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Response of Zucchini to the Electrical Conductivity of the Nutrient Solution in Hydroponic Cultivation

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Abstract

The effect of two levels of electrical conductivity (EC) at 2.2 dS/m⁻¹ and 4.4 dS/m⁻¹ in two nutrient solutions was studied in a hydroponic culture of zucchini *Cucurbita pepo* var. Abodanza, during the growing period in a heated glasshouse. The experimental premises consisted of 8 double sloping benches (10x 0.4 x 0.6 m), which were by two equipped for the collection of the runoff with a calibrated 100 L tank. The system of the water fertilization was fully automated and the hydroponic system was renewed every 1 hour daily. In order to study the impact of the EC over the hydroponic cultivation of zucchini, two interventions were conducted with a fully randomized design of 14 replicates. The environmental parameters controlled with sensors during the hydroponic cultivation had the following values: Temperature: (08:00) 19.6 °C, (14:00 h) 27 °C. The assessment of the impact of the EC during the growing period in hydroponic cultivation was conducted every second day from the 33th day after the zucchinis were transplanted into the hydroponic system and until and until 68th day after transplanting.

The weight of the fresh and dry fruit of the fruit's stalk did not statistically differ in the hydroponic sub-layer in any treatment. The mean value of the total soluble solid components of the fruits is significantly different in the two conductivity levels, that is in the conductivity of 2.2 dS/m⁻¹ it was 5.19 °Brix and in 4.4 dS/m⁻¹ it was 5.48 °Brix. The female flowers were fewer than the male flower. The number of male and female flowers of the zucchini in both conductivity levels was 7,52(male) and 4,01(female) in 2.2 dS/m and 7,50 (male) and 4,30 (female) in 4.4 dS/m EC, respectively. The length and the diameters of the zucchini fruits and of fruits stalk did not differ in the two the levels of electrical conductivity

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Keywords: hydroponic culture; *Cucurbita pepo*; electrical conductivity (EC); weight of fruit; total soluble solid components; male and female flowers; fruits stalk

1. Introduction

Hydroponics is a technology for growing plants in nutrient solutions with or without the use of an artificial medium to provide mechanical support (Kumar and Cho, 2014). According to Hickman (2011) the world hydroponic vegetable production is about 35,000 ha.

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Hydroponics consists of the production and feeding tank for the nutrient solution, where it is necessary to control the functional parameters of the nutrient solution, the pH, the dissolved oxygen, the temperature, the osmotic pressure and the electrical conductivity as well as the installation and growing area of the plants. The measurement of the electrical conductivity aims to control the concentration of nutrients. In general, increased electrical conductivity in the nutrient solution reduces the yield of vegetable crops, although in many cases it improves their nutritional quality, as observed in plants grown in both soil and soilless culture (Fallovio et al., 2009).

Zucchini (*Cucurbita pepo* L.) is grown throughout the world and is one of the most grown crops under protected cultivation systems (greenhouses, etc.) throughout the world. Zucchini is deemed a moderately salt tolerant plant species (Graifenberg et al., 1996) and is typically cultivated in newly reclaimed areas, where saline water is frequently used for irrigation (Habashy and Ewees, 2011). Savvas et al., (2009) demonstrated that the exposure of the plants to high external salinity (6.2 dS m^{-1}) restricted the mean fruit weight as well as the fruit yield of zucchini. The objective of this study was to evaluate the effects of the electrical conductivity of nutrient solution on zucchini weights of fruits, number of flowers, dimensions of the fruit stalks and the total soluble solids of the fruits.

2. Material And Methods

2.1. Hydroponic cultivation of zucchini

At the heated glasshouse located a hydroponic cultivation experiment for zucchini of the species (*C. pepo* L. cv. Abodanza) was carried out under the influence of two electrical conductivity levels (EC). The seeds of the zucchini were first sowed on turf at an air-conditioned chamber for growing plants (temperature $23 \pm 1^\circ\text{C}$, relative humidity: $70 \pm 5\%$). The seedlings remained for 10 days in the chamber for plant growing and then were transferred to the heated glasshouse and transplanted in plates (Grodan, Grodania SA) of the hydroponic system. The experimental premises consisted of 8 double sloping benches ($10 \times 0.4 \times 0.6 \text{ m}$), which were by two equipped for the collection of the runoff with a calibrated 100 L tank. The system of the water fertilization (AMI 5000, DGT Volmatic Denmark) was fully automated and the hydroponic system was renewed every 1 hour daily. In order to study the impact of the EC over the hydroponic cultivation of zucchini, two interventions were conducted with a fully randomized design of 14 replicates. The two levels of EC during the experiment varied in the witness nutrient solution 2.2 dS/m and the nutrient solution of increased salinity 4.4 dS/m . The environmental parameters controlled with sensors during the hydroponic cultivation had the following values: Temperature: (08:00) 19.6°C , (14:00 h) 27°C .

2.2. Measurements during experimental period

The assessment of the impact of the EC in the growth of zucchini in hydroponic cultivation was conducted every second day from the 33th day after the zucchinis were transplanted into the hydroponic system and until 68th day after transplanting. Every time the dimensions and weights of the plant's fruits were measured, as well as the number of male and female flowers, the lengths and widths of the fruit stalks and the total soluble solids of the fruits were measured.. Fruits were dried in a forced-air oven at 80°C for 72 h and weighed to determine dry matter.

2.3. Statistical analysis

All data was tested by the analysis of variance (ANOVA), using the SPSS 17 software. The means of the examined traits were ranked according to Duncan's multiple range test and the Post Hoc comparison was used alternatively with Dunnett and Tukey methods.

3. Results and discussions

The fruit fresh weight of the zucchini plants in the nutrient solution with the conductivity (EC) of 2.2 dS/m^{-1} and conductivity of 4.4 dS/m^{-1} did not statistically differ in the hydroponic sub-layer in all treatments (Fig. 1, Table 1). Zucchini has been reported as a moderately salt-tolerant crop (Graifenberg et al., 1996). In our case, the nutrient

solution of increased salinity 4.4 dS/m^{-1} did not have negative effects on fruit fresh weight (45,13g).

A similar trend was also observed for fruit dry weight in which the fruit dry matter (average 3.5%) showed no significant difference among two levels of electrical conductivity (EC) at 2.2 dS/m^{-1} and 4.4 dS/m^{-1} in the two nutrient solutions (Table 1).

The fruit dry weight results were fully consistent with those reported for the fresh weight. The length and the diameters of the zucchini fruits during the growing period in the two conductivity levels, did not present significant statistical difference. The length/width ratio of the witness was 3.97, and in the increased salinity 3.95 (Table 1).

In our study, the female flowers are fewer than the male flower (Fig. 2). The similar results are also mentioned in (Ikechukwu et al., 2007, Theis et al., 2009). The number of male and female flowers of the zucchini in both conductivity levels showed no statistic difference between them and was 7,52(male) and 4,01(female) in 2.2 dS/m^{-1} and 7,50 (male) and 4,30 (female) in 4.4 dS/m^{-1} EC. Figure 2 shows the pattern of male and female flower production in the two nutrient solution 2.2 dS/m^{-1} και 4.4 dS/m^{-1} in hydroponic culture over time. There was no significant difference in male or female flowers between the two levels of electrical conductivity.

Since zucchini is a moderately salt-tolerant crop, only the mean value of the total soluble solid components of the fruits is significantly different in the two conductivity levels, whereas in the conductivity of 2.2 dS/m^{-1} it was 5.19°Brix and in 4.4 dS/m^{-1} it was 5.48°Brix (Table 1). In our study, the high conductivity (EC) caused an increase of the total soluble solid components of the fruits, a parameter that defines the preference of the zucchini for dietary intake of humans. Similar results are also mentioned for tomatoes (Conversa et al., 2003, Juárez-López et al., 2013).

The weight and the length and width of the angular fruits stalk did not statistically differ in the hydroponic sub-layer in all treatments.

The results demonstrate that growing zucchini can be adopted using the two conductivity levels. The results also indicate that the effect of conductivity of 4.4 dS/m^{-1} on total soluble solid components of zucchini was significant and more pronounced than the effect of 2.2 dS/m^{-1} .

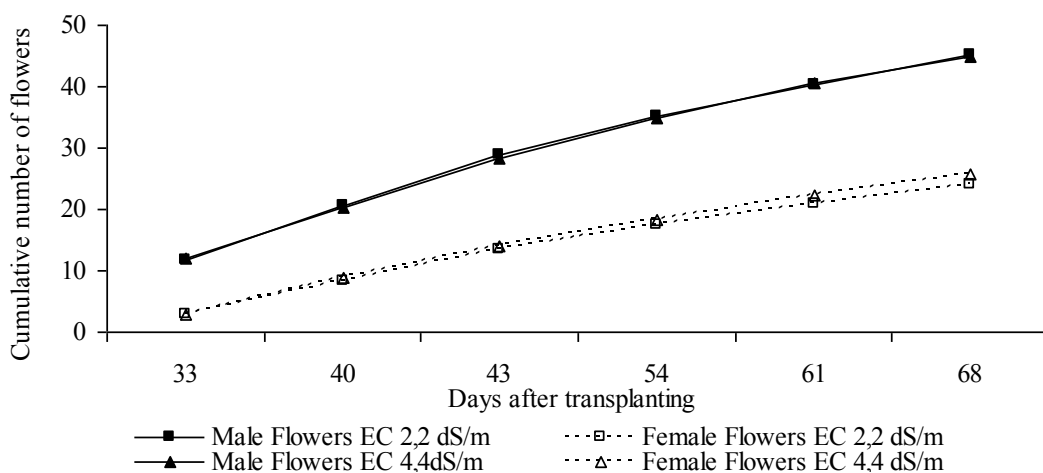


Fig. 2. Effect EC of the nutrient solution 2.2 dS/m και 4.4 dS/m in hydroponic culture number female and male flowers on duration of growth period, of zucchini.

Table 1. Effect of EC of the nutrient solution (2.2 dS/m^{-1} and 4.4 dS/m^{-1}) in hydroponic culture on fresh and dry fruit weight, fruit length and width, number of male and female flowers, total soluble solids, length and width of fruit stalk of zucchini.

		EC 2.2 dS/m^{-1}	EC 4.4 dS/m^{-1}
Fruit	Fresh weight (g)	47,24±2,67	45,13±2,70
	Dry weight (g)	3,47±0,36	3,49±0,36
	Fruit length (cm)	59,86±3,71	58,11±3,00

Fruit width (cm)	15,08±0,61	14,71±0,57
Length/Width ratio	3,97	3,95
Number of male flowers	7,52	7,50
Number of female flowers	4,01	4,30
Total soluble solids (⁰ Brix)	5,19 ^a ±0,11	5,48 ^b ±0,10
Stalk Weight (g)	6,03±0,5	6,07±0,4
Stalk length (cm)	2,62±0,07	2,52±0,05
Stalk width (cm)	1,77±0,04	1,72±0,03

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