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Production, water consumption and nutrient content of Chinese cabbage grown hydroponically in brackish water[1]

Produção, consumo hídrico e teores de nutrientes da couve chinesa cultivada hidroponicamente com águas salobras

Raquele Mendes de Lira[2], Ênio Farias de França e Silva[3], Gerônimo Ferreira da Silva[4]*, Alexandre Nascimento dos Santos[5] e Mário Monteiro Rolim[3]

ABSTRACT - Underground water reserves in the semi-arid region of Brazil are stored in the crystal formations that in large part have high concentrations of salt. However, the scarcity of this resource makes the use of this water necessary for various activities, including agriculture. The aim of this study was to evaluate the use of brackish water on the electrical conductivity and pH of the nutrient solution, and on the production, water consumption and the uptake of nutrients in Chinese cabbage (*Brassica pekinensis* L.) under a hydroponic system. The experimental design was completely randomised, with four replications and six levels of water salinity (0.2, 1.2, 2.2, 3.2, 4.2 and 5.2 dS m^{-1}), obtained by adding NaCl to the local water supply, with this water being used to prepare the nutrient solution and to make up the volume lost through evapotranspiration. The results showed that with the exception of the treatment at the lowest salinity, there was a tendency to increased electrical conductivity of the nutrient solution with the increasing salinity of the water; that the pH of the nutrient solution remained within the normal range throughout the cycle; that with the increasing salinity of the solution there was a reduction in all growth and production variables under analysis, in water consumption, and in leaf N, K, Ca and Mg, and an increase in leaf concentrations of Na and Cl. It is possible to use brackish water for the production of Chinese cabbage when grown hydroponically as an alternative for those producers who have an available supply of brackish water and a restricted supply of fresh water, however with a reduction in productivity.

Key words: *Brassica pekinensis* L.. Nutrient solution. Salinity. Mineral nutrition.

RESUMO - As reservas hídricas subterrâneas no Semiárido do Brasil estão armazenadas nas formações cristalinas que apresentam, em grande parte, elevadas concentrações salinas. Entretanto, a escassez do recurso obriga a utilização dessas águas para diversas atividades, inclusive a agricultura. Objetivou-se, com este trabalho, avaliar o emprego de águas salobras na condutividade elétrica e pH da solução nutritiva, na produção, no consumo hídrico e na extração de nutrientes, por couve chinesa (*Brassica pekinensis* L.), em sistema hidropônico. O delineamento experimental utilizado foi o inteiramente casualizado com quatro repetições e seis salinidades da água (0,2; 1,2; 2,2; 3,2; 4,2 e 5,2 dS m^{-1}), obtidos pela adição de NaCl na água de abastecimento local, sendo estas águas utilizadas no preparo da solução nutritiva e na reposição do volume evapotranspirado. Verificou-se por meio dos resultados obtidos que, à exceção do tratamento de menor salinidade, nos demais tratamentos houve tendência de aumento da condutividade elétrica da solução nutritiva, com o incremento da salinidade da água; o pH da solução nutritiva permaneceu dentro da faixa de normalidade durante todo o ciclo; houve redução de todas as variáveis de crescimento e de rendimento analisadas, do consumo hídrico, dos teores foliares de N, K, Ca e Mg e, aumento nos teores foliares de Na e Cl, com o aumento da salinidade da solução; é possível utilizar água salobra para a produção de couve chinesa, em cultivo hidropônico, como alternativa para produtores que tenham disponibilidade de água salobra e restrição à disponibilidade de água doce, porém com redução de produtividade.

Palavras-chave: *Brassica pekinensis* L.. Solução nutritiva. Salinidade. Nutrição mineral.

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INTRODUCTION

In Brazil, the semi-arid regions are the areas most affected by water shortages. These regions have reserves of groundwater which can be used to meet the demand, however the water from these sources often has a high concentration of salts, which restricts its use for the irrigation of crops grown in the ground (ANDRADE JÚNIOR *et al*., 2006).

In light of this, hydroponics has emerged as an alternative technology, enabling the use of brackish water in crop production (SANTOS *et al*., 2010). The expansion of this cropping system has become a reality in Brazil in recent years and various researchers have joined forces so as to produce information which will contribute to the spread of this technique to the semi-arid region of north-eastern Brazil; the main focus of these studies being the relationship between plant production in hydroponic systems and the use of brackish water (GOMES *et al.*, 2011; HOSSAIN; NONAMI, 2012; SANTOS *et al.*, 2011; SOARES *et al.*, 2013.).

In this type of cultivation, the level of salinity tolerated by crops is higher than in conventional farming due to the greater and constant availability of water and nutrients in the various types of hydroponic systems and the small or non-existent contribution the matric potential makes to the total water potential, with this representing a greater uptake of water and nutrients by the plants for the same quantity of salts (SOARES *et al*., 2007).

Given this hypothesis, crops in general, especially those of a short cycle, when grown in hydroponic systems should favour the use of brackish water, due to the lower exposure to salt stress reflecting directly in a reduction of the damage caused by such stress. So with the use of brackish water in hydroponics, it can expected that crops of interest be produced, such as the Chinese cabbage, with greater savings in water and input efficiency, lower environmental risk and less depletion of commercial revenue (MACIEL *et al*., 2012).

The Chinese cabbage also known as “nappa” cabbage, is very nutritious. It is an excellent source of folic acid (important for blood formation), vitamin A, the B vitamins, and calcium. It also provides vitamin C and mineral salts such as sodium, potassium, magnesium and calcium (EVANGELIST *et al*., 2009).

In Brazil, the use of Chinese cabbage in human food has been excessive, with a consumption of approximately 500 g person^{-1} day^{-1} (GORDIN *et al*., 2010). Nevertheless, information on production of the crop in hydroponic systems using brackish water is still relatively new or even non-existent in the country, this being reflected in a widespread lack of scientific studies related to the crop.

In this respect, the search for information on the use of brackish water in the hydroponic cultivation of Chinese cabbage becomes of fundamental importance to perfect investment in the hydroponic production of the crop, especially in the Brazilian semi-arid region. Furthermore, using this water in the production of the vegetable can be an alternative source of income for that farmer who can only count on the option of brackish water on his property.

In light of the above, this study aimed to evaluate the use of brackish water on the electrical conductivity and pH of the nutrient solution, and on the production, water consumption and nutrient uptake of Chinese cabbage in an NFT hydroponic system.

MATERIAL AND METHODS

The experiment was conducted at the Federal Rural University of Pernambuco (UFRPE), on the University Campus in Recife in the state of Pernambuco, Brazil (8°01’05” S, 34°56’48” W; altitude 6.5 m).

The research was carried out in a greenhouse having an arch-shaped cover of transparent, 0.10 mm thick polyethylene film of low density with anti-UV additive, 7.0 m wide and 24.0 m long, with a ceiling height of 3.0 m and height of 4.5 m at the centre. The front and side walls were made from screens with a 0.2 m baseboard of reinforced concrete.

A hydroponic structure was constructed comprising 24 plots. Each plot represented one independent NFT (nutrient film technique) hydroponic system, similar to that described by Soares *et al*. (2009), containing a plastic reservoir with a capacity of 60 litres and a 32 W, 220 V electric circulating pump. The structure consisted of hydroponic profiles of polypropylene, with a commercial diameter of 75 mm, length of 3 m and holes of 25 mm radius, at a spacing of 0.25 m between plants by 0.30 m between profiles and with five plants per profile.

The profiles were installed at a height of 0.85 m with a 5% inclination to promote the flow and drainage of the solution. The injected solution ran down the profile slope at an average rate of 1.5 L per minute, the flow being regulated with the aid of a stopcock. Any surplus not injected into the profile returned to the reservoir through a return pipe, thus favouring aeration of the nutrient solution.

Individual automatic supply systems (of 15 L in volume) were also set up for each plot for the replacement of water lost by evapotranspiration, the dispensers consisting of a continuous section of PVC pipe with a diameter of 150 mm, equipped with a graduated rule, fixed near a transparent hose for reading the water level, and connected to a ball cock, which automatically output water to the nutrient solution tank.

Seeds of Chinese cabbage were placed into 2 x 2 x 2 cm cells of phenolic foam to germinate, with three seeds per cell. After sowing, the phenolic foam plates were kept in a darkened environment until the seeds germinated, remaining in this environment for around 30 hours. The seedlings were then transferred to the NFT hydroponic nursery inside the greenhouse and irrigated with a 50% diluted nutrient solution (FURLANI, 1998).

During the day, from 0700 to 1800, irrigation of the nursery was controlled by an electric timer set for regular intervals of 15 minutes between each irrigation, also with a duration of 15 minutes. From 1800 to 0700, the timer was programmed for one fifteen-minute irrigation every 2 hours.

At eight days after sowing (DAS), the plants were thinned, leaving only one plant per cell. The seedlings continued in the nursery for 15 DAS, and were then transplanted to the hydroponic profiles and submitted to the above treatments, together with the nutrient solution proposed by Furlani (1998) for leafy vegetables.

The experimental design was completely randomised with six treatments and four replications. The treatments comprised the salinities of the water (0.2, 1.2, 2.2, 3.2, 4.2 and 5.2 dS m^{-1}), defined on the basis of salinities used by Santos *et al*. (2010), as there are no studies on the Chinese cabbage in the literature. The water was produced by applying NaCl to the supply water until the desired electrical conductivity was reached using a conductivity meter, this water was then used to prepare the nutrient solution and to replace the volume lost by evapotranspiration.

Each type of water was prepared in a 500 L capacity tank, by measuring the electrical conductivity (ECw) and pH and then adding the macro and micronutrients to produce the nutrient solution, following recommendations proposed by Furlani (1998). To add the micronutrients, 1 L of a 1,000x stock solution was prepared; an individual stock solution was made up for iron at the same proportion as the other micronutrients. After homogenisation, readings were taken of the pH and electrical conductivity of the solution (ECsol).

Data of temperature and relative humidity were collected daily inside the greenhouse for a period of 24 hours using a portable data logger, the temperature varying from 24.3 to 28.2 °C respectively for the minimum and maximum temperatures recorded. The relative humidity ranged from 74 to 86% respectively for the minimum and maximum humidity recorded. Readings of the ECsol and pH were also taken every other day. However, with a view to simulating real field conditions, and assuming that the farmer does not have the available material for such an adjustment, the pH was not corrected to the optimal range of 5.5 to 6.5. Replacement of the nutrient solution of the treatments was done whenever the ECsol of the control treatment reached a value of less than 1.0 dS m^{-1}.

Plants were harvested every two weeks and separated into shoots and roots. The shoots were weighed on precision scales (0.01 g) to obtain the fresh matter production, and were then dried in a forced air circulation oven at 65 °C to constant weight, to get dry matter production. After drying and weighing, the leaves were ground to determine the levels of mineral nutrients, as recommended by Bezerra Neto and Barreto (2011).

Leaf area was determined from leaves scanned with the aid of computer software. The number of leaves per plant was obtained by counting them individually, and the absolute growth rate (AGR) and relative growth rate (RGR) for each harvest were obtained according to Benincasa (1988).

Water consumption per treatment, daily and throughout the cycle, was evaluated by means of readings taken by the automatic dispensers, and the volume of evapotranspiration subsequently calculated according to equation (1):

$$VEtc = \underline{(Rf-Ri) \times \pi \times D^2}/\, 4 \times n \times \Delta T \times 10^6 \quad (1)$$

where: *VEtc* - volume of evapotranspiration, in mL $plant^{-1}$; *Rf* - final reading of the water level in the tank, m; *Ri* - initial reading of the water level in the tank, m; *D* - internal diameter of the reservoir, m; *ΔT* - time interval between readings, and *n* - number of plants in the profile for the time interval *ΔT*.

The results were submitted to variance analysis ($p \leq 0.05$). When a significant effect was found for the treatments, a breakdown of the degrees of freedom of these treatments was made, and the mean values for each treatment adjusted by a simple linear regression model.

RESULTS AND DISCUSSION

In Figure 1 are shown the values for electrical conductivity and pH of the nutrient solution of the treatments being studied.

It can be seen that in treatment 1 (T1), in which the nutrient solution was prepared only with water from the water supply (0.2 dS m^{-1}), there was a decrease in ECsol over time (Figure 1A). It is possible to attribute this to the nutrient consumption of the plants being greater than the accumulation of salts dissolved in the water used for replacement. On the other hand, in the remaining treatments there was a small increase in the salinity of the nutrient solution throughout the cycle due to an accumulation of salts from an increase in the salinity of the water used in preparing the nutrient solution and the absorption of less nutrients with these treatments.

In a study with NFT hydroponics using brackish water for the production of lettuce, Alves *et al*. (2011), Santos *et al*. (2010) and Smith *et al*. (2010) obtained results for electrical conductivity of the nutrient solution throughout the cycle similar to those seen in this study.

It can be seen that in general the pH of the nutrient solution varied within a range of 5 to 7.5 (Figure 1B), that is, within a range where the pH does not adversely influence the crop (Maciel *et al*., 2012). According to Furlani *et al*. (1999), variations in pH of between 4.5 and 7.5 do not affect plant development under hydroponics, however for situations where the acidity is less than 4, some damage may occur to the cell membrane, and in situations where the alkalinity is greater than 8, there is a deficiency of some nutrients, such as iron and phosphorus.

The increase in EC values of the nutrient solution reduced the value linearly for each of the variables of growth and yield being analysed (Table 1).

Percentage decreases can be seen of the order of 18, 8.05, 12.4, 12.5, 14.6, 7, 13.4 and 5.9% for the variables leaf area, number of leaves, shoot fresh weight and shoot dry weight, absolute growth rate of the shoot fresh and dry weight and relative growth rate of the shoot fresh and dry weight (Table 1).

The reductions in shoot fresh and dry weight seen in this study may be related to the reduction in osmotic potential of the solution resulting in an inadequate supply of nutrients, due to an ionic imbalance caused by an excess of Na^+ and Cl^- ions, as inferred by Tester and Davenport (2003). Similarly, finding a significant effect of water salinity on the variables LA and LN (Table 1) shows that under the conditions of salinity being tested, the crop of Chinese cabbage reduced FMS by a reduction in both the size and number of leaves.

The results for shoot fresh and dry matter found in this study are consistent with those observed by Paulus *et al*. (2010), who also noted reductions for these variables at the expense of increased salinity of the nutrient solution.

Figure 1 - Mean values for electrical conductivity (A) and pH (B) of the nutrient solution during the experiment at UFRPE in Recife, 2012

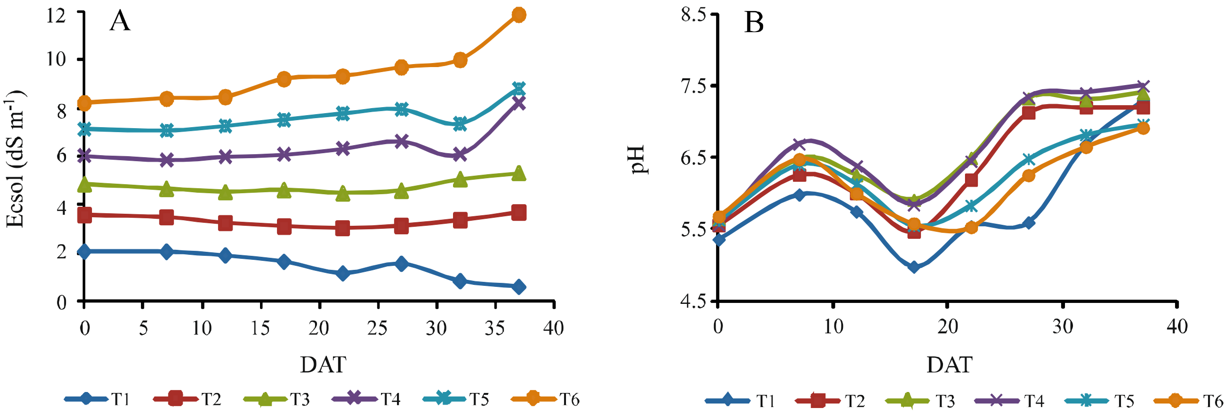


Table 1 - Summary of the variance analysis and regression equations adjusted to the growth and yield variables being analysed, as a function of water salinity - ECw

Variable	F-Test	CV (%)	Regression Equation	R^2
LA	104.07**	14.34	LA = 16.590 - 2.986**x	0.80
LN	18.57**	9.63	LN = 27.68 - 2.228**x	0.84
FMS	52.12**	12.08	FMS = 793.59 - 98.59**x	0.89
DMS	29.87**	13.34	DMS = 63.93 - 8.015**x	0.95
AGRFM	107.62**	9.24	AGRFM = 34.05 - 4.980**x	0.89
RGRFM	6.11**	15.51	AGRDM = 0.129 - 0.009**x	0.85
AGRDM	26.14**	16.03	RGRFM = 2.844 - 0.382**x	0.93
RGRDM	2.89*	17.66	RGRDM = 0.136 - 0.008**x	0.86

**and * = respectively, significant at 1% and 5% probability; LA = leaf area; LN = number of leaves; FMS and DMS = respectively, shoot fresh and dry weight; AGRFM e AGRDM = respectively, absolute growth rate of shoot fresh and dry weight; RGRFM e RGRDM = respectively, relative growth rate of shoot fresh and dry weight

In their experiments with other leafy vegetables, Silva *et al*. (2012) and Santos *et al*. (2010) observed a decline in the number of leaves in the crops being studied, proportional to the salinity of the solution. It is therefore evident that salt stress hinders the development of plants by considerably reducing both the number of leaves and the leaf area, the weight of the shoots, and the fresh and dry weight of the leaves and roots.

The rates for absolute growth of the fresh (AGRFM) and the dry matter (AGRDM) of the shoots and of relative growth of the fresh (RGRFM) and the dry matter (RGRDM) in the Chinese cabbage plants decreased with the increase in water salinity throughout the experiment, and at the lowest water salinity (0.2 dS m^{-1}) resulted in the maximum amount of 33.05 g day^{-1} for AGRFM, 2.77 g day^{-1} for AGRDM, 0.1272 g g^{-1} day^{-1} for RGRFM and 0.1344 g g^{-1} day^{-1} for RGRDM (Table 1).

This reduction in the absolute and relative growth rates of the fresh and dry weights of the plant shoots in relation to the salinity of the water may have been due to the decrease in leaf area and greater respiration rate of the plants. According to Taiz and Zeiger (2009), so that they can maintain themselves, plants subjected to salt stress need to divert metabolic energy in an attempt to adapt, which is reflected in reduced CO_2 fixation as a result of an inadequate rate of photosynthesis, an increase in breathing due to the condition of stress, a reduction in leaf area and consequently a reduction in the absolute and relative growth rates of fresh and dry weight of the shoots.

Other authors have also emphasized reductions in the absolute and relative growth rates of fresh and dry matter of the shoots in other crops due to salt stress, such as coriander cv. Tabocas e Verdão by Lima (2008), sorghum by Barreto (1997), and maize by Azevedo Neto and Tabosa (2000), these reductions varying depending on the tolerance and sensitivity of the cultivars.

Based on the results obtained for the production of Chinese cabbage using brackish water, it can be inferred that even with a decrease in relative production at the greatest salinity, the possibility exists for the application of this type of water in the production of hydroponic Chinese cabbage. For Paulus *et al*. (2010) and Paulus *et al*. (2012), the insignificant use of this water by farmers is due to the lack of information on the feasibility of its use. As an alternative, the producer can compensate for the decrease in relative production by increasing the plant population (ALVES *et al*., 2011).

Furthermore, the use of this water will enable an increase in agricultural production for those producers who have an available supply of brackish water but a restricted supply of fresh water, reflecting in greater environmental control and the preservation of the fresh water for other purposes.

The increase in salinity of the nutrient solution produced a decreasing linear effect on the water consumption of the Chinese cabbage, with an average water consumption being recorded during the cycle of 579.09 mL day^{-1} for the treatment without the use of brackish water (0.2 dS m^{-1}) and of 369.63 mL day^{-1} at the greatest salinity (5.2 dS m^{-1}). At the end of the cycle, the total water consumption for the plots where brackish water was not used was 21.52 L and in the plants subjected to the greatest salinity, this consumption was reduced to 9.71 L (Figure 2).

According to Figure 2, it can also be seen that the percentage reduction in total water consumption for the crop during the cycle, in relation to the nutrient solution without brackish water, was 10.3% per unit increase in electrical conductivity of the solution. This reduction may have been a reflection of physiological mechanisms induced by the situation of salt stress, which interfered in the phases of growth and development, reducing water loss by transpiration, as noted by Gomes *et al.* (2011). Several studies have reported reductions in water consumption in horticultural plants due to increases in the salinity of the nutrient solution (GOMES *et al.*, 2011; PAULUS *et al.*, 2012; SILVA *et al.*, 2012; SOARES *et al.*, 2010).

The levels of leaf nitrogen, potassium, calcium, magnesium, sodium and chloride were significantly affected by the increase in salinity of the solution; but no effect was found for this increase in salinity on the levels of phosphorus or sulphur (Table 2).

Regression analysis showed that an increase in the salinity of the nutrient solution produces quadratic decreases in the leaf concentrations of N and K (Figures 3A and 3B respectively); the minimum levels for leaf nitrogen (22.96 g kg-1) and potassium (4.14 g kg-1) being obtained at an electrical conductivity of 3 and 4.14 dS m^{-1} respectively.

Figure 2 - Total water consumption for the crop of Chinese cabbage as a function of water salinity - ECw

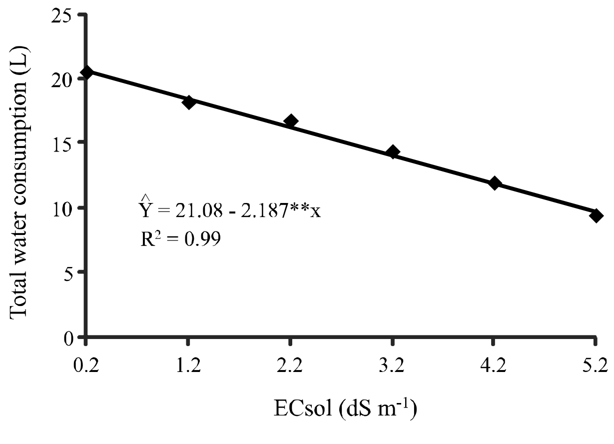
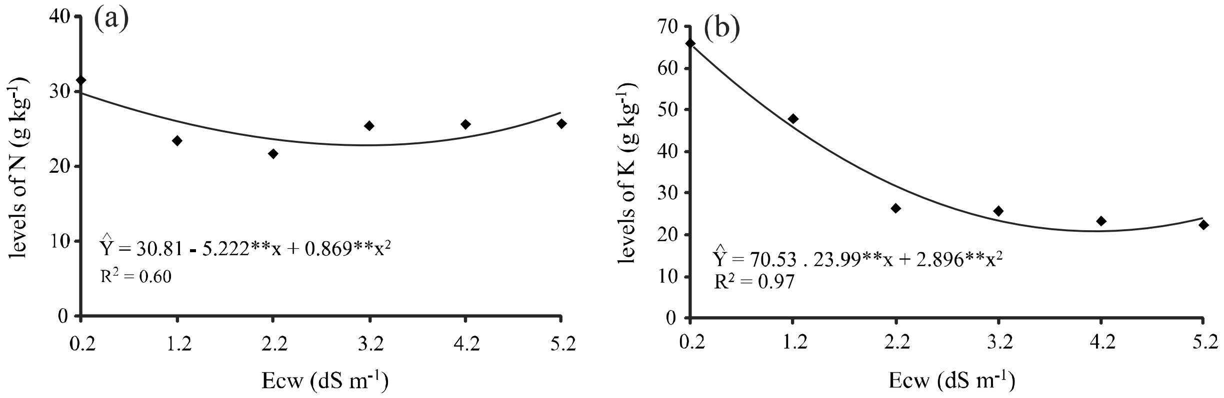


Table 2 - Summary of the variance analysis of the levels of leaf nutrients in Chinese cabbage, as a function of water salinity - ECw

Variable	ECw - F-test	CV (%)
N	6.36**	10.28
P	0.89^{ns}	12.84
K	12.56**	12.80
Ca	13.88**	14.64
Mg	20.96**	17.21
S	0.94^{ns}	17.34
Na	11.25**	17.02
Cl	9.18**	5.55

^{ns}: not significant and **: significant at 1% probability; N = nitrogen; P = phosphorus; K = potassium; Ca = calcium; Mg = magnesium; S = sulphur; Na = sodium; Cl = chloride; ECw = water salinity; CV = coefficient of variation

Figure 3 - Levels of leaf nitrogen (N) (a) and potassium (K) (b) in the crop of Chinese cabbage, as a function of water salinity - ECw



The average value for the level of N in the leaf (25.58 g kg^{-1}) obtained in this work was not within the concentration range (30-55 g kg^{-1}) considered to be adequate for cabbage crops, as established by Silva (1999). This result may reflect the high concentration of salts in the nutrient solution, since, according Debouba *et al*. (2006), an increase in the salt concentration of the medium may affect the absorption of nitrate (NO_3^-) and consequently, leaf nitrate levels. On the other hand, the average value for K (35.31 g kg^{-1}) was within the range considered as adequate (20 - 40 g kg^{-1}).

The results for leaf N levels obtained in this study differ from those obtained by Paulus *et al*. (2012) who, when studying nutrient uptake in hydroponic lettuce using saline water, found no significant differences in leaf nitrogen levels due to the increased salinity of the water used to prepare the nutrient solution. The same authors however found a reduction in the absorption of potassium when sodium was added to the nutrient solution, and attributed this to antagonism between the cations. A reduction in the absorption of K as an effect of the increase in salinity of the nutrient solution was also reported by Gondim *et al*. (2010) who evaluated electrical conductivities of between 0.5 to 4.0 dS m^{-1} and found that higher salt concentrations (4.0 dS m^{-1}) contributed to a greater reduction of K levels in the leaves.

The concentration of magnesium and calcium decreased with the increasing salinity of the water used to prepare the nutrient solution (Figures 4A and 4B respectively). With unit increases in salinity, percentage decreases of the order of 10% and 12% can be seen for the levels of Ca and Mg in the leaf respectively.

Paulus, Dourado Neto and Paulus (2012), working with a lettuce crop under different salinities, also found that increasing the sodium concentration of the nutrient solution led to reductions in the calcium concentration of the leaves.

The reduction in magnesium concentration of the plants was very similar to that of the concentration of Ca when undergoing the same increments in the sodium chloride concentration of the nutrient solution, with the decreasing linear equation model also being the best fit to the data (Figure 4B).

Concentrations of magnesium may remain constant or decrease in the shoots with an increase in salt stress (PAULUS; DOURADO NETO; PAULUS, 2012). However, Paulus *et al*. (2012) concluded that this variability in results highlights the importance of further study into the influence of salinity on the concentration of this macronutrient in different plant tissue.

The increase in salinity of the nutrient solution raised the levels of sodium (Na) and chloride (Cl^-) in the leaves (Figure 6A and 6B respectively), with the maximum accumulations of Na and Cl^- in the leaf being obtained at a CEsol of 3.76 and 3.84 dS m^{-1} respectively, values at which the concentrations of Na and Cl^- in the leaf began to decrease, possibly indicating a defence mechanism of the plant to the salt stress induced by those elements.

According to Marschner (1995), the chloride displays high mobility and transport as a free anion in the plant. However, under the conditions of this study, the concentration of Cl^- in the leaves of the Chinese cabbage was lower than the concentration of Na (Figure 5). For Taiz and Zeiger (2009), in general an appropriate level of Cl^- in the plant tissue would be from 1,000 to 2.000 mg kg^{-1} and, according to Marschner (1995), levels over 2,500 mg kg^{-1} can cause toxicity in sensitive plants.

Although most plants usually absorb Cl^- in greater amounts than are necessary for their metabolism (TAIZ; ZEIGER, 2009), the average levels of Cl^- found in the leaves of the Chinese cabbage in this work were not classified as being able to cause antagonistic effects in other nutrients, especially the anions, with respect to sulphur and phosphorus, for which no significant difference was seen between the treatments employed.

Analysis of the concentration of nitrogen, phosphorus, potassium, calcium, magnesium and sulphur in the shoots of the Chinese cabbage plants showed that, with the exception of the mean levels for nitrogen, on average, each of the other macronutrients were within the appropriate concentration ranges established for the crop by Silva (1999).

Figure 4 - Levels of leaf calcium (Ca) (a) and magnesium (Mg) (b) in the crop of Chinese cabbage, as a function of water salinity - ECw

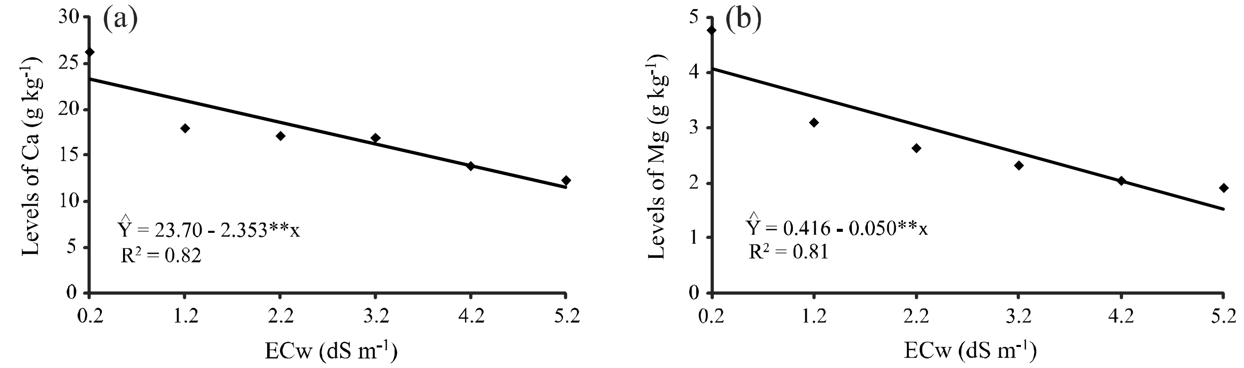
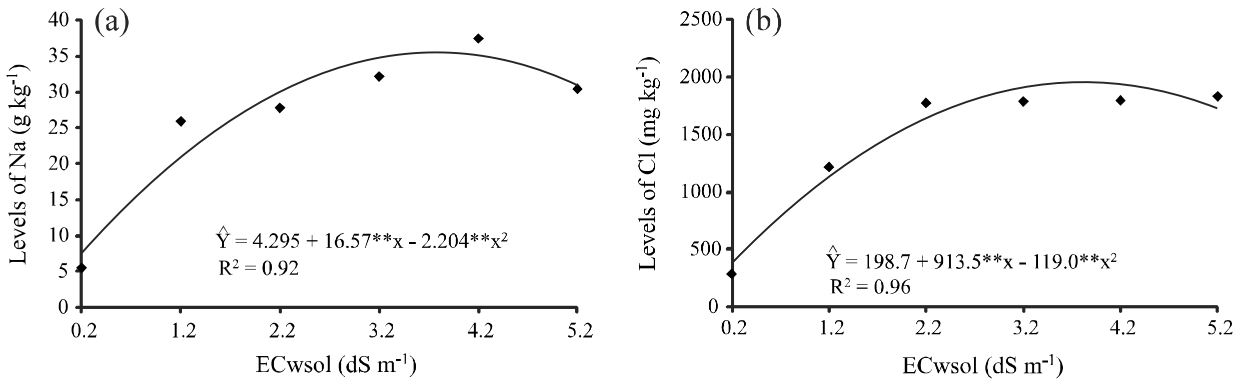


Figure 5 - Levels of leaf sodium (Na) (a) and chloride (Cl) (b) in in the crop of Chinese cabbage, as a function of water salinity – Ecw



Despite an increase in sodium levels in the leaves to a value of 34.44 g kg^{-1}, consumers who buy Chinese cabbage produced at the greatest salinity (5.2 dS m^{-1}) will be ingesting 0.68 g Na $plant^{-1}$ and 0.04 g Cl^- $plant^{-1}$, taking into account an estimated weight for shoot dry matter of 22.2 g $plant^{-1}$ and shoot fresh matter of 281 g $plant^{-1}$ (Table 1). Starting from the principle that the recommended limit is 6 g NaCl per day (PAULUS *et al*., 2012), it can be inferred that the amount of NaCl accumulated in the leaves of Chinese cabbage under the conditions of this experiment, does not present a risk to consumer health in relation to the levels of Na and Cl^- as measured in the leaves.

CONCLUSIONS

1. With the exception of the treatment at the lowest salinity, there was tendency in the remaining treatments to increasing electrical conductivity of the nutrient solution with the increasing salinity of the water;
2. The pH of the nutrient solution remained within the normal range throughout the crop cycle;
3. Water consumption and all the variables of growth and yield being analysed were reduced with the increase in salinity of the water used to prepare the nutrient solution;
4. An increase in salinity of the nutrient solution produced increases in the levels of leaf Na and Cl and a reduction in the levels of N, K, Ca and Mg;
5. It is possible to use brackish water in the production of Chinese cabbage grown hydroponically as an alternative for those producers who may have an available supply of brackish water but a restricted supply of fresh water, although with a reduction in productivity.

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