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Postharvest regulated deficit irrigation in early- and intermediate-maturing loquat trees

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ABSTRACT

Postharvest deficit irrigation (DI) strategies have been proven to advance bloom, harvest dates and economic return in loquat 'Algerie' trees because an early harvest results in higher loquat fruit prices. This fact poses the question of whether postharvest DI strategies could have a similar effect on more precocious cultivars than *cv*. Algerie, providing thus a more profitable option to farmers. In this work, the response of an early- and intermediate-maturing loquat cultivars (*cv*. Cardona and Algerie, respectively) to a summer early (DI_{early}) and late (DI_{late}) DI strategy was assessed in two parallel studies during three consecutive years. The effects of the DI_{early} and DI_{late} strategies on bloom date, percentage of fruit picked at harvest per picking date and yield of both loquat varieties were studied. Moreover, fruit quality of *cv*. Cardona at harvest was also assessed. Plant water status was monitored by midday stem water potential (Ψ_{stem}) measurements. Results showed that DI_{early} and DI_{late} strategies advanced bloom in both cultivars although a higher effect was observed with the DI_{early} than with the DI_{late} treatment. Water restrictions did not increase the percentage of fruit picked at any of the picking dates and did not affect yield or fruit quality in the early-maturing cultivar. In 'Algerie' trees, a higher percentage of fruit was generally picked during the first picking dates in the DI_{early} and DI_{late} treatments than in the control although differences were only statistically significant during the last experimental season. Yield was significantly higher in 'Algerie' DI_{late} trees than in control or DI_{early} trees two out of the three experimental seasons. Overall, results showed that the DI_{early} and DI_{late} strategies tested here did advance bloom in the early-maturing cultivar but did not have an effect on the percentage of fruit picked per picking date at harvest. Nevertheless, the fact that substantial water savings (> 30%) were obtained with no detrimental effect on yield presents the use of postharvest DI strategies as an interesting option to be followed in early-maturing cultivars for a more efficient crop production.

1. Introduction

Loquat (*Eriobotrya japonica* Lindl.) is an evergreen subtropical tree crop native from China, which is the first producing country in the world (Caballero and Fernández, 2003). Loquat requires humid and warm climate and therefore, its production has been well adapted to the Mediterranean climatic conditions (Llácer et al., 1995). In Spain, loquat is a minor crop in the country although its fruit is appreciated in other Mediterranean countries and exports are close to 50% of total production (Caballero and Fernández, 2003). Its interest lies in the fact that loquat trees are harvested during spring (loquat fruit ripens between March to May), when there is low competition with other fruit on the market. This characteristic makes loquat an interesting and profitable crop for growers, especially the most precocious cultivars, which usually reach higher value in the market.

Specific breeding programs have been design in Mediterranean

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countries to find new and early-maturing loquat cultivars (Badenes et al., 2013). Crop management practices have been also tested with success to advance full bloom and harvest dates in 'Algerie' trees. For instance, extensive work on loquat 'Algerie' trees has illustrated the suitability of this cultivar to regulated deficit irrigation (RDI) (Cuevas et al., 2007; Cuevas et al., 2009; Hueso and Cuevas, 2008, 2010; Rodríguez et al., 2007).

RDI is a water-saving strategy in which trees are deficit irrigated during certain phenological periods when trees are less sensitive to water scarcity while irrigation is applied to meet full water requirements during the most sensitive stages of the crop (Behboudian and Mills, 2010; Chalmers et al., 1981). Postharvest RDI strategies have been proven to hasten both bloom date and harvest date in 'Algerie' trees, increasing then crop profitability.

Studies on 'Algerie' trees by Cuevas et al. (2007) determined that the month of July is the most appropriate time to implement RDI strategies in order to do not harmless flower development. Cuevas et al. (2009), on the other hand, reported that short periods with severe water restrictions (0–25% ET_c) from mid-June to the end of July are more effective than sustained water stress strategies to advance bloom and harvest date. Therefore, implementation of this irrigation practice can lead loquat 'Algerie' producers to increase their incomes due to both a reduction in the costs associated with the water usage and an increase in the price reached by the fruit in the market (Hueso and Cuevas, 2010). This fact poses the question of whether postharvest DI strategies could have a similar effect on more precocious cultivars than *cv*. Algerie, providing thus a more profitable option to farmers.

The *cv*. Cardona is a somatic mutation from 'Algerie' (Carrera-García et al., 2011). 'Cardona' trees reach full bloom and maturation around two weeks earlier than 'Algerie' trees (Martínez-Calvo et al., 2000) and for that reason its cultivation is an interesting option in loquat producing areas. Postharvest RDI strategies in this particular cultivar could even increase the gap with the *cv*. Algerie. Nevertheless, it is not rare to find differences between cultivars in their sensitivity to water stress or other abiotic factors (Salón et al., 2004) and thus, assessment of RDI strategies on cultivars with different ripening season are encouraged.

The main objective of this work was to study the response of early- and intermediate-maturing loquat cultivars to postharvest deficit irrigation with special interest in blooming, percentage of fruit picked at each picking date at harvest and yield in order to explore whether summer DI strategies could be applied to early-maturing loquat cultivars to reach the market earlier in the season.

2. Material and methods

2.1. Experimental sites

Two contiguous sites were selected at Callosa d'En Sarrià (38°45′N, 0°08′W, elevation 247 m), Alicante (Spain) for studying the response of and early- and intermediate-maturing loquat varieties to RDI strategies. One site was a 0.6-ha terraced orchard planted with 'Cardona' trees in 2000 in which summer RDI strategies were studied from the 2009/10 to the 2011/2012 seasons. The second site was a 0.5-ha terraced orchard planted with 10-year-old 'Algerie' trees where RDI strategies were studied from the 2010/11 to the 2012/13 seasons. At both sites, trees were planted at a spacing of 3 m between trees within the same terrace.

Soil at both sites was of clay texture (45% clay, 25% silt, 30% sand), stony and with an effective depth of 0.80 cm and an organic matter content of 2.82%. Trees were drip irrigated with only one line per row and four emitters of 3.85 L h^{-1} per tree. As a normal practice in the area, a shading white net was used throughout the entire experiment in both sites to reduce the solar radiation to approximately 65% of the global solar incident radiation reaching the net. Meteorological data during the study was obtained from a weather station installed under the net.

Table 1
Irrigation amounts applied (mm from harvest to harvest) to 'Cardona' and 'Algerie' trees in the control, early deficit irrigation (DI_{early};) and late deficit irrigation (DI_{late};) treatments along with the reference evapotranspiration (ET_o, mm) and precipitation (P, mm) recorded during each of the experimental seasons. Water savings (%) for each DI treatment and season are shown between brackets.

Cultivar	Season	Control	DI_{early}	DI_{late}	ETo	P
Cardona	2009–2010	234	177 (24)	183 (22)	994	532
	2010–2011	252	202 (20)	206 (18)	768	403
	2011–2012	390	256 (34)	358 (8)	736	559
Algerie	2010–2011	291	263 (10)	237 (19)	777	403
	2011–2012	342	210 (38)	281 (18)	717	559
	2012–2013	273	173 (37)	184 (33)	721	280

Field practices were those commonly applied for loquat tree culture in the area and included fruit thinning applied to retain only the more developed 4–5 fruits per panicle.

2.2. Irrigation treatments

As an early-maturing cultivar, 'Cardona' trees reach full bloom earlier than 'Algerie' trees (11–20 days before in this study over the three seasons) and thus, RDI strategies were applied two weeks earlier in 'Cardona' than 'Algerie' trees. Two RDI strategies in which irrigation was withheld for four weeks were assessed at each site during three consecutive seasons, that is, from 2009 to 2012 at the 'Cardona' site and from 2010 to 2013 at the 'Algerie' site. Irrigation treatments consisted in an early (DI_{early}) and late (DI_{late}) deficit irrigation strategies. DI_{early} was applied from mid-June to mid-July to 'Cardona' trees and during the month of July to 'Algerie' trees. The DI_{late} strategy was applied from mid-July to mid-August to 'Cardona' trees and during August to 'Algerie' trees. Both RDI strategies were compared to a control treatment irrigated at 100% of the estimated crop evapotranspiration (ET_c).

The experimental design at each site was a randomized complete block, with three plots per treatment (a total of 9 experimental plots per site). Each experimental plot consisted in three rows of five trees each. The middle row was used for the plant determinations and perimeter trees were used as guards. All the experimental plots were instrumented with in-line water flow meters in order to record the volumes of water applied to the trees.

2.3. Plant water status

Effect of treatments on plant water status was determined by measuring the stem water potential (Ψ_{stem}) in two trees per replicate (six trees in total per treatment) with a Scholander pressure chamber (Model 600 Pressure Chamber, PMS Instrument Company, Albany, USA). Measurements were performed weekly at solar noon in two leaves per tree located in the north side of the canopies and bagged with aluminum foil at least two hours previous to the measurements.

2.4. Flowering determinations

The possible effect of the DI strategies on flowering was evaluated on ten panicles of two trees per plot (20 panicles per plot; 60 panicles per treatment). Panicles were properly labeled and flower opening was monitored weekly to determine the percentage of open flowers on a panicle basis thorough the season.

2.5. Yield determinations and fruit quality

Yield was determined at harvest by picking all the fruit from three trees per plot (nine trees per treatment in total). At both sites, fruit were picked in several days (over the tree seasons, 7–8 days for 'Cardona'