

INFLUENCE OF SALINE RECLAIMED WATER AND REGULATED DEFICIT IRRIGATION ON YOUNG GRAPEFRUITS

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ABSTRACT

A three year experiment (2007–2009) was conducted at a commercial mandarin orchard located in Campotejar (Murcia, Spain). The main objective was to evaluate the effects of different irrigation water qualities used in Mediterranean agriculture combined with the regulated deficit irrigation strategy, on mandarin tree crop and their effects on plant physiology, leaf mineral status, soil chemical properties, water content, yield and fruit quality.

Na, B and chloride concentrations exceeded the phytotoxic level in reclaimed water used for irrigation, although no toxic symptoms have been seen during the three seasons. A tendency was identified in terms of salts accumulation in the soil, during the last season in RW treatments. Soil infiltration problems can occur in the long term in RW and IW treatments, because SAR values exceeded the recommended range. Leaf B concentration was over the phytotoxic limit, more marked in RW treatments, although no toxicity symptoms were observed. Yield reductions were not significant between treatments, although a tendency to reduced number of fruit was detected in the RW treatments. Among fruit quality parameters, a tendency of higher fruit weight and size were observed in reclaimed water treatments. Nevertheless, further studies are required to assess the long-term effect of such combination.

KEYWORDS

Reclaimed water; irrigation; salinization; deficit irrigation; grapefruit

INTRODUCTION

Irrigated agriculture is the primary user of diverted water globally, reaching a proportion that exceeds 70–80% of the total in the arid and semiarid zones. In these regions, the use of efficient water management strategies, as regulated deficit irrigation (RDI), and the use of non-conventional water resources, as reclaimed water, in agriculture, have the potential to augment water supplies and narrow the gap between fresh-water availability and demand in water-scarce countries and regions.

Secondary salinization from irrigation water is a growing worldwide problem as more agricultural land has become saline. The combination of the deficit irrigation strategies and the use of reclaimed water, can increase soil salinization.

The main objectives of this study, were to evaluate the effects of different irrigation water qualities used in Mediterranean agriculture and the regulated deficit irrigation strategy, focused on young grapefruit tree crop and their effects on plant physiology, leaf mineral status, soil chemical properties, water content, yield and fruit quality.

MATERIALS AND METHODS

The experiment was conducted during the citrus production cycle (2007/2008/2009), at a commercial orchard located in Campotejar (Murcia) Spain (38°07'18''N; 1°13'15''W). The experimental plot of 0.5 ha was cultivated with 5-year young 'Star Ruby' grapefruit trees (*Citrus Paradisi Macf*) grafted on Macrophylla rootstock [*Citrus Macrophylla*]. The irrigation head was equipped and supplied with three water sources; the first (TW) was pumped from the Tajo-Segura water transfer ($EC \approx 1 \text{ dS m}^{-1}$), the second (IW) was delivered by the irrigators association of Campotejar ($1 \leq EC \leq 4$), and the third water sources (RW) was pumped from the "North of Molina de Segura" wastewater treatment plant (WWTP) ($EC \approx 3.5 \text{ dS m}^{-1}$). In 2008 and 2009, two irrigation treatments were differentiated for each water source. A control treatment (C) irrigated to recover 100% ETC throughout the growing season and a (RDI) treatment applying 50–30% Etc during the RDI period in 2008 and 50% Etc during all the RDI period in 2009.

Water analysis were realized monthly between 2007 and 2009 in order to characterize irrigation water quality. The measurements of macronutrients (Na, K, Ca, Mg), micronutrients (Fe, B, Mn), heavy metals (Ni, Cd, Cr, Cu, Pb, Zn), anions (chloride, nitrate, phosphate and sulphate), pH, electric conductivity (EC) and total dissolved solids (TDS), turbidity and microbial quality of irrigation water were made it. Soil samples were collected every three months during 2008 and 2009, from 0.2, 0.4 and 0.6 m depths at 0.1 and 0.3 m away from the emitter. Soluble-salt contents of soils were determined by the electrical conductivity of the saturated paste extract (EC_e), also the soluble Ca and Mg and Na were measured. In plant measurements, leaf mineral concentration of macro and micro-nutrients was measured each three months, vegetative growth at the beginning and end of each season, and yield and fruit quality at the end of each season.

RESULTS AND DISCUSSION

The water quality was different between each source of irrigation water. RW showed the highest values in salinity

(EC) and sodicity (SAR), and TW the lowest. IW water quality varied during the three seasons (figure 1). RW had dangerous values in the phytotoxic ions. This irrigation water had a significantly higher concentration in chlorides, Na and B (figure 1). The Na concentration in RW and IW ($>15 \text{ meq l}^{-1}$) produced higher sodium absorption ratio (SAR) in both irrigation water (figure 1). Both water quality treatments were in the slight to moderate degree of restriction on use (SAR 12–20 and EC 1.3–2.9 dS m^{-1}) because of soil infiltration problems (Ayers and Wescot, 1985). During the experimental period, B concentration in RW was in the phytotoxic range for sensitive crops (figure 1). Citrus are considered sensitive crops to B (Mass, 1993). Some peaks of different nutrients were located in RW and IW because of the industrial spills in the wastewater treatment plant (WWTP) and the different mix of irrigation water sources used by the irrigators association (figure 1).

IW presented the lowest and most uniform microbiological results throughout the experimental period. On many occasions, TW exceed the RW microbiological values, presenting the highest values.

Figure 1. Evolution of water quality indexes and chemical compositions.

These results showed that open channel irrigation water can have more microbiological risk than reclaimed water, although *E.coli* and helminth eggs (data not shown ($<10 \text{ eggs } 10 \text{ L}^{-1}$)) were observed in the normal level according to Royal Decree–Law 1620/2007 of Purified Water Reuse in Spain (2007) for trees with drip irrigation (figure 2).

Figure 2. Evolution of monthly measured microbiological quality indexes of irrigation–water sources.

In the chemical soil analysis made in the gravimetric samples, the EC_e was higher in the deficit irrigation period (July–August). During these periods the RW–RDI treatment was in dangerous levels for soil salinity problems. Although after the deficit irrigation period salt leaching was observed (December–January), a tendency in terms of salts accumulation was identified in the soil during the last season in the reclaimed water irrigation treatments. Leaf B concentration was over the phytotoxic limit ($>100 \text{ mg l}^{-1}$ according to Legaz et al., 1995) in 2009. These high B concentration were more marked in RW treatments, although no toxicity symptoms were observed. Macro–nutrients (P, K, Ca, Mg) and micro–nutrients (Fe, Mn, Zn) were always in the recommended range (Legaz et al., 1995). In the deficit irrigation period, the soil water store (SWS) of the RW treatment, was not reduced so marked than the

IW and TW treatments, especially in 2009. The yield and fruit categories were not significantly affected by the water quality treatments and regulated deficit irrigation applied during all the experimental period considered. A tendency to reduce number of fruit was detected in the RW treatments during these three seasons. However, according to the relationship found between yield and crop load, a tendency of higher fruit weight and size were observed in reclaimed water treatments.

CONCLUSIONS

RW irrigation water exceeded the phytotoxic level, although no toxic visual symptoms have been seen during the three seasons. A tendency was identified in terms of salts accumulation and soil infiltration problems in the soil, during the last season in RW treatments. No toxicity symptoms were observed in leaf mineral concentration. Yield reductions were not significant between treatments. A tendency to reduced number of fruit was detected in the RW treatments. The combined effects of RDI strategies and of using reclaimed water can increase some fruit quality parameters on grapefruit trees. Nevertheless, further studies are required to assess the long-term effect of such combination. However, it is important to remark that in arid and semi-arid areas, the combination of RDI strategies and reclaimed water-use can be affected in the long-term because of the salts and boron accumulation.

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