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Influence of the use of wastewater on nutrient absorption and production of lettuce grown in a hydroponic system

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ABSTRACT

The aim of this research was to evaluate the nutrient absorption and the fresh mass of lettuce plants cultivated using domestic wastewater in a hydroponic system during winter and summer seasons. The hydroponic system used was the Nutrient Film Technique with three treatments: 1) drinking water and chemical fertilizers (T1): 2) wastewater supplemented with chemical fertilizers (T2): and 3) only wastewater (T3) in a completely randomized experimental design with four replicates. The wastewater was previously characterized before being used in the treatments in order to quantify the need for nutrient supplementation in the T2 treatment. To determine the fresh mass, dry mass and nutrient absorption, three whole plant samples of each plot were collected at 1, 7, 14 and 21 days after transplanting. The nutrient absorption occurred according to a growing polynomial function for all treatments and most of the elements throughout the two cycles of the crop, except for potassium and magnesium in the T3 treatment in the winter crop. The results of fresh mass of the plant, pH and electrical conductivity of nutrient solutions were submitted to 2-way ANOVA, considering winter and summer as the first factor and treatments as the second one. A significant interaction between the factors for fresh mass and electrical conductivity was observed, and for that reason the average were submitted to Tukey test ($p < 0.05\%$). For T1 and T2 treatments, significant differences were found between the average of the fresh mass of winter and summer, with higher values in winter. For the T3 treatment, no difference was found between the evaluated periods, but there was a significant difference in relation to the other treatments in both periods. The plants of this last treatment had lower fresh mass, less accumulation of nutrients and visual symptoms of nutritional deficiency. Under the experimental conditions, it was concluded that there was no difference in the nutrient absorption between the T1 and T2 treatment, but in the T3 treatment, the absorption was slower and smaller, demonstrating that it is necessary to supplement the wastewater with nutrients.

1. Introduction

The interest in wastewater use in agriculture has been increasing since it represents an alternative source of water and nutrients for plant crops. In several developed and developing countries domestic wastewater has been used in agriculture (Rana et al., 2011; Roosta and Hamidpour, 2013). In addition to water reuse, the search for production systems that provide the most efficient use of water in agriculture has also increased.

Hydroponics, defined as the technique of plant cultivation without soil using only water and dissolved nutrients, presents many advantages, including faster growth, high productivity, easy handling, and greater efficiency in water use (dos Santos et al., 2013). According to Rana et al. (2011) this type of cultivation was developed to increase food production, but emphasized that the technique can also be used for effluent treatment. The same authors report that several vegetables and economically important flowers are able to use nitrogen and phosphorus for their growth from nutrient rich wastewater.

According to Paulus et al. (2012), for hydroponic lettuce (*Lactuca sativa* L.) cultivation, it is possible to use nutrient solutions prepared with low quality water, or reuse nutrient solutions. The use of alternative sources of water and fertilizers may represent a reduction in production costs in the hydroponic system (Azad et al., 2013), but there is a lack of information on the correct management of the nutrient solution (Bugbee, 2004). Although effluents contain macro and micronutrients, the contents found may be limiting to the growth of plants, either by excess or nutrient deficiency (Almuktar et al., 2015).

The characterization of the wastewater is essential for its use in

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hydroponic crops. However, knowledge of the amount of nutrients accumulated in a plant cultivated with wastewater at each stage of development can provide important information about the actual availability of these nutrients and possible handling of the nutrient solution.

Therefore, this study evaluated the performance of a hydroponic lettuce culture of curly variety with domestic wastewater during the winter and summer periods regarding the absorption and accumulation of nutrients in the plants along the growing cycle, as well as its influence on production.

2. Materials and methods

The cultivation was carried out at the installations of the Department of Natural Resources and Environmental Protection (DRNPA) in Federal University of Sao Carlos (UFSCar) in the city of Araras, State of Sao Paulo, Brazil (latitude 22° 18′22.4″S and longitude of 47° 23′11.1″W). The study was conducted in a greenhouse, composed of a metal structure of the type in arch, covered with transparent polyethylene, with a height of 3 m and a dimension of 20 m of length by 6.40 m of width, with sides closed by sombrite type. The temperature and relative humidity of the internal and external air to the greenhouse were monitored throughout the experimental period, and the average results are shown in Fig. 1.

The cultivar selected was the "Vanda," which is the curly segment type that predominates in the Brazilian market. The hydroponic system adopted was the Laminar Nutrient Flow Technique (NFT) (Azad et al., 2013). The lettuce seedlings were transplanted to a nursery where they remained for 14 days until they reached the ideal size to be transferred to the defined location of the experiment. The defined growing periods were from November 24th to December 14th, 2014 (summer) and from August 1st to 23rd, 2015 (winter). In the nursery the plants were grown in nutrient solution as proposed by Martinez and Silva Filho (2004) (Table 1).

Table 1
Nutrition solution proposed by Martinez and Silva Filho (2004) for the cultivation of lettuce.

Fertilizer	Chemical Formula	Concentration ($g\,m^{-3}$)
Calcium nitrate	$Ca(NO_3)\ 2.4H_2O$	900
Potassium nitrate	KNO_3	134
Potassium sulphate	K_2SO_4	280
Magnesium sulphate	$MgSO_4{\cdot}7H_2O$	495
Potassium chloride	KCl	138
Monoammonium phosphate	$NH_4H_2PO_4$	142
Ferric chloride	$FeCl_3{\cdot}6H_2O$	11.97
Manganese sulphate	$MnSO_4{\cdot}H_2O$	3.39
Boric acid	H_3BO_3	2.92
Zinc sulphate	$ZnSO_4{\cdot}7H_2O$	0.49
Copper sulphate	$CuSO_4{\cdot}5H_2O$	0.08
Sodium molybdate	$Na_2MoO_4{\cdot}2H_2O$	0.12
EDTA-disodium	$C_{10}H_{14}N_2O_8Na_2{\cdot}2H_2O$	16.42

The cultivation environment was composed of twelve workbenches (plots), each three meters in length, and with four polypropylene hydroponic profiles (75 mm) per workbench, in a greenhouse. The

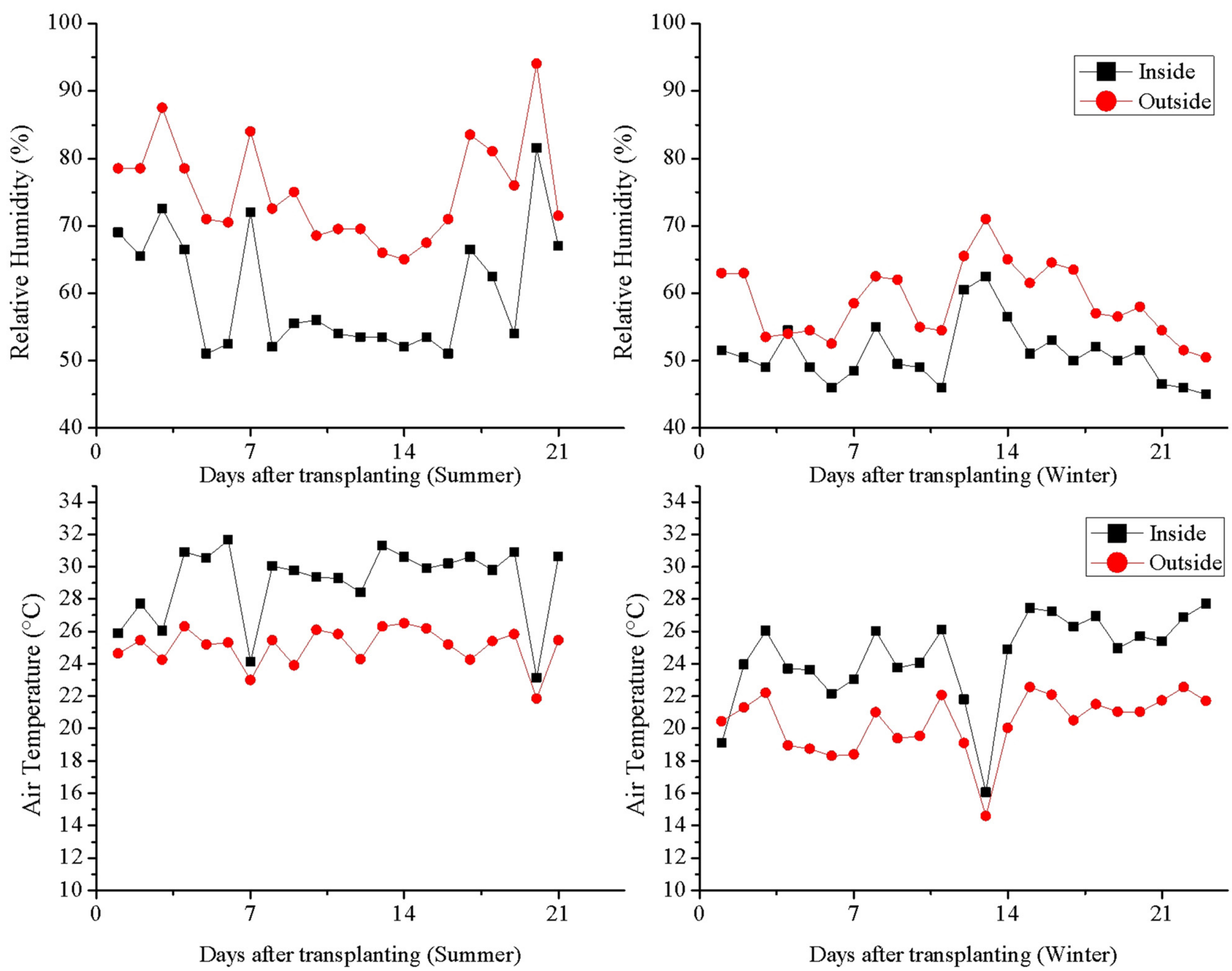

Fig. 1. Average values the relative humidity and air temperature monitored inside and outside the greenhouse, during the two crops (winter and summer).