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Growth, Fiber and Nitrogen Content in Sisal Plants (*Furcraea* sp) Under NaCl Salinity

F. Casierra-Posada¹ · A. Carreño-Patiño¹ · J. Cutler²

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Abstract Soil contains water and nutrients necessary for the development of cultivated plants and serves as a substrate and support in terrestrial ecosystems. For reasons inherent to the nature of soil, salt content can considerably limit the growth of plants. With the implementation of salinity-tolerant crops, saline soils can be transformed into productive and sustainable areas. In Tunja, Colombia, a trial was developed to quantify the changes in growth, water intake, fiber, nitrogen and chlorophyll content in *Furcraea hexapetala* plants exposed to NaCl saline conditions. Plantlets obtained from bulbs were grown in an aerated nutrient solution under greenhouse conditions. Measurements of 30, 60 or 90 mmol NaCl was added to the nutrient solution and control plants were left without addition of salt. As a consequence of salinity, leaf area, leaf area ratio, water uptake, absolute growth rate, relative growth rate, fiber content, dry matter, chlorophyll and nitrogen content in leaves were reduced. The accumulation of dry matter in leaves, stem and roots was especially affected when the plants were exposed to 90 mmol of NaCl. Accumulated dry matter increased in the stems, but reduced in the leaves. These results suggest that plants of *Furcraea hexapetala* can tolerate up to 60 mmol of NaCl (4.9 dS m⁻¹) without substantially affecting the parameters that determine the growth or the fiber content in the leaves.

Keywords Osmotic stress · Leaf area · Water uptake · Biomass · Chlorophyll

Wachstum, Faser- und Stickstoffgehalt in Sisalpflanzen (*Furcraea* sp) unter NaCl-Salinität

Zusammenfassung Der Boden enthält Wasser und Nährstoffe, die für die Entwicklung von Kulturpflanzen notwendig sind und dient als Substrat und Unterstützung in terrestrischen Ökosystemen. Wegen der natürlichen Zusammensetzung des Bodens kann der Salzgehalt das Pflanzenwachstum erheblich einschränken. Mit der Umsetzung von salztoleranten Kulturen können salzhaltige Böden in produktive und nachhaltige Bereiche verwandelt werden. In Tunja, Kolumbien, wurde eine Studie entwickelt, um die Veränderungen des Wachstums, der Wasseraufnahme, des Faser-, Stickstoff- und Chlorophyllgehaltes in *Furcraea hexapetala*-Pflanzen, die NaCl-Salzbedingungen ausgesetzt waren, zu quantifizieren. Aus Bulbillen wurden Pflänzchen gezogen und in einer belüfteten Nährlösung unter Gewächshausbedingungen gezüchtet. Zusätzlich zu den Messungen von 30, 60 oder 90 mmol NaCl, was in der Nährlösung zugesetzt wurde, wurden Kontrollpflanzen ohne Zusatz von Salz analysiert. Wegen des Salzgehalts wurden Blattfläche, Blattflächenverhältnis, Wasseraufnahme, absolute Wachstumsrate, relative Wachstumsrate, Fasergehalt, Trockenmasse, Chlorophyll und Stickstoffgehalt in Blättern der Pflanzen reduziert. Die akkumulierte Anhäufung von Trockenmasse in Blättern, Stamm und Wurzeln war besonders betroffen, wenn die Pflanzen 90 mmol NaCl ausgesetzt wurden. Die akkumulierte Trockenmasse nahm in den Stielen zu, wurde aber in den Blättern reduziert. Diese Ergebnisse deuten darauf hin, dass Pflanzen von *Furcraea hexapetala* bis zu 60 mmol NaCl (4,9 dS⁻¹) tolerieren können, ohne die Para-

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meter, die das Wachstum oder den Fasergehalt in den Blättern bestimmen, wesentlich zu beeinflussen.

Schlüsselwörter Osmotischer Stress · Blattfläche · Wasseraufnahme · Biomasse · Chlorophyll

Introduction

The genus *Furcraea* belonging to the family Agavaceae, is endemic to tropical America, specifically in the Andean region of Colombia and Venezuela, and is distributed both in continental and island localities, from Mexico to Bolivia, and all the islands of the Caribbean (Casierra-Posada and Gómez 2008). Based on its morphology and distribution, four patterns of geographic distribution are recognized: the Mesoamerican mountain region, Caribbean region, Andean region and Amazon region (Casierra-Posada et al. 2006). The plants of this family are traditionally used in the manufacture of food, beverages, sweeteners, and fibers and some species are a promising bioenergy crop (Stewart 2015). Particular species of *Furcraea* are cultivated in Colombia with the purpose of obtaining natural fibers from leaves (Casierra-Posada et al. 2006).

Saline soils have high salt content in the layers where plant roots develop. However, it is difficult to clearly define saline soils since salt damages caused to plants are dependent on species, variety, growth status, environmental supply and the nature of the salts (Yadav et al. 2011). At the global level, salinity considerably limits agricultural production in 397 million hectares in arid and semi-arid regions (Gong et al. 2013). Additionally, it is reported that in Colombia there is an area of 86,592 km² susceptible to salinity, among which 90.3% are in dry regions (Casierra-Posada et al. 2009).

Agave plants use crassulacean acid metabolism (CAM), which consists of a photosynthetic pathway to achieve maximum water use efficiency (WUE) by performing most of the CO₂ uptake during night hours (Lüttge 1993, 2004). In particular, plants of the genus *Furcraea* undergo the CAM pathway. The leaf sap has pH values lower than those found during daylight hours as a consequence of the formation of organic acids at night (Casierra-Posada and González 2009).

The negative effects of salinity on plants have been found to reduce the crude protein and fiber content in shoots and roots of *Lycopersicon esculentum* (Shiyab et al. 2013); high plant mortality, reduction of dry matter, and reduction of Ca, Mg, S and Mn contents in *Agave parryi* and *Agave utaensis* (Bergsten et al. 2016); and the reduction of water use efficiency, root/shoot ratio, specific leaf area and leaf area in *Furcraea* spp (Casierra-Posada et al. 2006). The level of tolerance to salinity in species of the genera *Agave*

and *Furcraea* are species-dependent and it is suggested that some species may be more tolerant to saline conditions than is commonly presumed (Bergsten et al. 2016; Casierra-Posada et al. 2006).

The objective of this study was the quantification of changes in specific growth rates, water intake, fiber content, nitrogen content and chlorophyll in leaves of *Furcraea hexapetala* when the plants grew exposed to saline conditions by NaCl. This information intends to propose alternatives for saline soil affected areas, through the implementation of crops that have some degree of tolerance to this stress-causing factor.

Materials and Methods

The study was carried out in the greenhouse of the Faculty of Agricultural Sciences of the Pedagogical and Technological University of Colombia – UPTC, in Tunja, at an altitude of 2690 m at coordinates 5°33'10.62" North latitude, and 73°21'23.97" West longitude. The average temperature during the test period was 18.6 °C with 71.3% relative humidity, and an average daily illumination of 685 ± 474 μmol m⁻² s⁻¹. The plantlets were obtained from *Furcraea hexapetala* bulbs and placed under hydroponic conditions in containers of 4 L capacity, in a solution, which had the following composition in mg L⁻¹: Nitrogen, 200; Phosphorus, 100; Potassium, 50; Calcium, 2; Magnesium, 10; Sulfur, 15; Iron, 0.2; Manganese, 1; Copper, 3; Zinc, 6; Boron, 4; Molybdenum, 0.1 and cobalt, 0.05. The pH of the solution was adjusted to 6.2 in all cases. The solution in each container was aerated with an aquarium pump in order to avoid conditions of hypoxia in the nutrient solution.

As dependent variables the accumulation of dry mass in leaves, stems and roots was determined by oven drying at a temperature of 50 °C; The leaf area was measured with a Li-Cor 3000A analyzer (Li-Cor, USA); Water consumption was determined by recording the water consumed by each plant every 3 days. Using the absolute growth rate methodology proposed by Hunt (1990), the relative growth rate and leaf area ratio were calculated. The chlorophyll concentration index (CCI) was determined by a Chlorophyll Content Meter CCM-200 (Opti-Sciences, Inc. USA). The crude fiber content in the leaves was determined using the 962.09 method of the Association of Official Agricultural Chemists (AOAC 2012), using a fiber extractor Fiwe 3 Velp® scientifica (Usmate (MB), Italy). The nitrogen content in leaves was determined by the Kjeldahl method, using the Velp® Scientifica DK6 digester and the Kjeldahl UDK 149 Velp® Scientifica distiller (Usmate (MB), Italy).

A completely randomized experimental design was conducted with the source of variation consisting of different doses of NaCl (30, 60 and 90 mmol). Control plants grew

Table 1 Growth and water uptake in plants of *Furcraea hexapetala* exposed to salinity by NaCl

NaCl salinity (mmol)	Leaf area (cm ²)	Leaf area ratio (cm ² g ⁻¹)	Water uptake (L)	Relative growth rate (g g d ⁻¹)	Absolute growth rate (g d ⁻¹)
0	164.18 a	23.58 a	7.02 a	7.3×10^{-3} a	2.90×10^{-2} a
30	145.05 ab	22.91 a	6.35 b	7.4×10^{-3} a	2.67×10^{-2} a
60	123.02 b	23.06 a	6.09 b	6.0×10^{-3} b	1.94×10^{-2} b
90	82.85 c	15.44 b	5.80 b	5.9×10^{-3} b	1.84×10^{-2} b

The information corresponds to average values. Values for a given trait accompanied by the same letter did not show statistically significant differences among treatments according to Tukey's range test ($P < 0.01$)

in the nutrient solution without the addition of NaCl. The electrical conductivity induced by the salinity showed values of 1.2, 3.1, 4.9 and 6.8 dS m⁻¹ for treatments of 0, 30, 60 and 90 mmol of NaCl, respectively. As a result, 4 treatments were obtained each with 20 replications for a total of 80 experimental units. A classical variance analysis was performed with the Tukey's honest significance test ($P < 0.05$). Statistical analyses were performed with version 20.0 of the IBM-SPSS Statistics application. Gradual application of NaCl was carried out 65 days after sowing, and in each case the total dose of the salt was completed in a period of 21 days. The plants were harvested at 204 days after sowing. In this manuscript, the figures are presented in bar format with their respective standard deviation.

Results and Discussion

Growth and Water Intake

Salinity by NaCl adversely affected the leaf size, so a statistically significant difference was found between the leaf area of the control plants and the plants exposed to 60 and 90 mmol of the salt, in which NaCl caused a reduction of 25.0 and 49.5%, respectively, in relation to the leaf area of the control plants (Table 1). Similar to the findings found in the present study, Murillo-Amador et al. (2015) report a decrease in leaf area in *Aloe vera* plants exposed to saline conditions. The leaf area in the different treatments was inversely proportional to the increase of the NaCl content in the substrate.

Based on the findings of different authors, Murillo-Amador et al. (2015) argue that compensatory growth after adjusting for salinity conditions, as well as the ability to increase both leaf area ratio and net assimilation rate, are physiological characteristics that allow plants to tolerate the negative effect of salinity. In addition, they refer to an experiment in which the relative growth rate and leaf area ratio in *Zea mays* (C₄) plants were significantly reduced as a consequence of the salinity by NaCl, after which the net assimilation rate was not affected. In the present work, the leaf area ratio was reduced in all plants exposed to salinity,

however there was no statistically significant difference in the values of this parameter between the control plants and those exposed to 30 and 60 mmol NaCl, despite that salinity reduced this value in the last two treatments. There was a significant difference between the control plants and those that grew under the influence of 90 mmol of NaCl, in which the value of the leaf area ratio was reduced by 34.5% in relation to the control plants (Table 1).

The salinity induced statistically significant differences in the values recorded for the water intake. In this respect, there was only a difference between the control plants and those exposed to salt, regardless of the concentration of NaCl in the nutrient solution. However, there was no significant difference between plants exposed to a salinity of 30 to 90 mmol NaCl. Salinity reduced water intake from 9.5 to 17.4% relative to the water intake recorded in the control plants (Table 1). It is mentioned that CAM plants require 33 and 16% of the water taken by plants C₄ and C₃, respectively, for the production of the same amount of dry matter (Lal 2004; Borland et al. 2009; Escamilla-Treviño 2012). However, these values are altered when the plants are exposed to salinity, according to Casierra-Posada et al. (2006), who mention that the plants of *Furcraea* spp. reduce transpiration under saline conditions, to reduce the transport of toxic ions to the aerial part. In this respect, plants of this genus reduced the amount of biomass produced per liter of water taken from 17.6 to 40.4%, when exposed to contents of 20 to 80 mmol of NaCl in the substrate. On the other hand, the salts in the substrate reduce their osmotic potential, which represents a limitation for water intake. According to Álvarez and Sánchez-Blanco (2014), the reduction in evapotranspiration is a consequence of a low leaf stomatal conductance in the short term and a reduction of leaf area in the long-term when the damages caused by the salts become noticeable in the adult leaves.

In plants exposed to a salinity of 60 and 90 mmol NaCl, the value of the relative growth rate was reduced by 17.9 and 19.4%, respectively, in relation to the control plants. For this variable, the values found in plants exposed to these two treatments presented significant difference with those treated with 30 mmol of NaCl and the control plants. However, no difference was found between the plants ex-

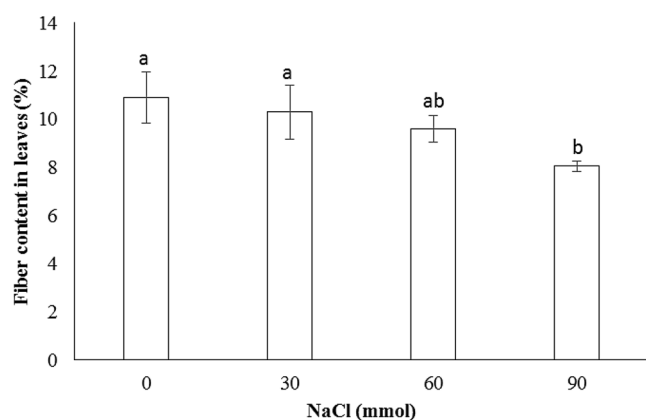


Fig. 1 Fiber content in leaves of *Furcraea hexapetala* exposed to salinity by NaCl

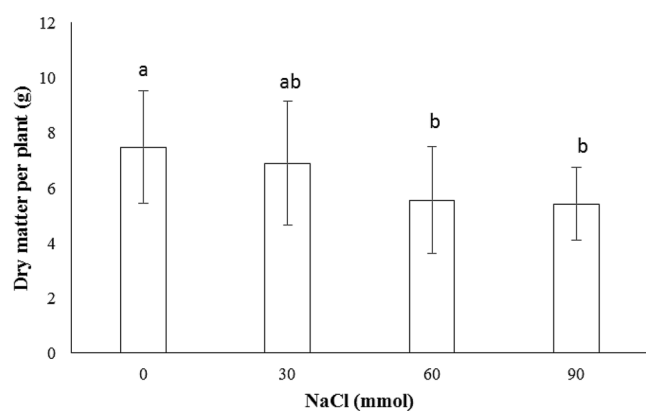


Fig. 2 Dry matter content in plants of *Furcraea hexapetala* exposed to salinity by NaCl

posed to the latter two treatments (Table 1). In this regard, Negrão et al. (2017) mention that that low NaCl concentrations in the substrate have little effect on plant growth, however, with increasing salinity, the relative growth rate is rapidly reduced as a quadratic function of the content of NaCl. Thus, leaf-related parameters such as leaf-specific area and leaf dry mass per unit area are significantly affected by exposure to salinity. Based on these results and considerations, it is possible to say that growth is reduced in plants of *Furcraea* sp. exposed to salinity, which together with the increase in the electrical conductivity of the substrate affects the accumulation of dry matter compared to preexisting dry matter.

The values found for absolute growth rate in plants exposed to 60 and 90 mmol NaCl showed a reduction of 33.0 and 36.6%, respectively, in comparison to the control plants. Only a significant difference was found between the plants submitted to these two treatments and those exposed to 30 mmol of the salt and the control plants (Table 1). In this sense, the salinity by NaCl had a greater negative effect on the absolute growth rate than on the relative growth rate, which indicates that absolute growth rate is more sensitive

to salinity by NaCl and the increase in the electrical conductivity than on the relative growth rate, as Blanco et al. (2007) demonstrated.

Fiber Content in Leaves

The fiber content found in the leaves of plants treated with excess NaCl in the nutrient solution was gradually reduced as the concentration of the salt in the nutrient solution increased. Thus, no statistically significant difference was found between the control plants and those treated with 30 and 60 mmol of NaCl, but between these three treatments and the plants exposed to 90 mmol (Fig. 1). Compared with the values of this variable found in the control plants, the fiber content in the leaves was reduced by 26.0% in the plants exposed to 90 mmol of NaCl. In agreement with this result, Shiyab et al. (2013) found that in *Lycopersicon esculentum* high salinity results in a reduction not only in fiber content, but also in the amount of crude protein, and ash in shoots and roots of these plants. The percentage of fiber of the plants decreased significantly with the increase of the saline stress in comparison with the control. On the other hand, Abdul Khalil et al. (2015) mention that fiber growth and development is affected by most of the factors affecting plant growth. Therefore, since fiber is mainly cellulose, any factor that alters the production of carbohydrates in plants, in the same way affects the growth of the fibers. Thus, salinity has negative effects not only on plant growth, but also on the content and quality of plant fibers.

Dry Material

Salinity caused a reduction in the amount of dry matter produced per plant. In this sense, no statistically significant difference was found between the control plants and those grown under the influence of 30 mmol NaCl, but there was a statistical difference between the control plants and the plants submitted to 60 and 90 mmol of NaCl (Fig. 2). The reduction in dry matter content per plant reached 25.6 and 27.5% in plants exposed to 60 and 90 mmol NaCl, respectively, in relation to the dry matter content found in the control plants.

It has been found that salinity has a negative effect on the photosynthetic rate in plants, which is especially due to the reduction in water potential in plants growing under this stress condition (Yadav et al. 2011). Water use efficiency (WUE) in different species of the genus *Furcraea* has reduced between 23.2 and 40.2% when the plants grew exposed to concentrations of NaCl of 20 to 80 mmol, in relation to the control plants without NaCl. In this regard, it can be argued that if saline stress is due to ionic toxicity, it induces an increase in respiration or a decrease in photosynthesis. Even at low concentrations of salt, the respiratory

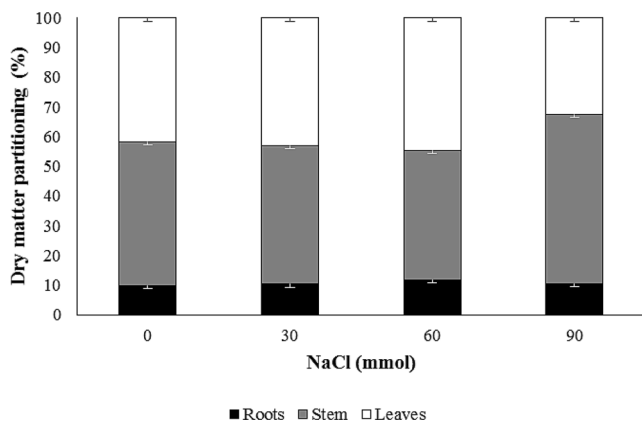


Fig. 3 Dry matter distribution in the organs of *Furcraea hexapetala* plants exposed to saline by NaCl

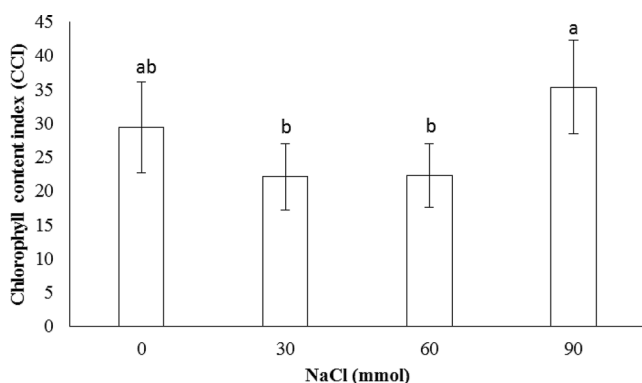


Fig. 4 Chlorophyll content index (CCI) in leaves of *Furcraea hexapetala* exposed to salinity by NaCl

rate increases, with the respective increase in the oxygen consumption, since, under conditions of excess NaCl in the substrate, the Na^+ promotes the formation of ADP and inorganic phosphorus, from the ATP. Therefore, ADP enters the respiratory chain and promotes increased respiration. Both the increase in respiration and the decrease in photosynthesis lead to a decrease in the amount of assimilates produced, which will cause a reduction in the accumulated dry matter in the plant per unit of transpired water, resulting in a low WUE. On the other hand, if stress is the result of low osmotic potential, the plants respond by closing the stomata. Because photosynthesis is affected less by stomatal conductance than by transpiration, WUE would be expected to increase with salinity. However, WUE and salinity showed an inversely proportional behavior, since the proportion of irrigation water used in transpiration is reduced as a consequence of the decrease in the osmotic potential of the substrate. Additionally, the excess of toxic ions, like Na^+ and Cl^- , influences the enzymatic activity and, therefore, has negative consequences on the photosynthesis. In addition, salinity reduces the photosynthetic rate by inducing

irreparable damage to the tonoplast, due to changes in its structure and function (Casierra-Posada et al. 2006).

The dry mass distribution pattern in the different organs of the sisal plants was altered by the exposure of the plants to salinity by NaCl. Statistically significant differences were found for the percentage of dry mass accumulated in leaves, stem and roots of plants exposed to different treatments. The salinity of 30 to 90 mmol of NaCl increased the percentage of dry mass accumulated in the roots. In leaves, the amount of accumulated dry matter was reduced only with the content of 90 mmol, whereas in the treated plants of 0 to 60 mmol, no difference was found and showed high values. On the contrary, in the stems, accumulation of dry matter increased only with the exposure of the plants to 90 mmol, whereas with the treatments of 0 to 60 mmol there was no statistically significant difference and they presented low values of accumulation of dry mass (Fig. 3).

As a consequence of salinity, some halophytic plants like *Atriplex nummularia* increase its leaf succulence. This is possibly due to osmotic adjustment in the cytosol of the cells by the high concentrations of salts and as a result the cells are widened (Silveira et al. 2003). Growth of aerial part organs has been reported to be inhibited when plants develop under salinity conditions. However, in many halophyte plants and in some CAM plant species, the root/shoot ratio decreases when they grow exposed to drought or salinity conditions, suggesting that in CAM plants, root respiration would be very sensitive to both salinity and water stress. In addition, nitrogen assimilation is a significant sink, so changes in sink capacity in salinity-exposed plants could cause a limitation in the rate of nitrate assimilation (Haider et al. 2012). Álvarez and Sánchez-Blanco (2014) found that irrigation with saline water in *Callistemon citrinus* plants resulted in a reduction in total root length. Thus, the number of roots with diameter greater than 0.5 mm increased as a consequence of salinity, although the amount of biomass accumulated in the roots was not affected. The same authors report that in the plants exposed to salinity not only a reduction of 24% was found in the dry weight in the leaves, but leaf area was also reduced by 12%. In this regard, the importance of the duration of saline stress is emphasized, since ionic stress has a more delayed effect than osmotic stress, when the salts reach toxic levels in the adult leaves.

Chlorophyll Content

Regarding the chlorophyll content index (CCI), a statistically significant difference was found between treatments. In the plants treated with the lowest NaCl contents (30 and 60 mmol), the CCI was reduced in relation to the control plants (Fig. 4). The salinity caused a reduction of 24.7 and 24.2% in the value of CCI in plants treated with 30 and

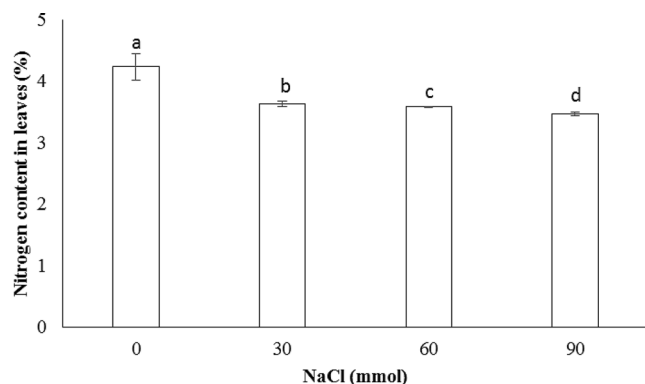


Fig. 5 Nitrogen content in leaves of *Furcraea hexapetala* plants exposed to salinity by NaCl

60 mmol of salt, respectively, compared to control plants. Plants exposed to 90 mmol of NaCl presented a CCI value 20.2% higher than the value measured in control plants.

In relation to the CCI, the effect of salinity found in plants usually decreases with the increase in electrical conductivity (Kiremit and Arslan 2016). However, in some cases the opposite effect has been found (Pirasteh-Anosheh et al. 2014). The higher CCI can be justified based on the approach of Pirasteh-Anosheh et al. (2016), who report an increase in the value of the CCI, directly proportional to the electrical conductivity. They indicate that salinity affects the biological yield more than the uptake of Na. In these findings, the leaves of the plants affected by salinity manifest a more intense green coloration than the control plants.

In Fig. 4, a reduction in the value of CCI was observed when the plants were exposed to the lower doses of NaCl (30 to 60 mmol) used in this assay, which was also reported by Jaleel et al. (2008), who mention that when some plants are exposed to low salinity levels, a reduction in chlorophyll content is observed. However, Pirasteh-Anosheh et al. (2016) refer that in salinity-tolerant species an increase in chlorophyll content can be observed as a consequence of high salinity levels, for the reasons already discussed. These authors also mention that the destruction of chlorophyll and the instability of the protein complexes of these pigments is the main consequence of the reduction in the contents of chlorophyll when the plants grow in moderate saline environments. This could be the consequence of the interference of the salts with the de novo synthesis of proteins that constitute these photosynthetic pigments, rather than of the destruction of the chlorophyll itself. Evidence is brought in the present work, in Fig. 5, where a reduction in nitrogen content was found in the leaves of the evaluated plants.

Nitrogen Content in Leaves

It was found that the nitrogen content in leaves showed a trend inversely proportional to the concentration of the salt in the nutrient solution, with significant differences between all treatments (Fig. 5). A reduction of 0.59, 0.65 and 0.76 units were found in the percentage of nitrogen in leaves of plants exposed to 30, 60 and 90 mmol of NaCl respectively, in comparison to the value recorded in the control plants.

In some cases, a direct relationship has been found between protein content and nitrogen content, however, it is also mentioned that analysis of crude protein content in plants could lead to erroneous conclusions. This is because all nitrogen in plants is assumed to be in the form of protein; however, some salinity-tolerant plants contain high levels of non-protein nitrogen (Masters et al. 2007). Benjamin et al. (1992) mention levels of non-protein nitrogen up to 42%. The reduction in nitrogen content as a consequence of NaCl salinity has caused $\text{Cl}^-/\text{NO}_3^-$ antagonism, reduction in water intake, and consequent decrease in the nitrogen input (Yadav et al. 2011). In addition, it is usual to find that chlorophyll content, photosynthetic rate and quantum yield are reduced in direct relation to the decrease in nitrogen content, which is especially true for CAM plants (Lüttge 2004). On the other hand Bergsten et al. (2016) found differences in nitrogen concentration in *Agave parryi* plants exposed to 3.0 and 6.0 dS m^{-1} , however, there was no clear trend of nitrogen content in relation to NaCl salinity; plants of *Agave parryi* and *Agave weberi* showed differences in nitrogen absorption, however, this result did not seem to be directly related to the level of salinity.

Ullrich (2002) mentions that the uptake of NH_4^+ and NO_3^- , as well as its assimilation in the vegetable can be seen inhibited by high Na^+ contents in different proportions. Çulha and Çakırlar (2011) mention that salinity causes nutritional imbalances, among other effects, thus affecting nitrogen metabolism (Kausar et al. 2014). In addition, salinity-exposed *Triticum aestivum* plants have been found to undergo a considerable reduction in protein content (Yildiz 2007) and also show a decrease in the synthesis of new proteins (Pirasteh-Anosheh et al. 2016). Alterations in nitrogen metabolism as a consequence of salinity occur because NO_3^- is replaced by Cl^- , which significantly alter both the metabolism and the transport of NO_3^- (Engels and Kirkby 2001). Finally, Memon (1999) reports that the activity of nitrate reductase is reduced considerably in plants that grow exposed to salinity, and nitrogen metabolism is altered in an important way.

Conclusions

Furcraea hexapetala plants exhibited moderate tolerance when exposed to NaCl salinity at a concentration of up to 60 mmol (4.9 dS m⁻¹) of salt, based on growth parameters, nitrogen and fiber content in the leaves evaluated in this study. However, when plants were exposed to a concentration of 90 mmol NaCl (6.8 dS m⁻¹) in the nutrient solution, growth rates were negatively modified for plants, and the dry matter content increased in the stem and reduced in the leaves. On the other hand, at this salt concentration, the total dry matter content in the plant decreased by 27.5% and the fiber content was reduced by 26.0% in relation to the control plants, which could significantly affect the income of the growers cultivating this plant for the purpose of obtaining natural fibers.

Conflict of interest F. Casierra-Posada, A. Carreño-Patiño and J. Cutler declare that they have no competing interests.

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