Scientia Horticulturae 162 (2013) 144–149

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

No need for further fruit thinning in water-deprived loquat trees at preharvest

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ARTICLE INFO

Article history:
Received 11 March 2013
Received in revised form 24 July 2013
Accepted 29 July 2013

Keywords:
Preharvest deficit irrigation
Fruit size
Fruit earliness
Yield
Profitability

ABSTRACT

Preharvest deficit irrigation (DI) during fruit growth may reduce fruit size in 'Algerie' loquat (*Eriobotrya japonica* Lindl.), but it can eventually enhance other parameters of fruit quality and earliness, making this crop more profitable. With the aim to determine the optimum level of fruit load per panicle under preharvest DI, we have compared harvest date, fruit size, yield, and revenue from 'Algerie' loquat trees analysing four different fruit loads under two irrigation treatments: T1, a control in which the trees' water requirements were fully satisfied from bloom to harvest; and T2 (a treatment of preharvest DI) in which irrigation was withheld from stage II of fruit development until the end of harvest (a total of 13 and 14 weeks, depending on the season). The four levels of fruit load were 1, 2, 3 and 4 fruits per panicle. The results showed the absence of significant interactions between irrigation and fruit load treatments, probably due to the low levels of water stress reached during preharvest. DI did not enhance fruit maturity substantially and therefore failed to advance the harvest date. Pack out was slightly improved by heavier fruit thinning treatments; however, that improvement did not compensate the important yield loss caused by the reduction in the number of fruit per panicle. Therefore, a crop load of 4 fruits per panicle provided the highest revenue in both irrigation treatments. An average water saving of 2281 m^3/ha (33% of the water applied in T1) was achieved by preharvest DI. In conclusion, the low levels of water stress reached by withholding irrigation in spring in SE Spain do not impose heavier fruit thinning in 'Algerie' loquats.

1. Introduction

Loquat (*Eriobotrya japonica* Lindl.) is an evergreen subtropical fruit crop native to southeast China (Lin et al., 1999) that belongs to the family Rosaceae, subtribe Pyrinae (formerly known as subfamily Maloideae) (Potter et al., 2007). Loquat sets abundantly and consequently the fruit is small. As fruit size is critical for loquat marketing, thinning has become a mandatory practice. In this regard, 4 fruits per panicle have been established as the optimum level of fruit load in well-managed trees of the cultivar Algerie (Leiva, 1999). Fruit thinning is usually performed by hand, but can be done also chemically (Agustí et al., 2000; Cuevas et al., 2004). By altering the sink-source ratio, thinning not only improves fruit size, it can also speed up fruit development, which results in earlier ripening. The annual cycle of loquat runs contrary to that of other well-known temperate-zone fruit crops. Loquat rests in summer and blooms in autumn; its fruits develop through winter and ripen in early spring, well before any other spring fruit. For this reason, early ripening is a crucial commercial factor in this crop, since the earliest harvests fetch the highest prices.

Loquat has become a model crop for the application of an irrigation strategy termed deficit irrigation (DI). DI is a system of managing soil water supply to impose periods of predetermined plant or soil water deficit that can result in some economic benefit (Behboudian and Mills, 1997). In loquat, postharvest (summer) DI is clearly beneficial as water stress promotes earlier bloom and harvest dates the following season. Such advancement leads to greater profit without any negative effect on fruit quality or yield. The increase in water use efficiency (around 30% more) and in water productivity (44% more) achieved after applying postharvest DI during ten consecutive years, clearly demonstrates that loquat growers may obtain greater profitability with less irrigation water (20% less) (Hueso and Cuevas, 2010).

Despite the outstanding results achieved by means of postharvest deficit irrigation, no previous experiments have analysed the implementation of an additional period of DI during loquat fruit development. This may well be due to the fact that water stress

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http://dx.doi.org/10.1016/j.scienta.2013.07.030

during fruit development is likely to diminish fruit size, which is a key determinant of loquat price. Nonetheless, fruit earliness, flavour, and firmness can be improved by a wisely managed water deficit (Behboudian et al., 2011; Naor, 2006). Therefore, the present work aims: (1) to explore the effects of preharvest DI on fruit quality and yield in 'Algerie' loquat and (2) to determine the interaction between crop load and DI in order to recommend the most profitable level of fruit thinning to growers of 'Algerie' loquat in a situation of unexpected water shortage.

2. Materials and methods

2.1. Plant material and location

The trial was carried out over two consecutive seasons (2010/11 and 2011/12) on a monovarietal orchard of 'Algerie' loquat planted in 1992 and grafted on 'BA-29′ quince (*Cydonia oblonga* Mill.). The orchard is located at the Cajamar Research Centre "Las Palmerillas" near El Ejido (Almería, SE Spain). This orchard is not at risk from frost due to its latitude (36°48′N, 2°43′W), low altitude (151 masl) and short distance from the Mediterranean Sea (11 km). Annual rainfall in the area is 262 mm, while mean annual ET_0 reaches 1283 mm per year. Trees are vase-trained and spaced 5 m × 5 m. The orchard is under non-tillage and the management can be considered adequate since the commercial yield averages almost 20 t per ha (Hueso and Cuevas, 2010).

2.2. Experimental design

In the experiment design, irrigation treatments were the main plots, replicated three times, and crop loads were split plots within the main plots. Irrigation treatments were arranged in randomised complete blocks and consisted of two treatments, T1 and T2.

T1 acted as a control irrigation treatment. These trees were fully irrigated from August (panicle initiation) to May (end of harvest); however, irrigation was withheld over a period of eight weeks during June and July in order to promote early flowering (Cuevas et al., 2012). This strategy has become the recommended practice for irrigating loquat in the area. Trees under T2 did not receive irrigation for 13–14 weeks between stage II of rapid fruit growth and the end of harvest. These trees were also deprived of irrigation during June and July and therefore displayed the same phenological advancement as T1 trees. Three replications were made of both treatments in different portions of the orchard. Each replication consisted of a single row of trees, the central two of which were selected for detailed measurements. No guard trees or rows were established, but lateral water movement between tree rows was prevented by placing a plastic film between them. We placed the plastic film digging a ditch to a depth of 1 m, in which most quince roots are restricted, and also confirmed that lateral movement of water was almost nil. Finally, the soil around T2 tree rows was covered with a plastic sheet to minimise the effects of rain on soil water content and on plant water status.

Four crop loads were selected as levels of the split plots. These ranged from 4 fruits per panicle (the standard for this cultivar) to only 1. These levels were established by hand fruit thinning performed in early February, when the irrigation suspension started, in order to simulate the intervention of a grower coping with an unexpected water shortage. These crop loads were applied on eight shoots per tree (48 panicles per treatment), evenly distributed around the canopy at 1.5–2.0 m height in such a way that all were included in each tree. The remaining panicles of the tree were hand thinned to 4 fruits per panicle in January, as per usual in this crop.

2.3. Soil and plant water status monitoring

The volumetric soil water content was determined with a time domain reflectometry (TDR) system (Trase 6050X1, Soil Moisture Equipment Corp., Santa Barbara, CA, USA). Readings were taken weekly during the water deficit period and immediately after re-irrigation using 45 cm long waveguides on one tree per row with three replications per irrigation treatment. Plant water status was monitored every week by measuring midday stem water potential (Ψ_s) with a pressure chamber (model 3000, Soil Moisture Equipment Corp., Santa Barbara, CA, USA). Measurements were performed on two adult healthy north-facing shaded leaves per replication (one per tree) randomly selected. Leaves were bagged and covered with aluminium foil early in the morning, more than 2 h before detachment (McCutchan and Shackel, 1992).

2.4. Earliness, yield, fruit size and revenue

Fruit earliness was compared by mean harvest date. Mean harvest date was calculated by averaging the date of harvest within each combination of irrigation and crop load. Yield and fruit quality parameters were also evaluated and compared by variance analysis. Fruit size (in weight and diameter) was measured at harvest for each single fruit in all tagged shoots of the two central trees of each tree row (six trees per irrigation treatment, two per replication), and the means were compared. Fruits were harvested based on their skin colour according to commercial practices. They were then graded and distributed according to official commercial categories as follows: GGG ≥ 53 mm; 46 ≤ GG < 53 mm; 39 ≤ G < 46 mm; 32 ≤ M < 39 mm (M.A.P.A., 1990). Seed weight and number were also determined on fruits harvested in 2011/12 and related to fruit size parameters by correlation analysis.

In order to check the negative effects of irrigation withholding on fruit growth, eight fruits per tree were tagged and their growth dynamic was monitored by measuring weekly changes in their equatorial diameter with a digital calliper. Once the fruits reached their maximum diameter, curves describing the fruit growth dynamic were constructed for each irrigation treatment and their slopes compared. This evaluation was performed in both seasons but only on shoots bearing 4 fruits per panicle with the aim to test the effect of water deprivation in the situation in which water stress could affect fruit growth in a higher extent.

Fruit size and harvest date strongly affect the price obtained by loquat growers, and consequently both were used to calculate the crop value. For this purpose, we considered the commercial categories achieved and the reference price in one of the most important cooperatives for loquat in the area on each harvest date. Changes in the prices obtained by loquat growers throughout the season for each commercial category are depicted in Fig. 1. Yield per shoot was calculated by totalling the weight of all fruits at harvest. The yield per shoot was estimated on eight shoots per tree, and this also allowed us to calculate the revenue per tree in order to establish the most profitable combination of treatments. Yield per tree was estimated considering an average number of 220 inflorescences per tree, counted after pruning T1 and T2 experimental trees in September, before bloom (early November).

3. Results and discussion

No significant interaction was detected between irrigation and crop load for any fruit quality parameter in either season (p values for the interaction between 0.19 and 0.68, depending on parameter and season). In other words, the preharvest DI had the same effects on fruit development at any crop load.