Effects of Different EC Levels of Nutrient Solution on Greenhouse Tomato Growing

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Abstract

This research was conducted in an unheated bitunnel during autumn and spring seasons of 1999 and 2000 to determine the effects of different EC levels in nutrient solution on yield and fruit quality of tomatoes grown in perlite.
Tomato cultivars Gökçe F_1 and FA 361 F_1 were tested in autumn (September, 1999-March, 2000) and spring seasons (April-July, 2000), respectively. The seedlings were planted in the horizontal pots placed 95 cm apart, filled with perlite (24 litres per pot) and containing three plants. Plants were fed with a complete nutrient solution at electrical conductivity levels of (a) 2.0 (control), (b) 3.0, (c) 4.0 and (d) 5.0 dS m^{-1}. Sodium chloride was added to the standard nutrient solution (control) to obtain higher EC levels.

Cumulative yield, harvested fruit number, average fruit weight, fruit classification according to diameter and some fruit quality parameters (total soluble solids, titratable acidity, pH and EC of fruit juice, dry matter content) determined. In both seasons, the highest total yield (13.72 kg.m^{-2} in autumn and 12.34 kg m^{-2}) was obtained from the control treatment (2.0 dS m^{-1}). EC level of 3.0 dS m^{-1} was ranked statistically as the second group followed by the third group composing of the treatments 4.0 and 5.0 dS m^{-1}. Harvested fruit number was not effected by salinity neither in autumn nor in spring, but average fruit weight decreased with increasing salinity.

In autumn season, EC and titratable acidity of the fruit juice and contents of total soluble solids and dry matter increased with increasing EC levels, whereas pH of the fruit juice was the highest at 2.0 dS m^{-1}. Similar results were obtained in respect to EC of fruit juice in the spring season. Although titratable acidity, total soluble solids and dry matter contents showed an increasing trend with increasing salinity, differences were not significant.

INTRODUCTION

There are several reasons causing salinity stress in greenhouses either for during cultivation in soil or in soilless culture, particularly in closed systems. With the upcoming phase out of methyl bromide under the Montreal Protocol, soilless culture is expected to become more common in the Mediterranean basin.

In soilless culture, the frequency of irrigation and the amount of nutrient solution applied to the plants vary according to the physical properties of the substrates (Mitchell et al., 1991; Peet and Willits, 1995) and leaching fraction of nutrient solution that affect the EC level in the root zone (Schwarz, 1995). Since, salinity risk always exists, close monitoring of nutrient solution is of high importance to prevent possible increases in the rhizosphere.

Previous studies have shown that high salinity affects crop performance adversely due to the decrease in water availability and water uptake (osmotic effect), and that salinity-induced disorders are associated with the excessive ion uptake (e.g. Na^+, Cl^-) or nutrient imbalance resulting from nutrient availability or competitive uptake, transport or partitioning within the plant (ionic effect) (Laüchli and Epstein, 1990; Marschner, 1995; Dorais et al., 2001). On the other side, high salinity improves tomato fruit quality, but may reduce fruit size and marketable yield (Adams, 1991; Soria and Cuartero, 1996; Willumsen et al., 1996; Petersen et al., 1998; Elia et al., 2001).

This investigation is aiming to determine the effects of different EC levels in nutrient solution on yield and fruit quality of tomatoes grown in perlite filled in horizontal pots.

MATERIALS AND METHODS

The experiments were conducted in a plastic covered bitunnel of the Horticulture Department at Ege University Faculty of Agriculture in İzmir-Turkey, during autumn and spring seasons of 1999 and 2000. Tomato plants were grown in horizontal pots having 2 cm deep reservoir of nutrient solution, which may also cause a possible salt accumulation due to the time.

Each 24 liter pot filled with perlite had 3 plants. Pots were spaced at 95 cm apart and were fed with a complete solution with N 210, P 40, K 250, Ca 150, Mg 50, Fe 2, Mn 0.75, B 0.4, Zn 0.5, Cu 0.1, Mo 0.05 (mg l^{-1}) (Day, 1991). The nutrient solution was supplied by trickle irrigation system. Irrigation was based on indoor solar radiation level of 1 MJ m^{-2} and the amount of irrigation was adjusted in order to get 15-25% drained solution. Drained solution was collected in tanks. The pH and EC of applied and drained solutions were monitored daily.

Salinity treatments started one month after the standard nutrient solution applications following transplanting. The nutrient solutions were maintained at constant electrical conductivity (EC) at (a) 2.0 (control), (b) 3.0, (c) 4.0 and (d) 5.0 dS m^{-1} by adding sodium chloride (NaCl).

The experimental design was a random parcels with four replicates. Each plot had 18 plants.

Harvest period extended for 15 weeks (November 25 - March 3) in autumn and for 7 weeks (May 31- July 7) in spring.

The harvested fruits were classified according to their diameters and grouped as 1^{st} (Ø > 4.5 cm), 2^{nd} (4.5 > Ø > 3.5) and 3^{rd} (Ø < 3.5 cm) class. Fruit samples were taken twice during the growing seasons (January 1 and February 17, 2000 in autumn; June 20 and July 2, 2000 in spring) and total soluble solids (TSS, %), total dry matter (DM, %) contents, pH, EC (µS m^{-1}) and titratable acidity (TA, mval/100 ml) of fruit juice were determined.

RESULTS

Yield

Salinity treatments affected total yields significantly in both growing seasons. The highest total yields were obtained at the EC level of 2.0 dS m^{-1} as 13.72 kg m^{-2} in autumn and 12.34 kg m^{-2} in spring (Tables 1 and 2).

In both seasons, total fruit number did not differ with the tested EC treatments but average fruit weight varied according to the EC levels (Tables 1 and 2). Average fruit weight decreased by the increase of EC levels in nutrient solutions. Thus, the effect of EC levels was found significant on fruit size. The highest 1^{st} class ratio was obtained from the control (2.0 dS m^{-1}) treatment.

Fruit Quality

In autumn, the pH, TSS and TA values of fruit juice and total dry matter content of fruits were significantly different in the two analyses dates (Table 3), whereas, these parameters did not show any difference according to the time of sampling in spring (Table 4).

In autumn season, EC, TA and TSS of fruit juice and total dry matter content of fruits increased linearly with the increasing EC levels (Table 3 and Fig. 1), whereas pH of fruit juice was the highest at 2.0 dS m^{-1}.

Similar results were obtained in respect to EC of fruit juice in spring. Although

TSS, TA and total dry matter content showed a linearly increasing trend with increasing EC levels of nutrient solution, differences were not significant (Table 4 and Fig. 1).

DISCUSSION

During the growing seasons, the EC of the feeding solution ranged between 2 and 5 dS m^{-1} with daily leaching, however the seasonal average of EC values in drained solutions which reflect salinity conditions in the plant root environment of the treatments varied between 2.6 and 6.55 dS m^{-1} in autumn and 3.64 and 7.48 dS m^{-1} in spring. Under these conditions, an average yield decrement for autumn and spring seasons were 10.6% (R^2=0.99**) and 9.6 % (R^2=0.95**) per 1 dS m^{-1} increase of EC in the nutrient solution.

Many studies were realized to determine the yield reduction value in tomato due to salinity by various researchers (Willumsen et al., 1996; Katerji et al., 1998; Elia et al., 2001; Tüzel et al., 2001). Data given in relation to salt tolerance depend on the current condition. In general, indepently of the soil and substrate used, decrement of yield varying between 1 to 10% for each increase of 1dS m^{-1} EC is to be expected within the salinity range of 2 to 10 dS.m^{-1}. Besides this, in the experiment, the threshold value was determined as 1.9 dS m^{-1} in both seasons for the EC of the nutrient solution which is very close to the relevant literature.

The yield reduction was mainly due to the smaller fruit size. However, the reduction of fruit weight in autumn was 10.4 % per 1 dS.m^{-1} EC (R^2=0.99**) in the nutrient solution, whereas it was 8.5 % (R^2=0.99**) in the spring season. In terms of quality parameters, EC, pH, TSS and TA of fruit juice were higher in spring, but they did not show significant differences between the treatments. This could be attributed to the effects of the interaction between salinity and environmental factors (Dorais et al., 2001).

It was concluded that the increasing EC levels of nutrient solution reduced the tomato yield but improved the taste and quality of fruits increasing the concentrations of TSS, TA and dry matter content. However, the leaching of the system could have decreased the yield loss, therefore, the growing system still plays the key role in terms of salt accumulation.

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Tables

Table 1. Total yield, fruit number, average fruit weight and percentage of fruits in class 1, 2 and 3 in the autumn season.

EC level (dS m^{-1})	Yield (kg m^{-2})	Fruit number (no.m^{-2})	Average fruit weight (g)	Fruit classification (%)		
				Class 1	Class 2	Class 3
2.0	13.72 a	133.2	103.1 a	63.6 a	20.2 c	16.2 c
3.0	11.98 b	129.2	92.9 b	56.5 b	21.8 bc	21.7 b
4.0	10.43 c	130.6	79.9 c	48.9 c	27.1 ab	24.0 ab
5.0	9.38 c	130.3	71.9 c	42.4 d	30.9 a	26.7 a
$LSD_{(0.05)}$	1.082	n.s.	9.60	6.45	6.12	4.11

Table 2. Total yield, fruit number, average fruit weight and percentage of fruits in class 1, 2 and 3 in the spring season.

EC level (dS m^{-1})	Yield (kg m^{-2})	Fruit number (no.m^{-2})	Average fruit weight (g)	Fruit classification (%)		
				Class 1	Class 2	Class 3
2.0	12.34 a	159.8	77.6 a	45.1 a	30.5 b	24.4
3.0	10.49 b	153.3	69.5 ab	38.2 ab	34.6 b	27.2
4.0	9.38 c	148.2	63.5 bc	31.0 b	36.8 b	32.2
5.0	8.83 c	153.6	57.6 c	18.6 c	50.2 a	31.2
$LSD_{(0.05)}$	0.94	n.s.	11.13	7.76	7.89	n.s.

Table 3. Some fruit quality parameters in autumn.

		EC (µS cm^{-1})	pH	TSS (%)	TA (mval/100 ml)	DM (%)
Sampling date	12.01.2000	5052	4.27 b	3.55 b	7.98 a	5.10 b
	17.02.2000	4931	4.34 a	4.56 a	6.77 b	6.50 a
$LSD_{(0.05)}$		n.s.	0.04	0.16	0.54	0.58
	2.0	4600 c	4.37 a	3.65 c	5.85 c	5.01 c
EC level	3.0	4827 b	4.29 b	3.73 c	7.30 b	5.21 bc
(dS m^{-1})	4.0	5197 a	4.29 b	4.13 b	7.72 b	5.98 ab
	5.0	5342 a	4.26 b	4.50 a	8.59 a	6.69 a
$LSD_{(0.05)}$		207.34	0.06	0.23	0.76	0.82

Table 4. Some fruit quality parameters in spring.

		EC (µS/cm)	pH	TSS (%)	TA (mval/100 ml)	DM (%)
Sampling	20.06.2000	6581	4.46	4.80	8.27	5.89
date	02.07.2000	6665	4.47	4.70	9.68	6.59
$LSD_{(0.05)}$		n.s.	n.s.	n.s.	n.s.	n.s.
	2.0	6090 c	4.49	4.60	8.34	5.52
EC level	3.0	6462 bc	4.47	4.65	9.03	6.18
(dS.m^{-1})	4.0	6817 ab	4.46	4.85	9.08	6.40
	5.0	7122 a	4.43	4.95	9.41	6.82
$LSD_{(0.05)}$		593.19	n.s.	n.s.	n.s.	n.s.

Figures

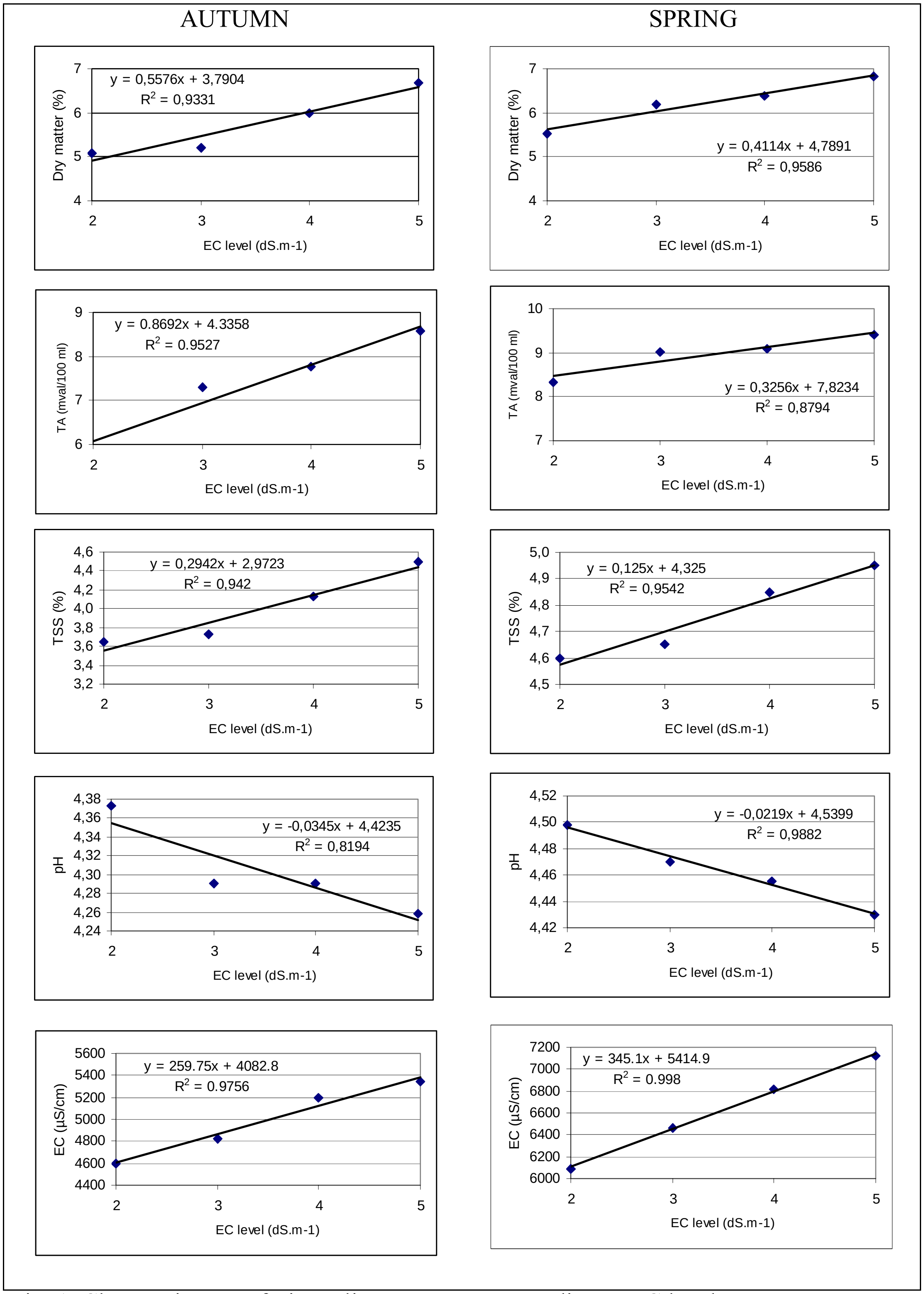

Fig. 1. Changes in some fruit quality parameters according to EC levels.