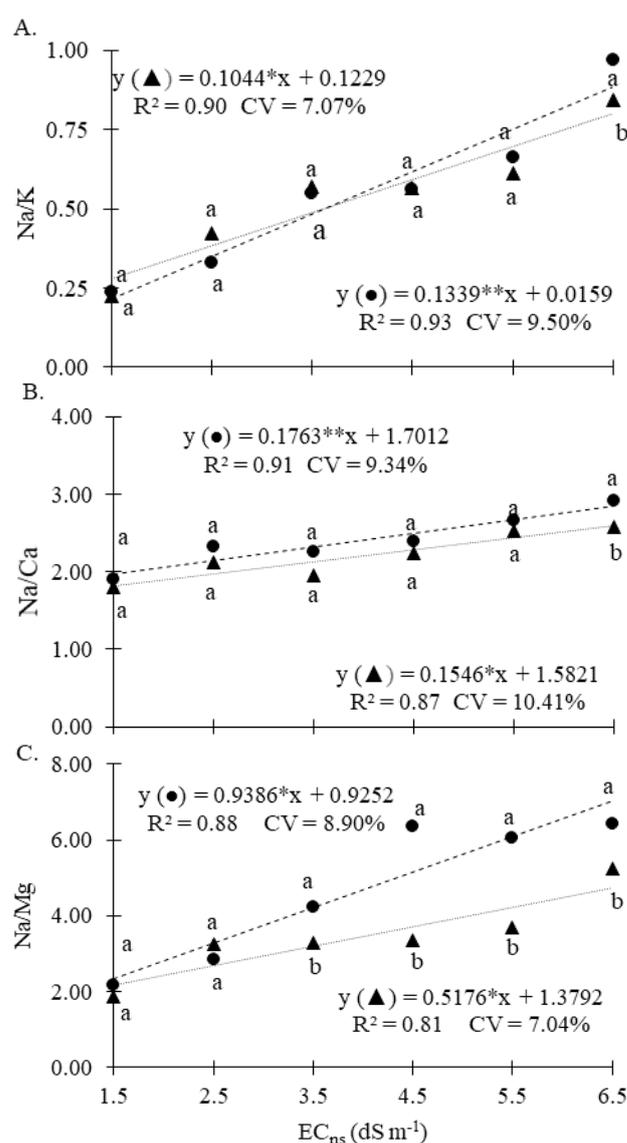
Grangeiro et al. (2006), working with lettuce cultivars Tainá, Babá de Verão and Verônica, obtained Ca accumulations of 0.063, 0.054 and 0.046 g plant⁻¹, respectively, corroborating the results obtained in this study.

There was a significant effect of the interaction between EC_{ns} and cultivars on all cationic ratios evaluated (Na/K, Na/Ca and Na/Mg), which can be verified in Figures 2A, B and C, respectively.

The increase in electrical conductivity of nutrient solution led to progressive linear increments in the Na/K (Figure 2A), Na/Ca (Figure 2B) and Na/Mg (Figure 2C) ratios for both cv. Betty and cv. Mimosa.

By analyzing the cultivars, considering each of the electrical conductivities evaluated (Figure 2A), it can be noted that they showed statistically different behaviors in relation to the Na/K ratio only at the highest electrical conductivity value of the evaluated nutrient solution (6.5 dS m⁻¹), thus evidencing a lesser control in the absorption of Na in comparison to K by the cultivar Betty compared to the cultivar Mimosa at this higher level of electrical conductivity of the solution.

Also according to Figure 2A, each unit increase in the electrical conductivity of the nutrient solution promoted increments in the Na/K ratio of 0.1339 and 0.1044 for the



* and ** - Significant at $p \leq 0.05$ and $p \leq 0.01$ by F test, respectively; Same letters of the mean values indicate non-significant differences between cultivars (● - Betty and ▲ - Mimosa) by the F test ($p \leq 0.05$)

Figure 2. Relations between the accumulations of Na/K (A), Na/Ca (B) and Na/Mg (C) in lettuce crop as a function of electrical conductivity of the nutrient solution (EC_{ns}) in two cultivars

cultivars Betty and Mimosa, respectively. These results can be justified by the fact that, with the increase in salinity, the concentration of Na ions in the nutrient solution also increases, which results in a reduction of K absorption since Na competes for the same absorption site as K (Souza et al., 2020), thus resulting in increase in the Na/K ratio.

Cova et al. (2017) studying lettuce grown with brackish water in different hydroponic systems observed that, with the increase in Na⁺ associated with the reduction of K⁺ accumulations, the Na⁺/K⁺ ratio was high and varied from 1.30 to 1.65 and the growth of plants was reduced; thus, these results were superior to that found in the present study. According to Greenway & Munns (1980), Na⁺/K⁺ ratios equal to or lower than 1.0 are necessary for the occurrence of optimal metabolic efficiency in glycophytes.

The Na/K ratio in the tissue of plants grown under saline conditions is an important indicator of antagonism between

these ions and can be used to quantify the level of competition between them. According to Schossler et al. (2012), the antagonism between K and Na suggests a competition between these ions for plasmalemma absorption sites, or a possible increase in the K efflux from the roots in the growing medium, due to disturbances in membrane integrity.

Likewise, in the Na/Ca ratio, the only statistically divergent level of salinity was also 6.5 dS m⁻¹, at which the cv. Betty showed a higher value (10.06%). Each unit increase in the electrical conductivity of the nutrient solution promoted increases in the Na/Ca ratio of 0.1763 and 0.1546 for the cultivars Betty and Mimosa, respectively.

For the Na/Mg ratio (Figure 2C), it can be noted that from the nutrient solution salinity level corresponding to 2.5 dS m⁻¹ the behavior of the Iceberg cv. Betty, regarding this ratio, was always statistically superior to that observed for the Green-leaf cv. Mimosa. These data show that the Green-leaf cv. Mimosa possibly had higher efficiency of absorption and accumulation of Mg and a greater control of excessive absorption of Na to the detriment of Mg, when compared to the cv. Betty.

It was also observed that the unit increase in electrical conductivity of the nutrient solution enabled increments in the Na/Mg ratio of 0.9386 and 0.5176 for the cultivars Betty (B) and Mimosa (M), respectively (Figure 2C). At high concentrations, Na may interfere in the absorption of both Ca and Mg, due to competition for the same absorption sites in the roots (Marschner, 2012), directly affecting the Na/Ca and Na/Mg ratios, as observed in the present study.

The decreasing order in the accumulation of the evaluated macronutrients and sodium in both cultivars was: K > Na > Ca > Mg. Gondim et al. (2010), evaluating the influence of different electrical conductivities on lettuce yield, verified the following decreasing order of macronutrient accumulation: K > N > Ca > P > Mg.

In fact, despite the fact that the plants have resistance mechanisms that allow to curb the increase of Na accumulation and consequently of all the relations of this ion with essential nutrients, the response of the cultivars Betty and Mimosa differ among the nutrients, showing statistically similar behavior for the relations between Na/Ca and Na/K and distinctions for Na/Mg.

CONCLUSIONS

1. Regardless of the evaluated cultivar, the increase in the electrical conductivity of the nutrient solution reduced the accumulation of dry matter in the aerial part.

2. The cv. Mimosa had Ca and Mg accumulations higher than those found in the cv. Betty, 21.9 and 34.2% higher, respectively, regardless of electrical conductivity of the nutrient solution.

3. The increase in electrical conductivity reduces potassium accumulation by 10.3%, regardless of cultivars evaluated.

4. The decreasing order in the accumulation of macronutrients and sodium in the two cultivars is: K > Na > Ca > Mg.

5. In both cultivars evaluated, the increase in the electrical conductivity of nutrient solution reduces the accumulation of K and Mg and increases the Na/K, Na/Ca and Na/Mg ratios.

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