Assessment of fruit quality of grapefruit at postharvest influenced by reclaimed water and deficit irrigation

Evaluación de la calidad en postcosecha de pomelos regados con agua regenerada y déficit hídrico

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Abstract

The aim of our research was to discover the effects of the long-term irrigation with saline reclaimed (RW) and transfer (TW) water and different irrigation strategies: control (C) and regulated deficit irrigation (RDI) on fruit quality of grapefruit during cold storage. Result showed sugar/acid ratio was mainly increased by RDI, but also by RW, due to an important increase in soluble solid content. However, RDI combined with RW, significantly decreased the number of fruits in the largest category 5 at the end of cold storage and TW-RDI showed lower values of juice content.

Keywords: cold storage; fruit diameter; juice content; peel thickness; soluble solid content.

Resumen

El objetivo de la investigación fue evaluar los efectos a largo plazo del riego con agua regenerada (AR) y agua del trasvase (AT) y diferentes estrategias de riego (control, C, y riego deficitario controlado, RDC) sobre la calidad de pomelos durante su almacenamiento en frío. Los resultados mostraron que el riego con AR y, principalmente, el RDC incrementaron la cantidad de solidos solubles, mejorando así el índice de madurez. Sin embargo, el AR combinada con RDC disminuyó el nº de frutos de la categoría de mayor tamaño al final del almacenaje y AT-RDC presentó el menor contenido en zumo.

Palabras clave: almacenamiento en frío; contenido de solidos solubles; contenido en zumo; diámetro de fruto; espesor de corteza.

1. INTRODUCTION

Current climate change predictions indicate increases in the frequency of drought periods for Mediterranean areas. In order to overcome this, the development of strategies to optimize water productivity at field is needed. A useful approach is regulated deficit irrigation (RDI), where water deficits are imposed during phenological periods least sensitive to water stress, with little or no impact on fruit quality. In fact, RDI has been shown to improve fruit quality in Citrus [1], a crop with species of great economical relevance in the Mediterranean and worldwide. Moreover, the use of non-conventional water sources such as reclaimed water (RW) is also an alternative in these regions. RW can be beneficial to crops due to its high macronutrient concentration, considering that an excess of them could be lost through leaching [2]. Besides, RW may imply risks to agriculture due to its salt concentration, resulting in negative impacts on fruit quality [3]. However, suitable use of RW can increase the juice soluble solid content and titratable acidity [4].

The maintenance of fruit quality depends on storage conditions to a great extent but environmental conditions and agronomic factors, such as the water quality and irrigation strategies, also have a marked influence on fruit quality at postharvest. The experiment reported here is the first one to evaluate of grapefruit quality after being irrigated with RW and RDI for eight years at field. The aims of this study were to assess the effects of these strategies on fruit quality at postharvest during cold storage for 31 days.

2. MATERIALS AND MHETODS

The experimental plot was cultivated with 'Star Ruby´ grapefruit (*Citrus paradisi Macf*). Two different water sources were used: The first one was pumped from the Tajo-Segura canal (transfer water, TW) and the second one was pumped from a tertiary wastewater treatment plant (reclaimed water, RW) with high levels of salinity and N, P and K. Two irrigation treatments were established: i) Control (C) irrigated to fully satisfy crop water requirements (100% ETc); ii) Regulated Deficit Irrigation (RDI) which received half the water amount applied to the C (50% ETc) during the second stage of fruit development.

Ninety fruits per treatment were stored in darkness at 10 ºC and 85% RH for 31 days. Quality parameters were measured on 15 fruits per treatment at 0, 10, 17, 24 and 31 storage days. Weight loss was determined at every sampling date in 10 marked fruits per treatment. The quality parameters evaluated included peel thickness, color index, juice content, soluble solid content (SSC), titratable acidity (TA) and SSC/TA ratio. Peel color was measured using a Minolta CR-300 colorimeter at two locations around fruit equatorial plane. Hunterlab parameters L, a and b were used, and color index was calculated as (a×1000) / (L×b), where L indicates lightness and a and b are the chromaticity coordinates. Juice content was calculated as juice weight/fruit weight × 100. SSC and TA were measured according to [3]. SSC/TA ratio was used for an indication of perception of taste by the consumer and expression of juice quality. Finally, commercial categories were established for fruit of postharvest according to Codex Standards for grapefruit [5]. A weighted analysis of variance (ANOVA; statistical software IBM SPSS Statistics v.21 for Windows) followed by HSD Tukey ´s test ($P \leq 0.05$) were used for assessing differences among treatments. The percentage values were arscine-transformed before statistical analysis.

3. RESULTS AND DISCUSSION

At the beginning of postharvest, no significant differences in peel thickness, color index and TA were observed among treatments (Fig. 1). Throughout the cold storage, fruit weight loss was significantly different between treatments (being greater in RW-C and lower in RW-RDI) and, in addition, it was also significantly different across time (p-value: 0.036) (Fig. 1A). Fruit diameter decreased during storage in all treatments, as expected. RW-RDI showed significantly lower values than the rest of the treatments from the beginning of storage (Fig. 1B); this was related with the lower fruit weight loss found in RW-RDI. Peel thickness decreased similarly in all treatments throughout the storage; therefore, one of the causes of weight loss could be that. Besides, the transpiration occurs in a greater proportion in the skin of the fruit than in the pulp as reported [6]. On the contrary, color index showed a tendency to increase during storage, mainly in Control treatments (Fig. 1D). The low temperature during storage probably resulted in a decrease in the chlorophyll/carotenoid ratio of the flavedo because chlorophyll was degraded over time [7]. Juice content also increased during storage (Fig. 1E), since it is based on fruit weight; TW-RDI showed significantly lower values than the rest of the treatments. Moreover, despite that grapefruit is a non-climacteric fruit, SSC increased during postharvest and it was probably due to a concentration effect by weight loss (Fig. 1F). TA, conversely, did not show a clear trend over time (Fig. 1G). Finally, SSC/TA ratio also did not have an evident trend through the storage. However, last day of the postharvest it was enhanced by water restriction, although also by the use of RW and their combination due to higher SSC values, increasing the differences already observed between treatments at harvest and 0 storage day (Fig. 1H). This result is important since grapefruit juices are produced by industries all over the world due to the preference of consumers based on its taste [8]. A positive linear correlation between SSC and preharvest water deficit was found by [9] for mandarin. Finally, at 0 day of storage, water quality did not affect fruit size. However, water restriction resulted in a smaller fruit size (Fig. 2). At the end of storage, as expected, all treatments decreased the percentage of category 3 fruits and increased those of categories 4 and 5; mainly TW-RDI and RW-RDI which increased category 5 by 20 and 30%, respectively.

4. CONCLUSIONS

The novelty of this study lies in the evaluation of grapefruit quality after being irrigated with RW and RDI for 8 years under field conditions. The findings of this study suggest that the application of both RDI and RW resulted in an improvement in perception of taste by the consumer due to the increasing of soluble solid content. Besides, water quality did not affect fruit size although water restriction resulted in a smaller fruit size. When RW was combined with RDI the number of fruits of small category (nº5) at the end of postharvest was increased.

5. ACKNOWLEDGMENT

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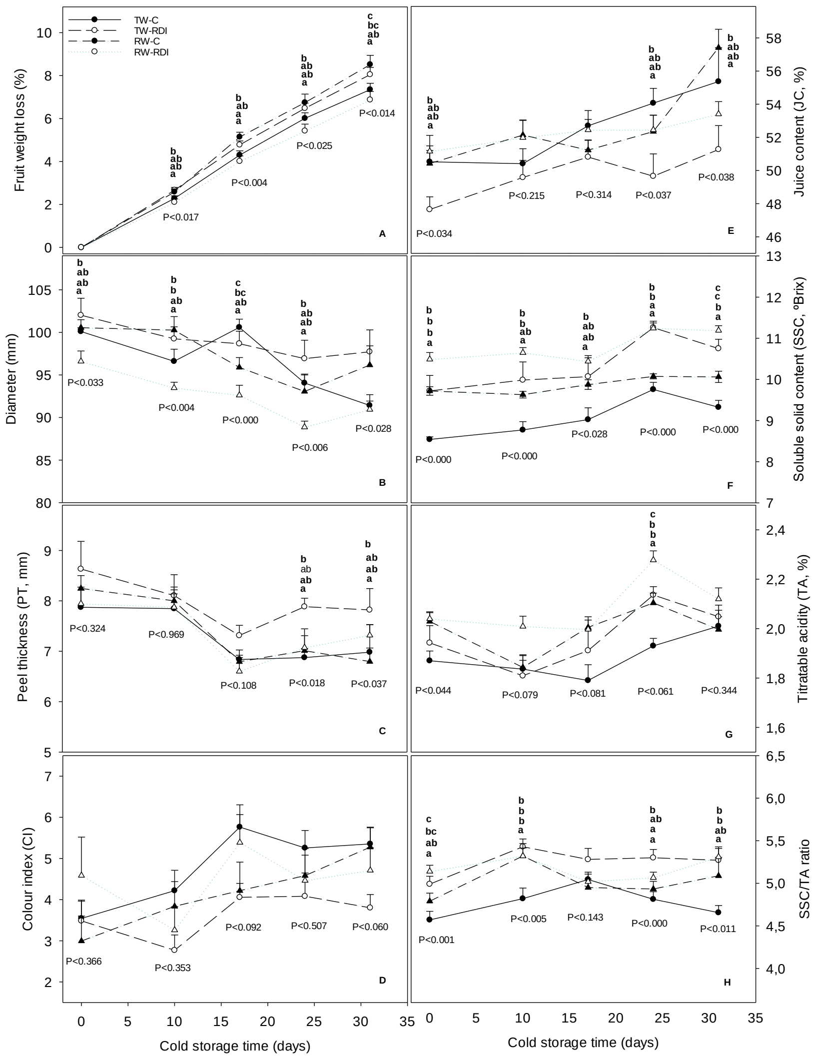

Figure 1. Seasonal pattern of fruit quality. Each point is the average ±SE of the measurements performed in 15 fruits per treatment. Within each date, P-value and different letters indicate differences among treatment by ANOVA analysis followed of HSD Tukey´s test (P≤0.05).

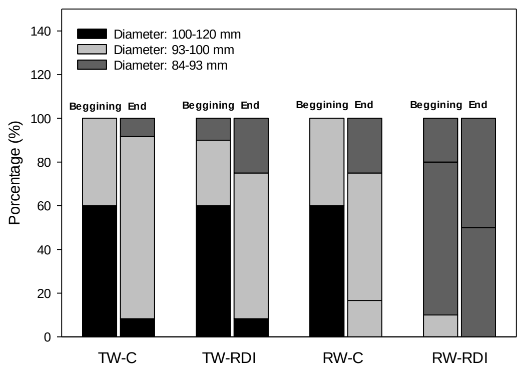

Figure 2. Percentage of fruit size category for each treatment. Fruit diameters 100-120, 93-100 and 84-93 mm correspond to categories 3, 4 and 5 , respectively. “Beginning” and “End” above the bars means at the beginning and at the end of storage.