

# Production of watercress with brackish water and different circulation times for the nutrient solution<sup>1</sup>

## Produção de agrião com águas salobras e diferentes tempos de circulação da solução nutritiva

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**ABSTRACT** - In view of the limitations on good quality water, the use of low-quality water in agriculture is seen as a suitable alternative. The aim of this study was to evaluate, in a protected environment, the production of broadleaf watercress in an NFT (Nutrient Film Technique) hydroponic system as a function of the use of brackish water and different circulation times for the nutrient solution. The experiment was carried out in the experimental area of UFC, in Fortaleza, Ceará, from December 2018 to March 2019 (two crop cycles). The treatments were distributed in a randomised block design in a 5 x 2 factorial scheme, five levels of water salinity (0.6, 1.6, 2.6, 3.6 and 4.6 dS m<sup>-1</sup>) and two circulation times for the nutrient solution (10 and 15 min), totalling 10 treatments with 4 replications, resulting in 40 experimental plots. The parameters under evaluation were plant height and number of leaves at 6, 10, 14, 20 and 25 days after transplanting (DAT), leaf area, shoot and root fresh weight, and shoot and root dry weight for each cycle. Water salinity maintained at 2.6 dS m<sup>-1</sup> was considered satisfactory for watercress production in both crop cycles under evaluation. A circulation time of 15 minutes for the nutrient solution gave the best results in the watercress at all levels of salinity.

**Key words:** Nasturtium officinale. Irrigation water salinity. Vegetable.

**RESUMO** - O aproveitamento de águas de qualidade inferior na agricultura tem se tornado uma alternativa condizente, tendo em vista a restrição de água de boa qualidade. Assim, o objetivo deste trabalho foi avaliar, em ambiente protegido, a produção da cultura do agrião d' água da variedade folha larga em sistema hidropônico NFT (técnica do fluxo laminar de nutrientes) em função do uso de águas salobras e tempos de circulação da solução nutritiva. O experimento foi realizado na área experimental da UFC, Fortaleza - CE, no período de dez/2018 a mar/2019 (dois ciclos de cultivo). Os tratamentos foram distribuídos em delineamento de blocos casualizados em esquema fatorial 5 x 2, cinco níveis de salinidade da água (0,6; 1,6; 2,6; 3,6 e 4,6 dS m<sup>-1</sup>) e dois tempos de circulação da solução nutritiva, (10 e 15 min), totalizando 10 tratamentos com 4 repetições, resultando em 40 parcelas experimentais. Os parâmetros avaliados foram altura da planta e número de folhas aos 6; 10; 14; 20 e 25 dias após o transplante (DAT), área foliar, massa fresca da parte aérea e raiz, massa seca da parte aérea e raiz em ambos os ciclos. A salinidade da água mantida em 2,6 dS m<sup>-1</sup> pode ser considerada satisfatória para produção da cultura do agrião, em ambos ciclos de cultivo avaliados. O tempo de 15 minutos de circulação da solução nutritiva foi o que proporcionou os melhores resultados para a cultura do agrião em todos os níveis de salinidade.

**Palavras-chave:** Nasturtium officinalis. Salinidade da água de irrigação. Hortaliça.

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## INTRODUCTION

Due to the current low availability of good quality water for agriculture, various studies and technologies have been generated to tackle these limitations. One of the alternatives is the use of brackish water in agriculture and the use of the hydroponics (SILVA *et al.*, 2018). This technique consists of cultivating without soil, where the plant roots are submerged in an aquatic medium and receive a nutrient solution composed of water and nutrients that are essential for development (SOARES *et al.*, 2015). The system most used in Brazil is NFT (nutrient film technique), in this hydroponic system plants tend to be more tolerant to salts due to the insignificance of the matrix potential (SILVA *et al.*, 2015).

The circulation time of the nutrient solution is an important factor in hydroponics, and is controlled by timer, thereby allowing the system to work according to a programmed schedule. The time interval varies widely between systems, benches, regions, types of cover, cultivated variety, time of year, relative humidity and air temperature, among other factors (FURLANI *et al.*, 2009).

Most studies, regardless of region, use a circulation interval for the nutrient solution of 15 minutes or longer. As such, there is a need to study irrigation intervals for each region, including whether a greater or lesser irrigation frequency (time interval) would reduce the effect of the salt concentration of the water allowing proper plant development, or even increase the effect due to greater exposure.

Cress is a semi-perennial plant that can be grown in water or in soil; it has elliptical leaves and a creeping stem, from which develop thin aquatic roots responsible for removing nutrients from the liquid medium (FILGUEIRA, 2012). It develops best under mild temperatures, and as it is a crop of mild climate and flooded environments, is favoured in hydroponics.

There is little information on this vegetable for either conventional or hydroponic cultivation, particularly cultivation with brackish water; further studies are required to increase this information. Lira *et al.* (2018), evaluating the use of brackish water in cultivating broadleaf watercress in an NFT hydroponic system, obtained results where the fresh and dry weight of the shoots were reduced for an increase in water salinity. Such an effect can be seen in various other crops; Souza Neta *et al.* (2013), evaluating the effect of the salinity of the nutrient solution on the production of arugula, found a reduction in plant growth due to increases in the electrical conductivity of the nutrient solution. Similar results were also found by Mahjoor, Ghaemi and Golabi (2016) in the eggplant, and

by Kiremit and Arslan (2016) in garlic, both showing negative effects due to the increase in water salinity.

In the above context, the aim of this study was to evaluate, in a protected environment, the production of broadleaf watercress in an NFT hydroponic system as a function of the use of water with different salt concentrations and different circulation times for the nutrient solution.

## MATERIAL AND METHODS

The experiment was carried out in a greenhouse of the agro-meteorological station at the Department of Agricultural Engineering (DENA), Pici Campus, Federal University of Ceará, in Fortaleza, located at 3°44'43" S and 38°34'56" W, at an average altitude of 22 m.

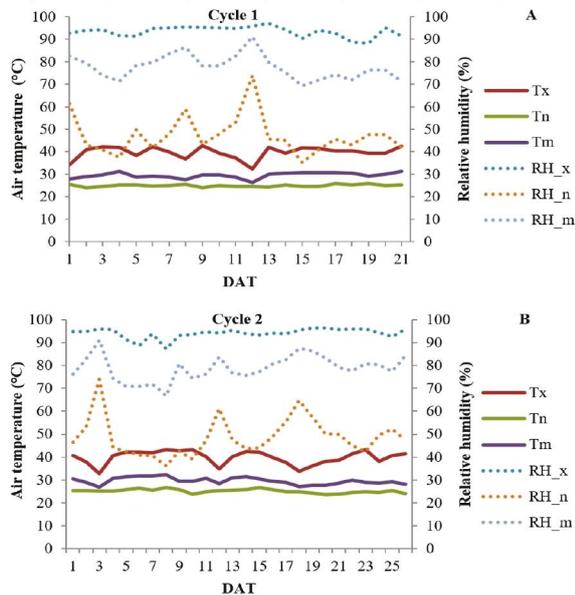
During the experiment, the climate data were collected inside the greenhouse by a HOBO portable weather station data logger (temperature/light/external channel) that took readings every 30 minutes over 24 hours. Figure 1 shows the mean (Tm), minimum (Tn) and maximum (Tx) air temperature, and the mean (RHm), minimum (RHn) and maximum (RHx) relative humidity obtained inside the protected environment during the experiment in the two crop cycles.

The experiment was conducted in an NFT hydroponic system, with the treatments distributed in a randomised block design in a factorial scheme (5 x 2), with five levels of water salinity used in preparing the nutrient solution, (0.6, 1.6, 2.6, 3.6 and 4.6 dS m<sup>-1</sup>), these levels being obtained by adding NaCl to the supply water (0.6 dS m<sup>-1</sup>), and two different circulation times for the nutrient solution (10 and 15 minutes), with 4 replications, giving 40 experimental plots.

After obtaining each of the salinity levels to be evaluated, the macro- and micronutrients were added to make up the nutrient solution as recommended by Furlani (1998). The circulation times were programmed by timer for 10 and 15 minutes.

Each experimental plot consisted of one profile in an independent NFT (nutrient film technique) system (SOARES *et al.*, 2009) composed of PVC tubes, 2.70 m in length and 100 mm in diameter, with 2 openings with a radius of 5 cm, at a spacing between plants and profiles of 0.25 m, to give a total of ten openings, where nine plants were grown per profile. The profiles were installed in the structure at an average height of 0.85 m, with a 3.0% slope to promote runoff and drainage. The nutrient solution, stored in drums of 50 litres, was carried through PVC tubing and injected into the profile via microtubes at a flow rate of 1.5 L min<sup>-1</sup>.

**Figure 1** - Air temperature and relative humidity, (A) Cycle 1 and (B) Cycle 2 in the greenhouse, in the experiment with watercress



Seeds of the broadleaf variety of watercress were used, and sown on 8 December 2018 (first cycle) and 5 January 2019 (second cycle) in trays containing a substrate of coconut fibre. After germination, at 8 days after sowing (DAS), the seedlings received a nutrient solution as recommended by Furlani (1998), diluted to 50%. At 10 DAS, the plants were thinned, leaving one seedling per cell. Thirty days after sowing the seedlings were transplanted to the hydroponic profiles, and the treatments started.

At 6, 10, 14, 20 and 25 days after transplanting (DAT), the following growth characteristics were evaluated: number of leaves per plant and plant height (cm), the latter with the use of a graduated metric rule.

At 20 DAT (Cycle 1) and 25 DAT (Cycle 2), the plants were harvested and weighed with the aid of a precision digital balance (0.01g), to obtain the shoot (SFW) and root fresh weight (RFW). The plants were then packed in previously identified paper bags and left to dry in a forced air circulation oven at 65 °C to constant weight. They were then weighed on a digital balance to give the shoot (SDW) and root (RDW) dry weight. The leaf area ( $\text{m}^2 \text{plant}^{-1}$ ) was determined using a LI-COR model 3100C leaf area meter.

The resulting data were tested for normality and then submitted to analysis of variance (F-test). When significant effects were found, the quantitative data were

submitted to regression analysis and the qualitative data to Tukey's test at 5% probability using the SISVAR v. 5.3 software.

## RESULT AND DISCUSSION

It can be seen from Table 1 that plant height (PH) and number of leaves (NL) were significantly affected by the salinity in both crop cycles. For the time factor, only NL suffered a significant effect from the treatments, at 20 DAT in Cycle 1 and at 25 DAT in Cycle 2. For the interaction of salinity x circulation time, there was an effect from both factors, at 20 DAT for PH in Cycle 1, and for NL in both of the cycles under study.

Figure 2 shows the regression analysis for the isolated effect of salinity on height for each of the evaluation periods in Cycle 1 (6, 10 and 14 DAT) and Cycle 2 (6, 20 and 25 DAT), with the effect of the interaction salinity x circulation time in Cycle 1 (20 DAT), in watercress over two crop cycles.

It can be seen in Cycle 1 that PH (Figure 2A) at 6 DAT showed a negative linear effect, with a reduction of  $0.8209 \text{ cm plant}^{-1}$  for each unit increase in ECa; at 10 and 14 DAT, the adjusted model was quadratic, with fewer ECa values of  $4.6 \text{ dS m}^{-1}$  seen for each of the evaluation periods.

The linear model best fitted the data for the interaction of salinity x circulation time (Figure 2B). However, plant height showed a reduction of  $2.3043 \text{ cm plant}^{-1}$  for Time 1, and  $2.1043 \text{ cm plant}^{-1}$  for Time 2 with each unit increase in ECa.

In Cycle 2 (Figure 2C), the regression models adjusted for 20 and 25 DAT were linear, with a decrease of  $0.902$  and  $2.899 \text{ cm plant}^{-1}$  for each unit increase in ECa respectively.

Lira *et al.* (2019), in studies on the cultivation of watercress and Chinese cabbage using groundwater with an ECa of up to  $13.84 \text{ dS m}^{-1}$ , saw a decrease in growth variables, such as absolute growth and leaf area, in the watercress, due to the frequent application of water with high ECa values, corroborating the results seen in the present study. Prolonged exposure of the crop to water with a high ECa possibly causes a reduction in growth due to the high osmotic potential of the water; strategies that include the use of better quality water to replace the volume lost through evapotranspiration are important (LIRA *et al.*, 2018; SILVA *et al.*, 2015) in order to mitigate the impact on plant development.

From the regression analysis for the number of leaves (Figure 3), it was seen that for the isolated effect

of salinity the linear model best adjusted the data (Figure 3A) in Cycle 1 and (Figure 3B) Cycle 2, and for the interaction of salinity x circulation time in the first and second cycle, the quadratic and linear models were found to be the most appropriate (Figure 3C) (Figure 3D). There was also an isolated effect from the time of circulation for the periods of 10 and 25 DAT during the second crop cycle (Figure 4).

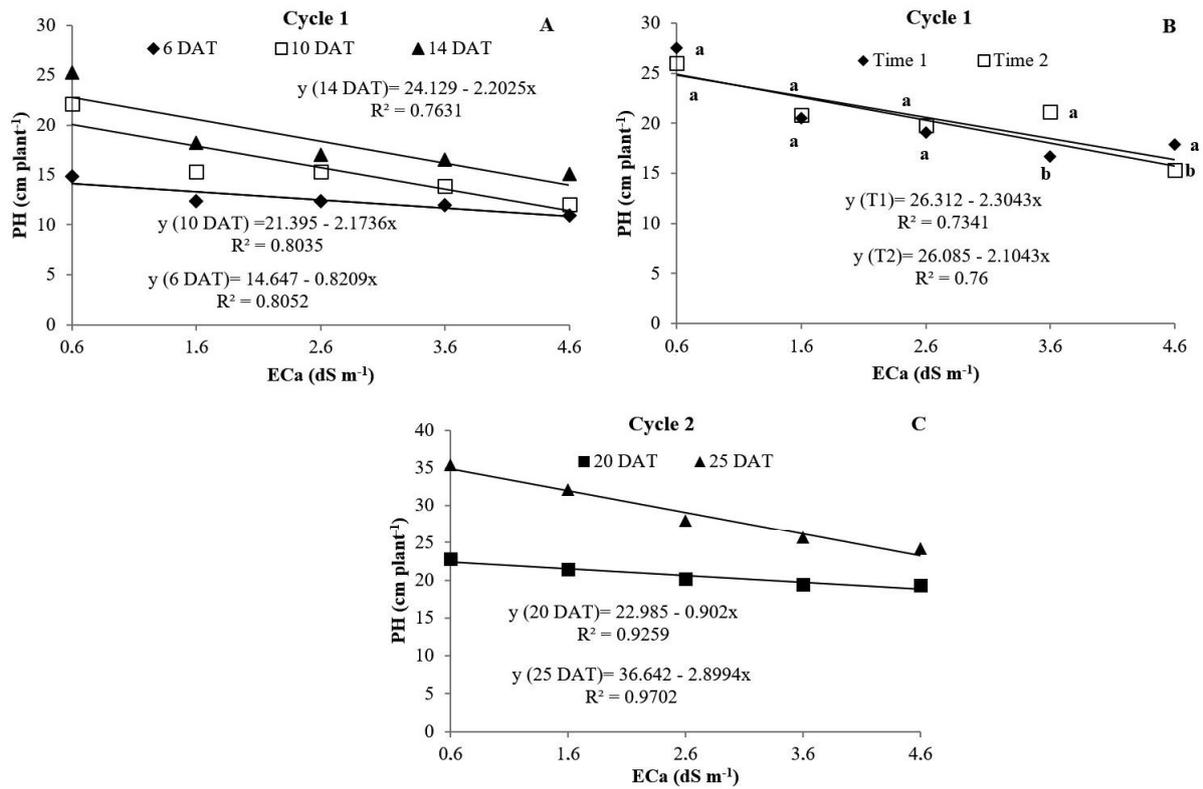
For NL in the different periods under evaluation during Cycle 1 (Figure 3A) the adjustment was linear, with a reduction of 0.4812 leaves plant<sup>-1</sup> at 6 DAT, 0.3668 leaves plant<sup>-1</sup> at 10 DAT and 0.900 leaves plant<sup>-1</sup> at 14 DAT for each unit increase in ECa. In Cycle 2 at 25 DAT (Figure 3B) the decreasing linear regression model best fitted the data, with a reduction of 8.2562 leaves plant<sup>-1</sup> for each unit increase in ECa.

**Table 1** - Summary of the analysis of variance for the growth variables plant height (PH) and number of leaves (NL) in watercress under cultivation with brackish water and different circulation times for the nutrient solution, in two crop cycles

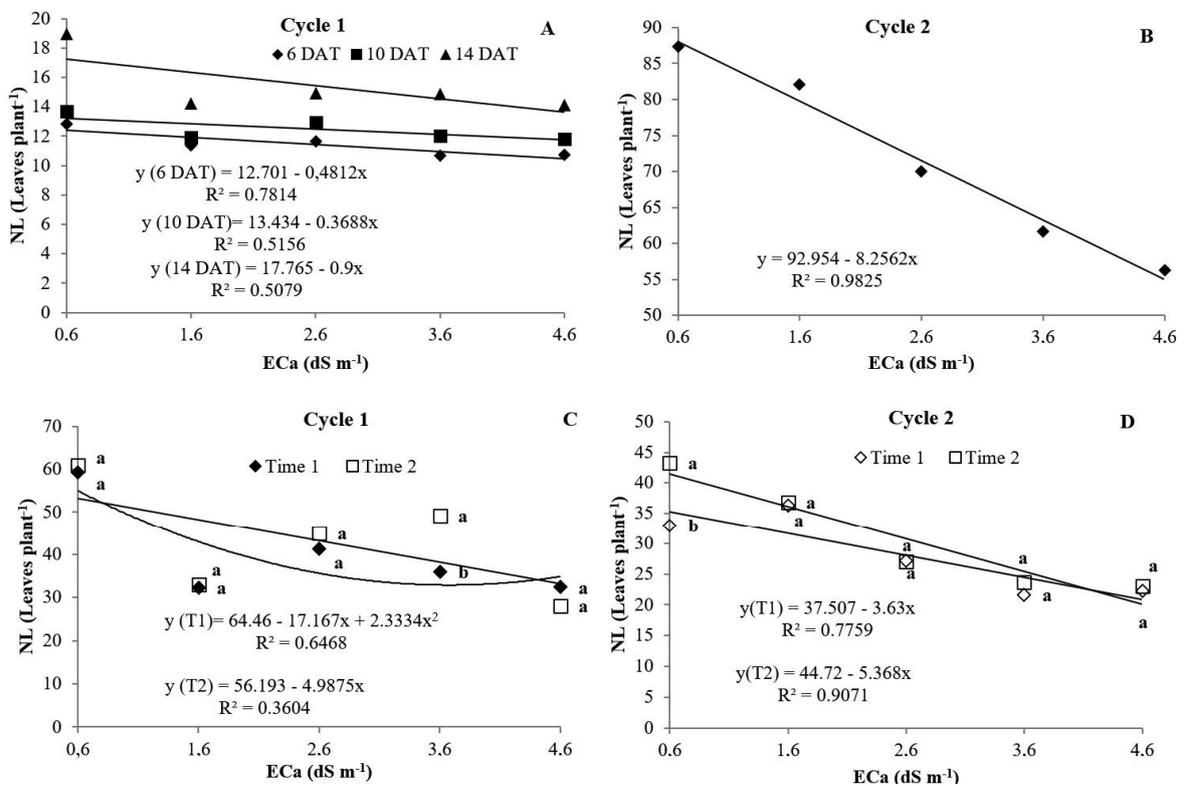
SV	DF	Mean Square				
		PH				
		6 DAT	10 DAT	14 DAT	20 DAT	25 DAT
----- Cycle 1 -----						
Block	3	0.17 <sup>ns</sup>	0.64 <sup>ns</sup>	2.06 <sup>ns</sup>	9.17 <sup>ns</sup>	-
Salinity	4	16.73**	117.60**	127.13**	116.11**	-
Period	1	1.59 <sup>ns</sup>	2.1 <sup>ns</sup>	1.26 <sup>ns</sup>	0.85 <sup>ns</sup>	-
Salinity*Period	4	0.47 <sup>ns</sup>	1.46 <sup>ns</sup>	7.26 <sup>ns</sup>	14.47**	-
Residual	27	0.85	1.94	2.69	2.98	-
CV (%)		7.40	8.85	8.93	8.45	-
----- Cycle 2 -----						
Block	3	0.35 <sup>ns</sup>	1.82 <sup>ns</sup>	5.39 <sup>ns</sup>	1.02 <sup>ns</sup>	1.78 <sup>ns</sup>
Salinity	4	5.55 <sup>ns</sup>	3.19 <sup>ns</sup>	7.95 <sup>ns</sup>	17.57**	173.29**
Period	1	1.1 <sup>ns</sup>	0.99 <sup>ns</sup>	1.46 <sup>ns</sup>	0.062 <sup>ns</sup>	7.78 <sup>ns</sup>
Salinity*Period	4	1.08 <sup>ns</sup>	1.59 <sup>ns</sup>	1.31 <sup>ns</sup>	2.60 <sup>ns</sup>	3.82 <sup>ns</sup>
Residual	27	0.62	1.56	4.00	2.45	4.58
CV (%)		8.46	9.91	13.34	7.60	7.36
----- NL -----						
----- Cycle 1 -----						
Block	3	1.08 <sup>ns</sup>	0.64 <sup>ns</sup>	1.49 <sup>ns</sup>	19.16 <sup>ns</sup>	-
Salinity	4	5.92**	5.27*	31.89**	1117.39**	-
Period	1	1.6 <sup>ns</sup>	1.6 <sup>ns</sup>	0.025 <sup>ns</sup>	87.52*	-
Salinity*Period	4	0.77 <sup>ns</sup>	1.78 <sup>ns</sup>	3.75 <sup>ns</sup>	82.39**	-
Residual	27	0.52	1.06	3.06	14.99	-
CV (%)		6.34	8.26	11.34	9.28	-
----- Cycle 2 -----						
Block	3	1.14 <sup>ns</sup>	0.10 <sup>ns</sup>	0.90 <sup>ns</sup>	1.96 <sup>ns</sup>	44.17 <sup>ns</sup>
Salinity	4	0.96 <sup>ns</sup>	0.70 <sup>ns</sup>	1.94 <sup>ns</sup>	450.23**	1387.64**
Period	1	0.42 <sup>ns</sup>	5.25*	3.30 <sup>ns</sup>	72.63**	459*
Salinity*Period	4	0.36 <sup>ns</sup>	0.39 <sup>ns</sup>	0.57 <sup>ns</sup>	37.24**	112.99 <sup>ns</sup>
Residual	27	1.09	0.87	1.33	5.54	65.69
CV (%)		9.80	7.95	8.06	8.00	11.34

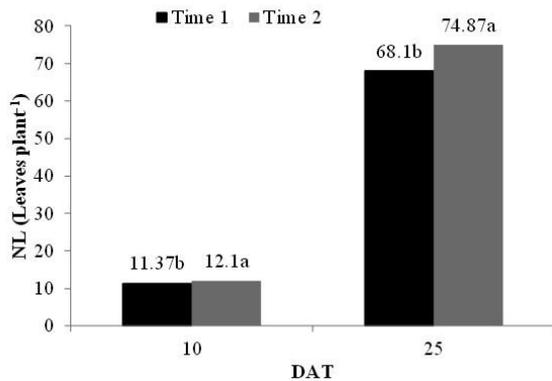
SV - Sources of variation; DF - Degrees of freedom; CV - Coefficient of variation; PH - Plant height; NL - Number of leaves; <sup>ns</sup> - Not significant, \*\*, \* - Significant at 1% and 5% by F-test

**Figure 2** - Regression analysis applied to plant height (A, B) Cycle 1, and (C) Cycle 2, with circulation times of the nutrient solution, in broadleaf watercress under cultivation with brackish water



**Figure 3** - Number of leaves as a function of the isolated effect of salinity (A and B), and the interaction of salinity x circulation time (C and D), in watercress during both crop cycles



**Figure 4** - Isolated effect of time for number of leaves at 10 and 25 DAT (C), in the watercress during Cycle 2

This reduction in the number of leaves in the watercress may have been influenced by the difficulty of the plants to absorb water due to undergoing salt stress from the increase in the ECa of the nutrient solution. A reduction in the number of leaves under conditions of salt stress is an adaptation by the plants to maintain water absorption, and is a result of morphological and anatomical changes in the plants, reflected in a reduction in transpiration to maintain water absorption (FERNANDES *et al.*, 2018).

A quadratic model was seen in Cycle 1 (Figure 3C) for the interaction of salinity x circulation time, with lower ECa values of 4.6 dS m<sup>-1</sup> for Time 1; for Time 2, a linear model was seen, with a decrease of 4.9875 leaves plant<sup>-1</sup> for each unit increase in ECa. A reduction in the number of leaves was also found by Moraes *et al.* (2014), in lettuce when using wastewater, with good crop yields up to a salinity of 3.6 dS m<sup>-1</sup> the.

In Cycle 2 (Figure 3 D), a linear effect was seen for the interaction of salinity x circulation time, with a reduction of 3.63 leaves plant<sup>-1</sup> for Time 1 and 5.36 leaves plant<sup>-1</sup> for Time 2, for each unit increase in ECa.

Figure 4 shows the mean values for the number of leaves in Cycle 2 at 10 and 20 DAT as a function of the circulation time of the nutrient solution. It can be seen that the circulation time of 15 minutes (T2) afforded a greater number of leaves (mean of 12.1 and 74.87 leaves plant<sup>-1</sup>). This may have been due to the longer circulation time.

According to the analysis of variance (Table 2), there was a significant effect from water salinity on all the variables in both cycles ( $p < 0.05$ ). There was a significant interaction between the salinity and time treatments for leaf area and shoot fresh weight in Cycle 1, and shoot dry weight in both cycles.

**Table 2** - Summary of the analysis of variance for leaf area (LA), root fresh weight (RFW), root dry weight (RDW), shoot fresh weight (SFW) and dry shoot weight (SDW), in watercress under cultivation in brackish water and different circulation times for the nutrient solution, in two crop cycles

SV	DF	LA	RFW	RDW	SFW	SDW
Cycle 1						
Block	3	0.000049 <sup>ns</sup>	0.84 <sup>ns</sup>	0.059 <sup>ns</sup>	1.91 <sup>ns</sup>	0.31 <sup>ns</sup>
Salinity	4	0.00105**	1.62 <sup>ns</sup>	0.062**	652.92**	10.99**
Time	1	0.000023 <sup>ns</sup>	0.69 <sup>ns</sup>	0.193**	31.38**	0.032 <sup>ns</sup>
Salinity*Time	4	0.00015 <sup>ns</sup>	2.38 <sup>ns</sup>	0.077**	15.29**	0.34*
Residual	27	0.00011	0.92	0.05	2.14	0.10
CV (%)		22.36	18.23	10.84	7.36	11.33
Cycle 2						
Block	3	0.000224*	0.27 <sup>ns</sup>	0.025 <sup>ns</sup>	3.63 <sup>ns</sup>	0.078 <sup>ns</sup>
Salinity	4	0.002618**	17.74**	0.037 <sup>ns</sup>	681.12**	10.27**
Time	1	0.000397*	0.057 <sup>ns</sup>	0.193 <sup>ns</sup>	2.76 <sup>ns</sup>	0.011 <sup>ns</sup>
Salinity*Time	4	0.000759**	0.98*	0.046 <sup>ns</sup>	32.48 <sup>ns</sup>	0.34**
Residual	27	0.000061	0.24	0.016	14.05	0.64
CV (%)		18.26	7.57	21.70	14.86	7.50

SV - Sources of variation; DF - Degrees of freedom; CV - Coefficient of variation; LA - Leaf area; RFW - Root fresh weight; RDW - Root dry weight; SFW - Shoot fresh weight; SDW - Shoot dry weight; <sup>ns</sup> - Not significant, \*\*, \* - Significant at 1% and 5% by F-test

Figure 5A shows an isolated effect of water salinity on leaf area in Cycle 1, where the linear model best fitted this variable, with a reduction of 0.0064 m<sup>2</sup> plant<sup>-1</sup> for each unit increase in ECa. These results show that a high salt concentration affects the leaf area of the watercress.

In Cycle 2 (Figure 5B), a linear model (Time 2) and quadratic model (Time 1) were found for the interaction of salinity x circulation time. For Time 1, the greatest value for leaf area was 0.047 m<sup>2</sup> plant<sup>-1</sup> at a salinity of 1.7 dS m<sup>-1</sup>, showing a reduction of 43.41% in relation to the ECa of 4.6 dS m<sup>-1</sup>. However, a linear model was found for Time 2, with a reduction of 0.015 m<sup>2</sup> plant<sup>-1</sup> for each increase in ECa. Comparing the two circulation times using the mean value comparison test, a difference can be seen for salinity of 0.6, 2.6 and 3.6 dS m<sup>-1</sup>, with higher mean values for Time 2 followed by Time 1.

This reduction in leaf area under saline conditions may be a way for the plants to prevent water loss. A reduction in leaf area is an important adaptive mechanism of plants grown under both an excess of salts and water stress. Under

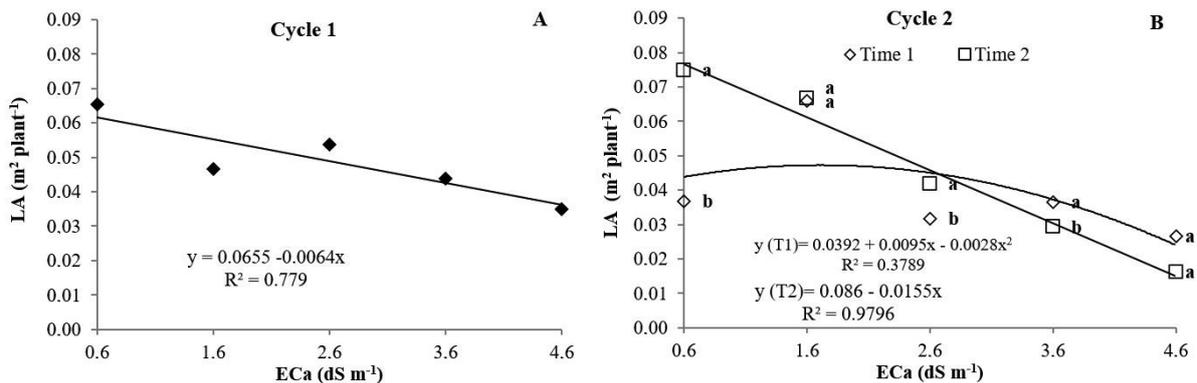
such conditions, it is important to conserve water in the plant tissue, reduce transpiration and, consequently, the loading of Na<sup>+</sup> and Cl<sup>-</sup> ions to the xylem (TAIZ *et al.*, 2017).

When plants are subjected to salt stress, leaf expansion is reduced due to the delay in leaf emission, thereby reducing the leaf area available for photosynthesis, this effect being even more pronounced when exposure to stress is prolonged (NIU; STARMAN; BYRNE, 2013).

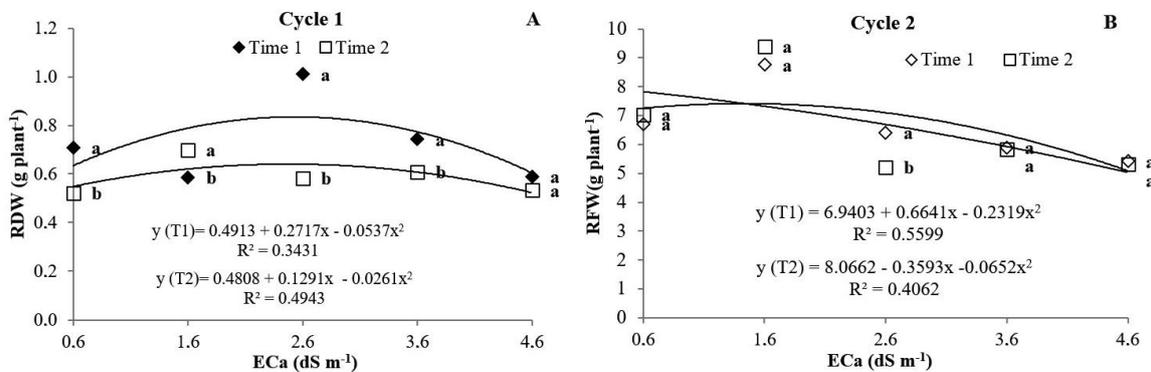
The quadratic regression model best adjusted the RDW and RFW data in Cycle 1 and Cycle 2 as a function of the interaction of salinity x circulation time of the nutrient solution (Figure 6).

The maximum production of root dry weight in Cycle 1 (Figure 6A) for Time 1 and Time 2 was 0.83 and 0.57 g plant<sup>-1</sup> for a salinity of 2.5 dS m<sup>-1</sup>, with a reduction of 29% and 9% due to this lower production. In Cycle 2 (Figure 6B), the maximum production of shoot fresh weight for Time 1 and Time 2 was 7.41 and 6.62 g plant<sup>-1</sup> for a salinity of 1.5 and 2.7 dS m<sup>-1</sup>, with a reduction of 27% and 20% at the highest EC values.

**Figure 5** - Leaf area in watercress as a function of water salinity in Cycle 1 (A), and the interaction of water salinity x circulation time in Cycle 2 (B)



**Figure 6** - Effect of water salinity and circulation time on root dry weight (A) and root fresh weight (B) in the first and second production cycles



One factor that may have contributed to the greater accumulation of root matter at the circulation time of 10 minutes for the nutrient solution was the more-frequent application of the treatment providing more available water, possibly favouring root development in the crop.

Silva *et al.* (2018), evaluating the production of two lettuce cultivars in a hydroponic system, found that root dry weight in red lettuce showed a significant difference between treatments with fresh water and water containing NaCl; furthermore, the water containing NaCl gave low RDW values.

From the regression analysis for shoot fresh and dry weight, it was found that the decreasing linear model best fitted the interaction of water salinity x circulation time of the nutrient solution (Figure 7).

The values for shoot fresh weight in Cycle 1 (Figure 7A) for both Time 1 and Time 2 showed a reduction of 5.0354 g plant<sup>-1</sup> and 5.6996 g plant<sup>-1</sup> respectively for each unit increase in ECa.

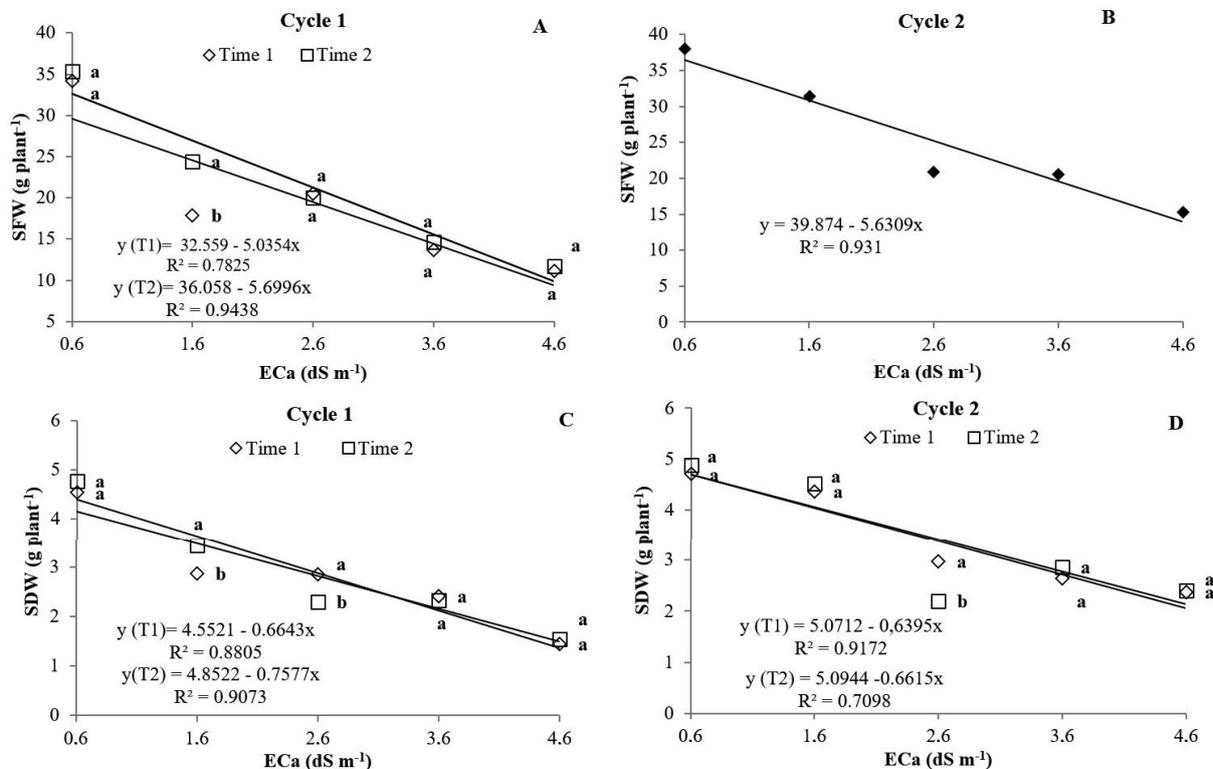
These results are similar to those found by Rebouças *et al.* (2013), who evaluated the effect of using five levels of saline waste mixed with well water on the growth of coriander in a hydroponic system, and saw a

linear reduction in the production of shoot fresh weight for increases in the level of salinity, and by Guimarães *et al.* (2017), who also found a significant effect from water salinity, causing a reduction in shoot fresh weight in cultivars of hydroponic lettuce.

For shoot dry weight (SDW), the linear model best fitted the interaction of water salinity x circulation time in both crop cycles (Figure 7C and D). However, SDW showed a reduction of 0.6643 g plant<sup>-1</sup> for Time 1 and 0.7577 g plant<sup>-1</sup> for Time 2 in the first cycle, and 0.6395 (Time 1) and 0.6615 (Time 2) g plant<sup>-1</sup> in the second cycle for each unit increase in ECa. The mean value comparison test between circulation times at the different salinities under evaluation showed a statistical difference at the salinity of 1.6 dS m<sup>-1</sup> with the greatest mean value in Time 2, and for the salinity of 2.6 dS m<sup>-1</sup> with the greatest mean value in Time 1, for the first and second crop cycles respectively.

A linear reduction in shoot dry weight in coriander plants was found by Rebouças *et al.* (2013) of 79%, from the lowest (2.55 dS m<sup>-1</sup>) to the highest (12.34 dS m<sup>-1</sup>) salinity. Jesus *et al.* (2015), evaluating the response to salinity of two arugula cultivars grown in a hydroponic system, found that due to the increase in salt concentration there was a progressive reduction in shoot fresh and dry weight. Lira *et al.* (2018), evaluating the use of brackish

**Figure 7** - Effect of water salinity and circulation time of the nutrient solution on shoot fresh weight (A and B) and shoot dry weight (C and D) in the first and second production cycles respectively



water in cultivating broadleaf watercress in an NFT hydroponic system, found a reduction in shoot fresh and dry weight for increases in water salinity.

Bonasia *et al.* (2017), studying the best management for a nutrient solution in two genotypes of arugula, found that the electrical conductivity of the nutrient solution at 3.5 dS m<sup>-1</sup> afforded greater yield, and that at the highest EC value, the fresh and dry weight of the crop was reduced. Gioia *et al.* (2018), also found this effect when evaluating the application of saline and non-saline irrigation water in broccoli, the authors found that the application time of the saline water influenced the growth and yield of the crop.

## CONCLUSIONS

1. Water salinity maintained at 2.6 dS m<sup>-1</sup> can be considered acceptable for watercress production in both of the crop cycles under evaluation;
2. The circulation time of 15 minutes for the nutrient solution afforded the best results for the watercress at all salinity levels.

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