Strawberry Growth and Fruit Yield in a Saline Environment

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Summary

Up to 20% of irrigated arable land in arid and semi-arid regions worldwide is salt-affected. The problem of salt-affected soils is also present in the Croatian Mediterranean coastal region where seawater intrudes through porous media into calcareous aquifers, mixes with freshwater and salinizes both ground and surface waters. Climatic conditions enable continuous growing of several crops throughout a year, but increasing demand for irrigation water forces the growers to utilize water of poor quality. In 2005, the effect of rising salinity levels (control, 4, 6, and 8 dS m^{-1}) on strawberry vegetative growth and fruit yield was studied in a greenhouse experiment. Salinity treatments had a negative effect on total fresh fruit yield (29-59%), total number of fruits (24-45%), fruit size, as well as on the number of runners (23-86%) and the length of the longest runner (1.3-2.6 times). Furthermore, NaCl salinity stress accelerated leaf senescence and reduced the strawberry growing period by 12-22 days.

Key words

salinity; strawberry; electrical conductivity

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Introduction

According to their ability to grow in a saline environment, horticultural crops can be generally classified either as halophytes or glycophytes. The former group, salt tolerant plants or halophytes, have the ability to grow normally at an excess salt concentration (100-200 mM NaCl) in the growing environment (Flowers et al., 1990). In contrast, glycophytes do not grow well when the osmotic pressure of the soil solution rises above 2 bars and are relatively low salt tolerant plants (Miller and Doescher, 1995). Most horticultural crops are glycophytes (Greenway and Munns, 1980) and also strawberry can be considered as a salinity sensitive specie (Martinez Barroso and Alvarez, 1997).

Two main salinity effects on salt non-tolerant plants are reflected in osmotic and ionic stress. Ionic stress induces nutrient imbalances and thereby affects nutrient bioavailability, competitive uptake, transport or partitioning of nutrients within the plant, while osmotic stress reduces water availability to plants and also causes water stress (Grattan and Grieve, 1994).

On the global scale, about 15 x 10^6 km^2 is cultivated land, of which at least 20% is salt affected. Around 2.4 x 10^6 km^2 is under irrigation, of which more than 40% is salt affected to various degrees (Rhoades and Loveday, 1990; Ghassemi et al., 1995). The problem of salt affected soils is also present in the Croatian Mediterranean coastal region where seawater intrudes through porous media into calcareous aquifers, mixes with freshwater and salinizes both ground and surface waters (Romic et al., 2005). Climatic conditions enable continuous growing of several crops throughout a year, but increasing demand for irrigation water forces the growers to utilize water of poor quality. Gradual build–up of Na and Cl in the root zone may be detrimental to plant growth and yield (Flowers, 1999).

The present study was conducted to investigate the influence of strawberry exposure to different irrigation water salinity levels upon plant growth and yield.

Materials and methods

Study site and conditions

The experiment was carried out 2005 in a polyethylene greenhouse (130 m^2) located at the Faculty of Agriculture, University of Zagreb, Croatia.

Cold-stored runner plants (frigo) of strawberries (*Fragaria x ananassa*, Duch. Elsanta) were planted on August 30 into 1.7 l pots (1 plant per pot) filled with a peat substrate (Klasmann, Potground H). During the first two weeks after transplanting, seedlings were fertigated with a basic nutrient solution (Sonneveld and Straver, 1994), and afterwards the treatment with different salt concentrations in the nutrient solution was applied. Salinity treatments involved four EC levels: 4, 6 and 8 dS m^{-1} plus control (C) of 1.7 dS m^{-1}. The three highest salinity treatments were obtained by addition of commercial sea salt to the basic nutrient solution.

The trial was laid out according to the completely randomized block design with 4 replicates, including 9 plants per replicate, a total of 36 plants per treatment. The fertigation management (rate and frequency) was the same for all treatments and was adjusted to the plant phenology and to the climatic conditions in the greenhouse.

Measurements and data processing

Electrical conductivity (EC) of the substrate was measured at 10 cm depth with a portable field conductometer (CON 5) three times: 30, 60 and 90 days after planting.

Depending on ripening, fruits were harvested 1-3 times weekly and were counted, weighed and measured (height and width). Runners were not pruned during the growing season; they were counted at the end of the experiment, and the length of the longest runner was determined.

Data on growth and yield parameters were subjected to the analysis of variance using the SAS statistical software package (SAS Institute, 2001). The significance of differences between means was determined with Tukey's test at $P \leq 0.05$.

Results and discussion

Salinity and vegetative growth

Electrical conductivity (EC) in pots, at 10 cm, was slightly higher than in the supplied nutrient solutions in all treatments during all three measurements (Figure 1). During the last measurement (75 days after starting the salinity treatment), almost all leaves of salt affected plants (4, 6 and 8 dS m^{-1}) died or developed severe leaf tip burn symptoms. Namely, one of the harmful effects of increased salinity is earlier leaf senescence, due to decreasing chlorophyll content and increasing membrane permeability (Chen et al., 1991; Lutts et al., 1996; Kaya et al., 2001; Munns, 2002), which was detected in this study as well. In the treatment with 4 dS m^{-1}, the growing period ended 12 days earlier, while in treatments with 6 and 8 dS m^{-1} the growing period finished 22 days earlier compared to the control (data not shown).

The number of runners as well as the length of the longest runner was significantly influenced by the salinity

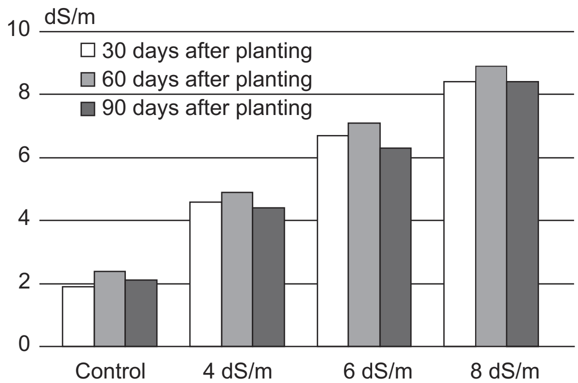

Figure 1.
Electrical conductivity (EC) at 10 cm depth in pots per treatment

Table 1.
Total number of runners (per plant), and the length of the longest runner (cm)

Treatment	Number	Lenght
Control	3.5a	71.3a
4 dS m^{-1}	2.7b	54.4b
6 dS m^{-1}	1.9c	44.4c
8 dS m^{-1}	0.5d	27.4d

Means with the same letter are not significantly different (P≤ 0.05)

Table 2.
Fruit yield (g plant^{-1}), number of fruit (per plant) and average height and width of fruit (mm) per treatment

Treatment	Yield	Number of fruit	Height	Width
Control	96.1a	10.3a	25.5a	27.1a
4 dS m^{-1}	68.6b	7.8b	24.7ab	26.4ab
6 dS m^{-1}	62.8b	7.5b	23.9bc	25.6b
8 dS m^{-1}	39.1c	5.7c	22.7c	24.2c

Means with the same letter are not significantly different (P≤ 0.05)

treatment (Table 1). At the end of the trial, the number of runners was 23-86% lower in salt stressed variants compared to the control, while the length of the longest runner in the control treatment was 1.3-2.6 times higher compared to the other treatments.

Salinity and fruit production

Besides reducing growth, raised salinity had a significantly negative impact on strawberry fresh fruit yield (Table 2). As compared to the control, in the treatments with 4 and 6 dS m^{-1}, total yield was 29 and 35% lower, respectively, and even 59% lower in the treatment with the highest salinity (8 dS m^{-1}). Similarly, NaCl had a negative effect also on the number of strawberry fruits and on average fruit size (height and width) (Table 2). The number of fruits was reduced by 24, 27 and 45%, respectively, in 4, 6 and 8 dS/m treatments compared to unstressed (C) plants. These results are in agreement with Kaya et al. (2001) for strawberry and Satti and Al-Yahyai (1995) for tomato, while Adams and Ho (1989) found that high salinity resulted in small tomato fruits.

Conclusion

During the investigated growing season of hydroponically grown strawberry, NaCl-induced salinity depressed both vegetative growth and fruit yield parameters, as well as accelerated leaf death and shortened the growing period.

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