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RESEARCH ARTICLE

ELECTRICAL CONDUCTIVITY OF NUTRIENT SOLUTION ON CRISPHEAD LETTUCE FERTIGATED AT SAND

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ABSTRACT

Nutrient solution aspects such as the electrical conductivity are extremely important in hydroponic systems, with few studies related to that being performed in fertigation of crisphead lettuce at substrates. The aim of this work was to evaluate nutritional and productive aspects of crisphead lettuce, cv. Mauren, submitted to electrical conductivities of nutrient solution fertigated in pots with sand. The experiment was carried out in a greenhouse at the Agrarian Sciences Center of the Londrina State University (UEL), Londrina, PR, using a randomized block design with five treatments (0,8; 1,3; 1,8; 2,3 and 2,8 dS m^{-1} at nutrient solution) and five replications. It was evaluated the total mass of fresh matter (TMFM) and the total mass of dry matter (TMDM) of shoots, as well as the concentrations of macronutrients. The data were submitted to ANOVA and, when significant, were adjusted to regression models. The increase of the electrical conductivity at nutrient solution did not influence both TMFM and TMDM, providing response only for phosphorus (quadratic) and potassium (positive linear) concentration at shoots, which were, as the other nutrients, near to the sufficiency range.

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INTRODUCTION

Lettuce (*Lactuca sativa* L.) is a plant from *Asteraceae* botanical family. It presents a diminish stem in which the leaves, smoothed or crisped, are attached forming a rosette. The species is originated from South Europe and Western Asia (Filgueira, 2012). Several production systems are used for growing lettuce, both in open and protected environment (Sganzerla, 1997). In fertigation system, the nutrients are supplied together with irrigation water. According to Souza *et al*. (2012), the main advantage of fertigation is the enhanced efficiency of fertilizers use. Also, Medeiros *et al*. (2001) reported that when growing lettuce in protected environment, using substrates for fertigation is more indicated than soil. Andriolo *et al*. (2004) demonstrated the viability of fertigation at substrates compared to the hydroponic system NFT (*Nutrient Film Technique*), which is the most common used for lettuce crop and other leafy vegetables. Although less adopted for the cultivation of these plants, the fertigation system may represent benefits compared to NFT, especially because of the absence of recirculation of nutrient solution. Thus, it reduces the dissemination of plant diseases and the frequency needed for the controlling of pH and nutrients concentrations. When it comes to hydroponics, the aspects related to the nutrient solution are extremely important (Martinez *et al*., 1997). Among them, the ionic concentration is one of the parameters most used for the management of the system. However, an alternative simpler and less expensive to measure is the electrical conductivity (EC), given that the ionic concentrations present a direct relation with the ability of the solution to conduct electrical current (Helbel Junior *et al*., 2008). A few studies related to the electrical conductivity of nutrient solution were performed for lettuce fertigation system at substrates, while the most researches are focused on NFT system (Filgueiras *et al*., 2002; Andriolo *et al*., 2005; Cometti *et al*., 2008; Helbel Junior *et al*., 2008; Gondim *et al*., 2010). Thereby, we aimed to evaluate the nutritional and yield aspects of crisphead lettuce when submitted to electrical conductivities of nutrient solution in a fertigation system with pots containing coarse sand as substrate.

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MATERIALS AND METHODS

The experiment was carried out in a greenhouse with plastic cover (polyethylene with 150 µm thickness) of the Agrarian Sciences Center of State University of Londrina, Londrina, Parana, Brazil (23º 23' S, 51º 11' W and 560 m high). The seedlings of crisphead lettuce, cv. Mauren, were produced in Styrofoam cell tray with commercial substrate 'Turfa Fértil' (Germina Plant®), presenting a pH between 5.8 and 6.0 and EC = 0.50 dS m^{-1}. The transplantation occurred in September 24, 2013, at polyethylene pots with 5.0 dm^3 spaced 0.8 m between rows. The substrate was a coarse sand with the following chemical characteristics: pH CaCl2 = 6.30; C-org. = 2.85 mg dm^{-3}; P = 3.30 mg dm^{-3}; Ca^{2+} = 0.65 $cmol_c$ dm^{-3}; Mg^{2+} = 0.10 $cmol_c$ dm^{-3}; K^+ = 0.15 $cmol_c$ dm^{-3}; Al^{3+} = 0.05 $cmol_c$ dm^{-3}. The fertigation system was composed by tanks with 250 L, Atman® pumps (model AT 203, with 32 W and 18.6 kPa), polyethylene hoses, micro sprinklers and timers. The activation of the pumps was performed four times a day, during 40 seconds at each time, directing the nutrient solution application to the plant lap. The nutrient solutions stocked in the tanks were prepared by dissolving the following salts in water: $Ca(NO_3)_2$, $CaCl_2$, $MgSO_4$, KNO_3 and KH_2PO_4 (macronutrients); Rexolin M48® and Rexolin BRA® (micronutrients). The experimental design was randomized block with five treatments and ten replications. The plots were constituted by one pot with one lettuce plant. The treatments were five electrical conductivities (EC) of nutrient solution (0.8; 1.3; 1.8; 2.3 and 2.8 dS m^{-1}). The initial EC (0.8 dS m^{-1}) of nutrient solution corresponded to the concentrations of 79.20 mg N L^{-1}; 17.44 mg P L^{-1}; 60.80 mg K L^{-1}; 93.20 mg Ca L^{-1}; 10.80 mg Mg L^{-1}; 15.60 mg S L^{-1}; 2.0 mg Fe L^{-1}; 0.2 mg B L^{-1}; 0.2 mg Mn L^{-1}; 0.02 mg Zn L^{-1}; 0.008 mg Cu L^{-1} and 0.004 mg Mo L^{-1}. The other treatments had increments of these concentrations equivalent to the raise of EC. The plants were harvested in November 10, 2013, at 47 days after transplantation (DAT), by cutting them in the stem close to the substrate surface. The shoots were evaluated for total production of fresh mass (TFM, g $plant^{-1}$) and dry mass (TDM, g $plant^{-1}$), by weighing the plant tissues in semi analytical balance, right after the harvest for TFM and after drying in ventilated oven (40 ºC, 96 h) for TDM. A representative sample of the shoots was separated, proceeding the drying (60 ºC, 72 h), milling (Wiley mill) and digestion (Block digester) of the plant tissues with sulfuric acid for N determination and nitric-perchloric acid for P, K, Ca, Mg and S determinations. After that, the analytical procedures for evaluating the concentrations of these nutrients in the extracts were performed according to the methods described by Malavolta *et al*. (1997). The data were tested for parametric assumptions of homoscedasticity and normality of errors, by Hartley and Shapiro-Wilk tests, respectively. After that, ANOVA was performed and, in case of significance ($p<0.05$), the means were adjusted to regression models.

RESULTS AND DISCUSSION

No effects were observed of EC treatments for TFM (p=0.132; CV%=39.43) and TDM (p=0.328; CV%=23.28). The general means obtained were 212.06 and 20.39 g $plant^{-1}$, respectively. Similar results were found by Filgueiras *et al*. (2002) for crisped lettuce, cv. 'Verônica', in NFT hydroponic system. These authors reported no influence of EC treatments from 1.0 to 3.0 dS m^{-1} on the production of fresh and dry mass of the plant shoots. On the other hand, Andriolo *et al*. (2005), also in NFT system, observed an increase of 28.5% in the fresh mass of shoots in lettuce cv. 'Vera' when the EC was raised from 0.8 to 1.85 dS m^{-1}, followed by a reduction of 16.5% within the increase of EC to 5.0 dS m^{-1}. Cometti *et al*. (2008), working with lettuce cv. 'Vera' in NFT system, observed that shoots dry mass was not influenced by the reduction from 100 to 50% in the concentration of nutrient solution, with corresponding ECs of 1.84 and 0.98 dS m^{-1}, respectively. However, when the dilutions were 25 and 12.5% of ionic force, the plant growth was reduced from 50 to 80%. Also in NFT system with lettuce cv. 'Vera', Helbel Junior *et al*. (2008) obtained higher values of shoots fresh biomass in a nutrient solution with 1.2 dS m^{-1}, compared to 0.8 and 2.5 dS m^{-1}. The authors attributed that to a lack of nutrients in the 0.8 dS m^{-1} solution and a high osmotic pressure in the 2.5 dS m^{-1} solution as possible causes to the lower mass productions. Gondim *et al*. (2010), cultivating lettuce cv. 'BR 303' in NFT system, reported a quadratic response for dry mass production of leaf, stem and shoots as a function of raising electrical conductivities (0.5; 1.0; 2.0 and 4.0 dS m^{-1}), reaching maximum values near to 2.68 dS m^{-1}. With respect to the macronutrients concentrations in the shoots, the EC treatments only affected phosphorus (p=0.038; CV%=13.06) and potassium (p=0.012; CV%=19.84), which presented quadratic (Figure 1a) and linear (Figure 1b) responses, respectively. The maximum point for phosphorus was estimated as 2.60 g kg^{-1}, obtained with the EC 2.03 dS m^{-1}. The concentration of potassium reached 61.16 g kg^{-1} with the highest EC tested. For the other nutrients, the general means obtained were 30.45 g N kg^{-1}; 22.17 g Ca kg^{-1}; 3.81 g Mg kg^{-1} and 2.06 g S kg^{-1}. For recently expanded leaves, from half to 2/3 of the cycle, Trani and Raij (1997) indicate sufficiency ranges of 30 to 50 g N kg^{-1}; 4 to 7 g P kg^{-1}; 50 to 80 g K kg^{-1}; 15 to 25 g Ca kg^{-1}; 4 to 6 g Mg kg^{-1} and 2 to 3 g S kg^{-1}.

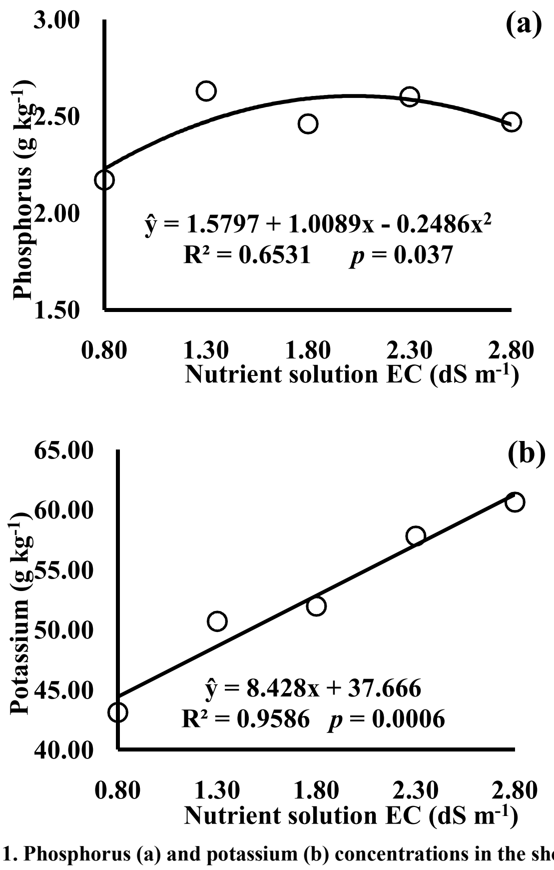

Figure 1. Phosphorus (a) and potassium (b) concentrations in the shoots of crisphead lettuce, cv. 'Mauren', submitted to electrical conductivities (EC) of nutrient solution in a fertigated system as coarse sand

The values found in the present study are close to those suggested, except for K within the lowest EC and for P in a general way, which are lower than the referred optimum concentrations. However, it must be pointed out that these sufficiency ranges refer to index leaf, which is not the case of the present study, wherein the whole shoots were evaluated. When considering the shoots, the major volume of plant material comes from older leaves, which already passed through the process of redistribution of mobile elements such as N, P, K, Mg and S (Malavolta, 2006). Thus, it is expected that the concentrations of these nutrients are lower than what is considered optimum for index leaf. Calcium, on the contrary, presents low mobility and concentrates in older leaves (Conn; Gilliham, 2010), what may explain the fact that the contents observed were near the upper limit of the sufficiency range for index leaf. The low influence of EC on the concentrations of nutrients in the shoots and the fact that these were, overall, nearly to the sufficiency, may be related to the high frequency (daily) of nutrients solution application. Therefore, it becomes a factor that allows to attend the nutrients requirement of the plants, independently of the solution concentration.

Conclusion

We concluded that it was possible to provide an adequate mineral nutrition to the crisphead lettuce in fertigated system with coarse sand as substrate, even with lower values of nutrient solution EC (0.8 dS m^{-1}), which justifies the absence of response on the production of fresh and dry mass of the plant shoots. For this reason, considering the fertilizer saving, it is preferable to adopt this lower EC for the production system used in the present study.

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