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COIR EMPLOYED AS SOILLESS CULTIVATION SUBSTRATE AND ITS INTERFERENCE WITH NUTRIENT SOLUTION DURING TWO TOMATOES CROPPING PERIODES (CASE STUDY)

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ABSTRACT. The experiment was conducted in the glasshouse of TEI of Thessalia, for two growing periods, in soilless tomato cultivation, with coir substrate (open system). The electrical conductivity of the inflow solution to crops, fluctuated from 1.80 to 2.55 dS m-1 and pH values ranged from 5.5 to 6.8, while for the efflux solution from the crops, ranged from 2.00 to 3.50 dS m-1 for electrical conductivity, and from 5.5 to 6.9 for pH. On the coir substrate, the electrical conductivity ranged from 0.3 to 1.13 dS m-1 (water extract of 1 part of coir : 5 parts of H2O) and for pH from 5.87 to 6.83 during the first crop period; during the second cultivation, the electrical conductivity it fluctuated from 0.65 to 1.91 dS m-1 and for pH from 5.7 to 6.7. According to this study, 20% of substrate was decomposed, CEC increased, also the salinity status of the coir increased essentially during the second cultivation period, correlated with nitrate and phosphate forms enrichment of the substrate, while a slight negative affection to the crop production was observed; in generally, the coir substrate, is a good choice with excellent results for cultivation return.

Keywords: *soilless cultivation, nutrient solution, coir substrate, tomato.*

INTRODUCTION

In an efficient soilless cultivation (hydroponics), the plants are free from diseases, and grow faster than in the soil; naturally in hydroponics, nutrient solutions used, must be constantly controlled, as far as it concern their chemical composition and concentration as well as the chemical stability of the

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substrate employed must be assessed; adverse effects of soilless cultivations result concerning particularly the high cost of controlling systems provision and solution preparation; a significant factor affecting efficiency of nutrient solution in open hydroponic culture systems, is the observed loss of fertilizer and soil pollution, due to non-recycling of the liquids drained [1,2].The development of today's hydroponic's growing systems [3-7], is based on modern distribution systems of nutrient solution [8-12]. In the present study, the efficiency of used method for nutrient solution preparation is assessed, and as it concerns coir as substrate used in the present study, its alteration, during two crop periods, was evaluated [13].

RESULTS AND DISCUSSION

Nutrient solution: It was observed that in the inflow of the solution in two cropping periods, with regard to the electrical conductivity, it was produced a solution with slightly higher values of electrical conductivity (Figure 1). Also the runoff solution for both crops showed values of electrical conductivity, higher than the respective values of the influx solution, affected by the accumulation of salts in the substrate. In (Figure 2) is noted that during the inflow of the solution in both crops, with regard to the pH, it was produced a solution with slightly higher values; the runoff solution showed values of pH, also in generally higher values than the respective values of the influx solution.

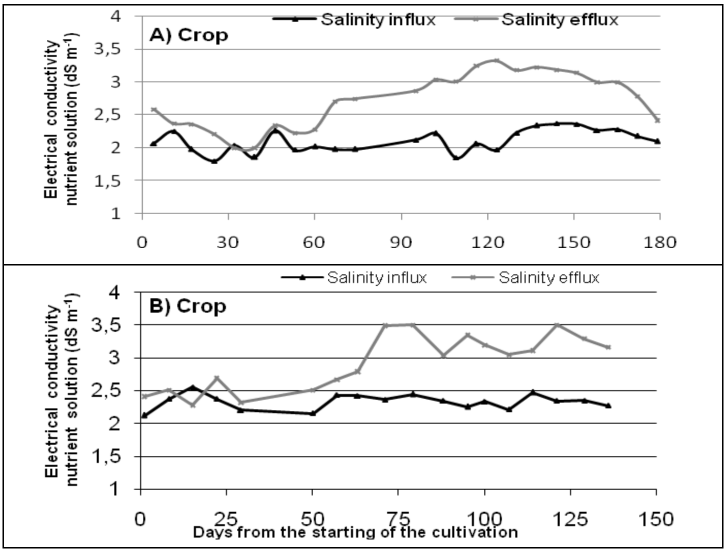

Figure 1. Fluctuations of electrical conductivity of influx and efflux of the nutrient solution of soilless tomato cultivation, during of two crops development

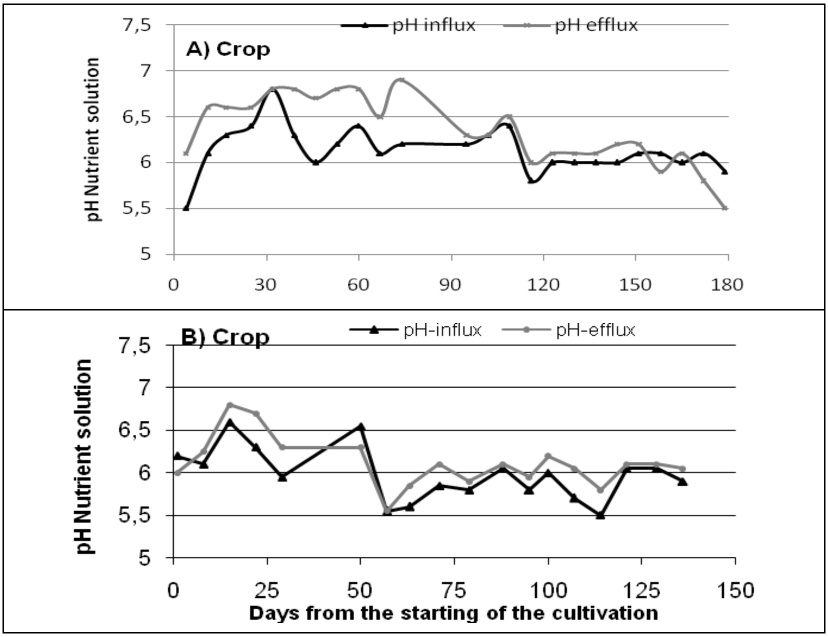

Figure 2. Fluctuations of pH values of the nutrient solution influx and efflux of soilless tomato cultivation, during the two crops development.

Substrate: The values of electrical conductivity were recorded concerning the substrate, during the development of two cultivation periods, as they were affected by the nutrient solution (Figure 3). In the first crop period, it was observed that during early days of cultivation, the electrical conductivity of the substrate was fluctuated, thereafter it was reduced and stabilized at the value of 0.63 dS m^{-1}, 90 days after the starting of the cultivation. At the second crop period, it was observed that for the early days of cultivation the electrical conductivity of the substrate was fluctuated, thereafter it was reduced and stabilized with low fluctuations at the value of 1.40 dS m^{-1}, 79 days after the starting of the cultivation. The values of pH were also recorded concerning the substrate during the two cultivation periods, as they were affected by the nutrient solution, (Figure 4). In the first crop period, the pH of the substrate during the cultivation was fluctuated from 5.87 to 6.83, while during the second crop, it was fluctuated from 5.7 to 6.7. Then, for the second cultivation period (B crop), it was revealed that the electrical conductivity was stabilized at higher values and for pH at lower values, in comparison to A crop; then a significant amount of salts was accumulated in coir during the second cultivation.

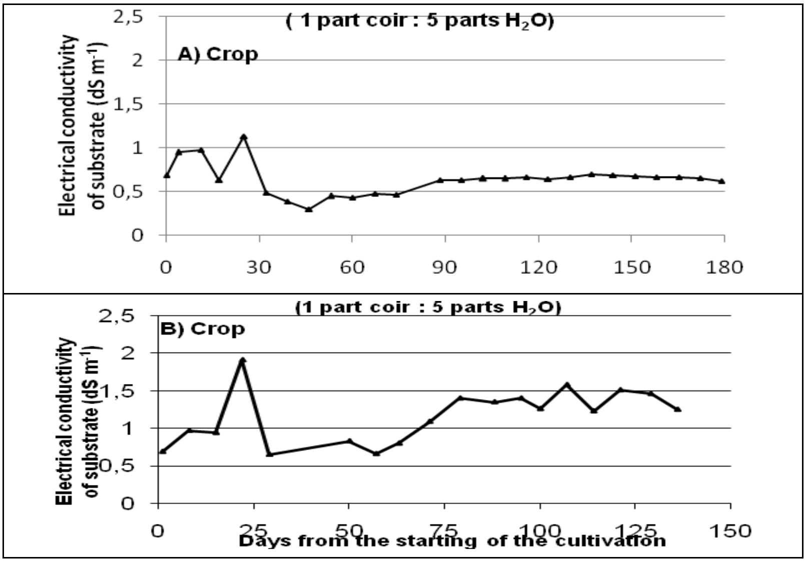

Figure 3. Fluctuations of electrical conductivity the coir substrate of soilless tomato cultivation, during the two crops development.

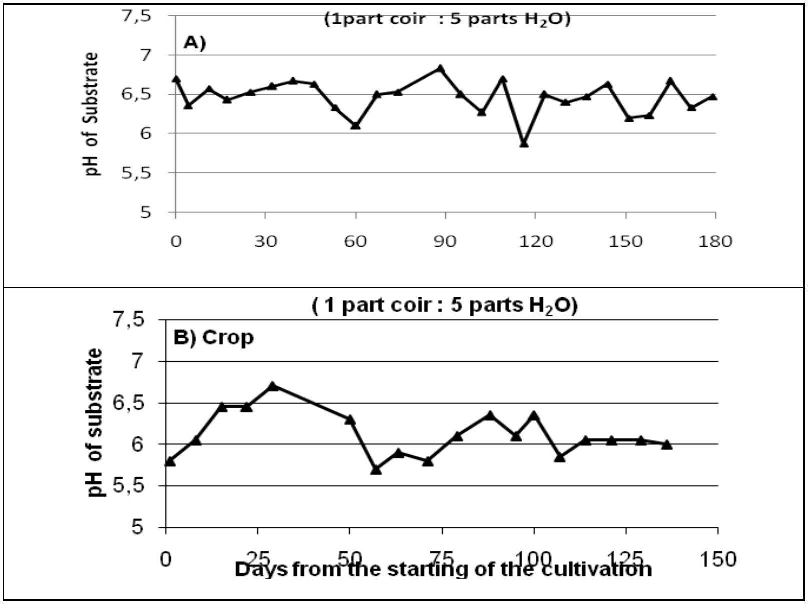

Figure 4. Fluctuations of pH values the coir substrate of soilless tomato cultivation, during of two crops development.

The increased values of electrical conductivity are accompanied by nitrate and P-Olsen forms accumulation in substrate particularly at the end of the B crop, compared with the respective values in the initial material (Table 1). In contrast, the values of pH of substrate resulted at the end of the B crop, decreased compared with the respective values of substrate, resulted at the end of the A crop and the initial substrate. The exchangeable - K forms of substrate resulted, at the end of the A and of the B crop, decreased compared to respective values of the initial substrate. In contrast, available forms Zn, Cu, Mn (extracted with DTPA) of substrate resulted, at the end of the A and of the B crops, increased compared with the respective values of the initial substrate.

Table 1. Chemical properties of the coir substrate used, before and after utilization.

Chemical Property	**Initial Coir (since the starting of the crop)**	**Final Coir at the end of the A crop (or Initial Coir for the starting of the B crop)**	**Final Coir (at the end of the B crop)**
	Commercial material	**wet basis**	
pH (1part substrate: 5parts H_2O)	6.7 ± 0.05	6.1 ± 0.05	5.75± 0.03
$CaCO_3$ (%)	0.13 ± 0.01	0.13 ± 0.01	0
Organic matter (%)	11.71 ± 1.1	8.39 ± 0.8	9.41± 1.0
CEC (cmol kg^{-1} substrate)	49.5 ± 5.7	75.2 ± 6.2	73.25± 6.3
Electrical conductivity, extract (1part substrate: 5 parts H_2O) (dS m^{-1})	0.68 ± 0.01	0.65 ± 0.01	0.94± 0.01
N -total (g kg^{-1})	0.333 ± 0.12	0,19 ± 0.05	0.56 ± 0.18
N-NH_4^+ (mg kg^{-1})	214 ± 14.5	22.6 ± 4.8	5.6 ± 1.7
N-NO_3^- (mg kg^{-1})	119 ± 11.3	167.6 ± 19.4	172,9± 18.6
Exchangeable-Na (mg kg^{-1})	402.5± 10.2	69.0 ± 3.6	92.0 ± 5.8
P -Olsen (mg kg^{-1})	14.73 ± 2.2	80.36 ± 9.8	145 ± 14.9
Exchangeable-K (mg kg^{-1})	2072.1 ± 101.2	733.2 ± 56.7	898.9 ± 44.8
Zn -Total (mg kg^{-1})	6.03 ± 0.5	24.59 ± 1.1	21.2 ± 1.2
Cu -Total (mg kg^{-1})	-	11.11 ± 0.8	24.1 ± 1.4
Mn -Total (mg kg^{-1})	-	-	31.1 ± 4.7
Zn -DTPA (mg kg^{-1})	1.66 ± 0.07	17.53 ± 2.4	12.66 ± 1.9
Cu -DTPA (mg kg^{-1})	0.56 ± 0.02	4.60 ± 0.8	0.67 ± 0.06
Mn -DTPA (mg kg^{-1})	1.7 ± 0.1	2.85 ± 0.2	2.13 ± 0.2
Moisture (%)	79.65	87.21	82.5

Data represent average means and SE deviation

In briefly, substrate after the second cultivation period utilization, is subjected to some alteration affected by salinity accumulation from nutrient solution, or by relative decomposition of that organic material; the CEC, nitrate forms and P available values of substrate increased but K available forms decreased.

Despite the variations in pH and electrical conductivity of the nutritive solution influxes [14], the plants showed a good development as well as the foliar chemical analysis of plants (Table 2), showed satisfactory nutritional status. The annual production of the first cultivation (A crop) was 100 tn/ha, with mean fruit weight 0.25 kg and of the second cultivation (B crop), 90 tn/ha, with mean fruit weight 0.23 kg.

Table 2. Foliar analysis of plants

	N (%)	P (%)	K (%)
A crop (120 days after the starting of the cultivation)	3.47	0.65	4
B crop (90 days after the starting of the cultivation)	3.22	0.63	3.90

CONCLUSIONS

The effectiveness of a soilless cultivation system in glasshouse conditions, with coir as substrate, was evaluated, in an experiment of two successive cultivations periods. In according to these results, the produced nutrient solution, showed several fluctuations, in comparison to the values expected, concerning electrical conductivity and pH values.A certain divergence upwardly was observed of the electrical conductivity values for produced nutrient solution; as for pH, it was found also higher values, for both growing periods (A crop & B crop). With regard to the runoff solution (efflux), which seeps of the substrate, also studied during of the two crops periods, the corresponding solution was found with higher values concerning electrical conductivity and pH, in comparison with influx**.** In both crops the coir substrate reached a stabilization status in salinity, after the middle of each cultivation period, but in significantly higher levels for the second cultivation period (B crop).

Particularly, as far as it concerns **coir substrate** evaluation, after two cropping periods utilization, a certain decomposition of the organic material was observed (≈ 20%), and an increase of salinity accumulation correlated with nitrate and phosphate forms enrichment of the substrate; the pH of the substrate was reduced and a significant accumulation of Zn amounts (total and available forms) was recorded.

Despite the marked adverse effects, crops returned satisfactory yields, but a reduction of tomato production about 10%, for B crop was remarked, and that could be attributed to substrate salinity increased values. Nevertheless, coir is estimated as an excellent substrate despite the certain alteration assessed after two periods of employment; the most important is to adopt the necessary recommendations, in order to be respected the necessary settings to the system irrigation-fertilization unity.

EXPERIMENTAL SECTION

In the glasshouse of TEI of Thessalia, situated in Larissa, an open hydroponic's system, with automatic control and production unit of nutrient solutions has been established. Tomato plants in an area of 100 m^2 were cultivated, the first period lasted (A crop) from 14-10-2010 to 11-04-2011 and the second period (B crop) from 17-10-2011 to 29-02-2012. The substrate used was pressurized packages of coir (Table 1); the unit contains three stock solutions, that are in three different barrels (photo:1). The necessary amounts of solution from each barrel come out automatically, by creating the final nutrient solution regulating the EC and pH values by the unit program. According with directives of the supplier, it is recommended for tomato a nutrient solution with pH:6 and electrical conductivity EC: 2 dS m^{-1}.

The content of the three parent nutrient solutions for the first and second crop were:

A΄ Barrel: (Ca^{2+} = 507, NO_3^- = 680.6, K^+= 116.8, NH_4^+= 55, Fe^{2+} = 1.8) me/L H_2O.
B΄ Barrel: (Mg^{2+}=195, K^+= 644.2, H^+= 286, SO_4^{2-} = 580, NO_3^- = 115.2, PO_4^{3-} = 430) me/L H_2O.
Γ΄ Barrel: 6.6 mL concentrated HNO_3 / L H_2O.

Each watering had a duration of 3 min and the inflow of the nutrient solution was 58.9 mL/min. In the first crop, the first 60 days after the starting of the crop, three watering times were applied per day, the next 50 days 4 times and the next 69 days 5 times per day. In the second crop, the first 40 days of the start of the crop, three watering times were applied per day, the next 40 days 4 times, and the next 56 days, 5 times per day.

The purpose of the experiment is to assess the chemical stability of substrate used, to investigate the effectiveness of the system that ensures the desired pH (6) and electrical conductivity values (2dS m^{-1}),and to adopt efficiently the appropriate variations in that adjustment in the unity installed.

METHODS OF ANALYSES

Coir samples were analyzed using the following methods which are referred by [15,16]:

Organic matter was analyzed by chemical oxidation with 1 mol L^{-1} $K_2Cr_2O_7$ and titration of the remaining reagent with 0.5 mol L^{-1} $FeSO_4$.

Both ammonium and nitrate nitrogen were extracted with 0.5 mol L^{-1} $CaCl_2$ and estimated by distillation in the presence of MgO and Devarda's alloy, respectively.

Available P forms (Olsen P) was extracted with 0.5 mol L^{-1} $NaHCO_3$ and measured by spectroscopy.

Exchangeable forms of potassium ware extracted with 1 mol L^{-1} CH_3COONH_4 and measured by flame Photometer (Essex, UK).

Available forms of Mn, Zn, and Cu were extracted with DTPA (diethylene triamine pentaacetic acid 0.005 mol L-1 + CaCl2 0.01 mol L-1 + triethanolamine 0.1 mol L^{-1}) and measured by atomic absorption.

For the determination of total metals Mn, Cu and Zn, 1 g of wet material of coir, were analyzed by digestion at 350 ^{0}C. According to the method described by [17]., (1974) and [18] the sample containing 10 mL HNO_3 + 5 mL $HCLO_4$ were analyzed by Atomic Absorption (Spectroscopy Varian Spectra AA 10 plus, Victoria, Australia). The detection of Mn, Cu and Zn in coir was done with the use of flame of air-acetylene mixture.

Every value of the electrical conductivity or pH, corresponds to the mean of three replicates. Statistical analyses were performed by the use of statistical program MINITAB [19]. Data represent average means and SE deviation.

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