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Application of treated wastewater for cultivation of roses (*Rosa hybrida*) in soil-less culture

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Abstract

No information is available today concerning the effect of irrigation with secondary treated sewage water on growth, production or quality of roses or other cut flowers. In the present study we investigated the effect of irrigation with treated sewage water on roses cultivated in two soil-less medium, perlite, an inert mineral medium and Choir (coconut fibers), an organic medium of high ion absorption capacity. During 12 months of exposure to the treated water, the visible appearance of the plants, their growth, the quantity and size of the flowering stems and their postharvest performance were not affected by the irrigation treatments. Contents of macroelements in the leaf tissues were unaffected by the irrigation with the secondary treated sewage water. At the same time, Cl contents increased 47% in perlite and 73% in Choir grown plants reaching levels characteristic of exposure to moderate salinity. Mn, Cu and B contents increased as well under cultivation in both perlite and Choir under irrigation with treated sewage water. On the other hand, contents of Fe, Zn, Mo and Al, were similar in all treatments. In all treatments contents of all the examined micro and macroelements were within the range accepted for proper plant function.

Keywords: *Rosa hybrida*; Treated sewage water; Soil-less culture

1. Introduction

Shortage of water in Israel and other arid and semi-arid regions throughout the world dictates that continued and increased agricultural production will depend on utilization of marginal waters for irrigation. The largest source of marginal water for agriculture in Israel is treated municipal sewage water. Legislation in Israel prescribes that all municipal sewage water of municipalities larger than 10,000 capita, should be treated and made available for agricultural and industrial usages. To date, up to 25% of the water used for irrigation in Israel are treated municipal sewage water and this percentage is anticipated to increase to 45% in 2010. The current law in Israel requires secondary treatment plants to produce water with biological oxygen demand (BOD) and total suspended soluble (TSS) not higher than 20 and 30 mg l^{-1}, respectively. The use of the water for irrigation is supervised by the Ministry of Health according to purification standards, and chlorination standards fitting various agricultural usages.

Ornamental crops in Israel make up 30% of the total exported fresh agricultural production. One of the most important crops among the ornamental species is roses, cultivated in soil-less culture, which make up 15% of the exported ornamental production. Since all the cut flowers in Israel, including roses, are irrigated with fresh water or recycled fresh water, no information is available concerning the effect of irrigation with secondary treated sewage water on growth, production or quality of roses or other cut flowers.

Organic matter, TSS, salts (mainly Na, Cl and bicarbonates), nutrients and microelements, are present in higher quantities in the recycled treated water than in fresh water (Feigin et al., 1991). While a lot of information is available concerning the effect of irrigation with saline water on rose production (Yaron et al., 1969; Fernandez Falcon et al., 1986; Hughes and Hanan, 1978; De Kreij and van den Berg, 1990; Baas and van den Berg, 1999; Raviv and Bloom, 2001; Urban et al., 1994), only little is

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known of the combined effects of various components of treated sewage water on plants. Therefore, the main goal of the present project was to study the effect of irrigation with secondary treated sewage water on production and quality of cut roses for commercialization.

The chemical composition of the irrigation water is known to affect the quality of cut flowers. Flower color, as well as shelf life and resistance to diseases might be affected (Halevy and Mayak, 1981; Serek, 1990; Gerasopoulos and Chebli, 1999). The physiology of flowers grown under irrigation with the treated sewage water might therefore differ from that of flowers grown under irrigation with potable water. Excess salts is known to induce genes normally induced by ethylene (Atta Aly et al., 1998; Fujimoto et al., 2000) and high B concentration that is known as a factor in leaf senescence (Riley, 1987) might also stimulate cut flower senescence. Therefore, cut flowers from plants irrigated with treated sewage water might senescence faster than flowers from potable water grown plants.

Roses in Israel are cultivated mainly in soil-less culture. The treated sewage water in Israel and throughout the world is currently used mainly for irrigation of soil-grown plants and only little information is therefore available on the potential these water hold for soil-less cultivation. The high dissolved organic matter and salt contents and the altered salt composition and pH values might affect adsorption and release of inorganic nutrients such as phosphorus, iron and microelements and of toxic elements such as aluminum, from the medium, and hence plant performance. The various soil-less media utilized for cultivation of roses might be affected differently by treated sewage water. A media characterized by high buffer capacity and high cation and anion absorption capacity is expected to moderate the chemical effects of the treated sewage water more than an inert media.

We know of no study, or agricultural production system, which has evaluated comparatively the suitability of different soil-less cultivation media for irrigation with treated sewage water. In this study we have investigated the effect of irrigation with treated sewage water on roses cultivated in two soil-less medium, perlite, an inert mineral medium and Choir (coconut fibers)—an organic medium of high ion absorption capacity. We have studied the effect of treated sewage water on yield, quality and postharvest performance of roses.

2. Materials and methods

2.1. Plant material and growing conditions

The experiment was conducted in ''Lachish'', an agricultural experimental farm in Israel (from September 2002 to December 2003), in a climate controlled greenhouse using a heating system and an evaporative cooling system. The set-point minimum and maximum temperatures in the greenhouse were 26 and 18 °C day/night. The minimum day and maximum night relative humidities were 60% and 90%, respectively.

The cultivar used was 'Long Mercedes' grafted on the rootstock *Rosa indica.* The plants were grown in perlite or Choir beds, 40 cm width × 17 cm height. The plants were planted 20 cm apart, two rows per bed. The experiment had a random block design, with five replicated plots of 5 m length (50 plants per plot) per treatment. Irrigation was supplied two to four times a day (during the winter and summer months, respectively), via 1.6 l h^{-1} discharge-regulated drippers, one dripper per plant, two laterals per bed, one lateral per plant row. The volume of irrigation in each irrigation pulse was set to allow 25–35% of drainage in an open system.

Planting took place in September 2002 and the first flowers were harvested in November 2002.

2.2. Irrigation treatments

Plants were irrigated with either potable waters, or secondary treated sewage water. The treated sewage water applied were primarily domestic effluents from the town of Kiryat-Gat, treated at the Gat effluent treatments facility. The treated sewage water was chlorinated according to regulations of the Ministry of Health in Israel, to the level of 0.5 mg l^{-1} chlorine in the irrigation solution. Chemical compositions of both sources of irrigation waters are detailed in Table 1.

The fertigation solution was adjusted to contain similar levels of macronutrients for both irrigation treatments. Since the treated sewage water contained higher levels of P, N and K than the potable waters (Table 1), lower levels of these elements were added to the treated sewage water. The treated sewage water used in the experiment contained high levels of N-NH_4, for example 2.5 mmol l^{-1} on September 2003 (during the summer) and 3.5 mmol l^{-1} on July 2003 (during the winter). Therefore, we have selected to use a low N-NH_4 liquid fertilizer, named Mor (4% N, 2.5% P_2O_5, 6% K_2O, 2% Ca, 0.5% Mg, 0.06% Fe, 0.03% Mn, 0.015% Zn, 0.0022% Cu and 0.0016% Mo, 1.21 g cm^{-3} density) (Fertilizers and Chemicals Ltd., Israel), which contain only 10% of the N as N-NH_4 and

Table 1
Chemical composition of the potable waters and treated effluents utilized in the project

Parameter	Potable water	Treated effluents
EC (dS m^{-1})	1.15	2.0–2.5
pH	7.4	7.7
COD (mg l^{-1})	N.D.	86
TOC (mg l^{-1})	N.D.	37.1
N-NH_4 (mmol l^{-1})	0.03	2.5–3.5
N-NO_3 (mmol l^{-1})	0.05	0.01
HCO_3 (mmol l^{-1})	2.9	10.0
P (mmol l^{-1})	0.03	0.21
K (mmol l^{-1})	0.22	1.75
Ca (mmol l^{-1})	1.5	1.75
Mg (mmol l^{-1})	1.5	1.7
Na (mmol l^{-1})	5.6	9.2–12.9
Cl (mmol l^{-1})	7.5–8.5	7.6–11.8
Fe (mg l^{-1})	<0.001	0.079
Mn (mg l^{-1})	<0.0001	0.020
Zn (mg l^{-1})	0.04	0.05
Cu (mg l^{-1})	<0.0001	0.003
B (mg l^{-1})	0.18	0.49
Cd (mg l^{-1})	<0.0001	0.0009
Ni (mg l^{-1})	<0.0001	0.016