Deficit Irrigation Schedules to Promote Early Flowering in 'Algerie' Loquat

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Abstract

Deficit irrigation initiated 8 weeks after harvest has been proven to be a suitable and more profitable strategy for producing loquat. To precise optimal water savings during that period an experiment was established comparing reproductive phenology in trees suffering 50%, 75% or 100% water cuts during six weeks (mid-June to end of July). Full irrigated trees were controls. Trees undergoing original postharvest deficit irrigation during an additional period of five more weeks, with 75% water cuts act as second control. All deficit irrigation treatments promoted earlier flowering when compared with control trees; the greatest advancement in full bloom date was achieved when water savings reached 75% (season 2004/05) or 100% (season 2005/06), during a period of water stress limited to six weeks. 75% water cuts anticipated full bloom 27 (2004/05) and 21 days (2005/2006) with respect to controls. Complete (100%) suppression of watering during six weeks anticipated full bloom 25 and 27 days, seasons 2004/05 and 2005/06, respectively. Trees subjected to an extended period of water stress advanced full bloom date in a lesser extent (13 and 18 days, 2004/05 and 2005/06, respectively). A water cut of 50% brought an anticipation of full bloom of only 12 and 10 days, depending on the year. Deeper water cuts allowed also a desirable concentration of bloom. Dry weight of flowers was negatively affected by water stress, although no impact was translated into initial fruit set. Earlier bloom derived in an earlier harvest date without detrimental effects on fruit quality and productivity.

INTRODUCTION

Loquat blooms at fall, develops its fruits during winter, and ripens them at early spring. Its unusual phenology allows loquat to reach market before any other spring fruit. Avoidance of such a competence makes earliness of paramount importance for loquat. In Spain, prices are very high at the beginning of the season (March and April), but sharply fall on May and June when cherries, peaches, plums and other spring fruits arrive to the market. For above reasons, any technique able to improve loquat earliness may have a significant impact on loquat profitability. Of great interest in semi-arid climates is to improve loquat earliness by means of modifications of the reproductive phenology using deficit irrigation as a tool. At this regard, during the last year we developed different approaches to induce early bloom and harvest by deficit irrigation. First, we compared loquat response, in term of precocity, between a strategy of regulated deficit irrigation (RDI) from the end of May to the end of August versus a continuous mild deficit of water along the year. Hueso and Cuevas (2004) demonstrated more usefulness of RDI for our purpose. Secondly, we determined June and July as the best dates to implement RDI, finding that water stress during August provides scarce advancement in blooming date and strongly diminishes flower size (Cuevas et al., 2003). The aim of this work is to precise optimal water savings comparing reproductive phenology, and bloom quality and intensity in trees subjected to 50%, 75% or 100% water cuts during six weeks (from mid-June to the end of July) with respect to fully irrigated trees and with respect to trees undergoing an extended postharvest deficit irrigation during an additional period of five more weeks.

MATERIALS AND METHODS

The trial was carried out during two consecutive seasons (2004/05 and 2005/06) in a solid block of 'Algerie' located in 'Las Palmerillas' Experimental Station near El Ejido (Almería, SE of Spain). Trees, 12 years old at the beginning of the experience, are grafted on 'Provence' quince and spaced 5 X 5 m. Orchard soil is a well-aerated sandy loam with low water retention capacity (field capacity=13.4%, wilting point=5.1%). Two lines of 2.3 l h^{-1} drip emitters per tree row are used for watering. Emitters are pressure compensating and extruded into the tubing every 0.5 m. Average precipitation in the area limits to 231 mm whereas evaporation from an "A" pan (Epan) reaches average values of 1922 mm per year. Fertilizers were applied trough the watering system at a rate of 160 FU ha^{-1} N, 120 FU ha^{-1} P_2O_5 and 120 FU ha^{-1} K_2O. Trees were hand-thinned on January leaving 4-5 fruit per panicle on main shoots and only 1-2 fruits in lateral, weaker, shoots.

Five treatments were selected. First treatment was a control in which trees were irrigated with about 40% of Epan measured with a Class A pan placed in the orchard (≈7100 m^3 with slight variations depending on the year). Next three treatments were different RDI strategies in which trees were programmed to receive a 50%, a 25% or 0% of the water applied to controls (treatments W50%, W25%, and W0%, respectively) during a period of six weeks, from mid-June (around 8 weeks after end of previous harvest) to the end of July. Last treatment was the original RDI regime (named in above tables as Long RDI) in which trees suffered a 75% of water cuts, but during an additional period of five weeks (until the end of August). This treatment, previously successful, acts as a second control. Soil water content was monitored using Watermark sensors; plant water status was followed during the period of deficit by determinations of predawn leaf water potential (Ψpd) (only first year) and stem water potential (Ψst) using a Scholander pressure chamber (for details see Fernández et al., 2005).

Effects of deficit irrigation treatments on reproductive phenology, flowering intensity and quality were analyzed following a randomized block design with two trees per block and three blocks. Blocks were smaller portions of the orchard, each one containing a row of trees per treatment. Central trees of the row were chosen for sampling. Phenology was followed from summer rest to bloom using phenological stages described by Cuevas et al., (1997). Date and advancement of full bloom were calculated based on these observations. Flower quality was estimated by its size measured as flower dry weight using 60 king flowers from 6 different trees (2 per block). Flowers were sampled at late balloon stage. This analysis was performed in main terminal shoots as well as in lateral shoots. Deficit irrigation effects on flower fertility were evaluated counting the number of fruit carried out on eight left-intact panicles of each kind per tree. Bloom intensity was estimated by the percentage of main and lateral shoots forming a terminal panicle on ten randomly chosen shoots of each type per tree. The number of flowers was counted on four terminal panicles per tree and treatment every year.

RESULTS

Water deficit progressively diminished soil water content. At the end of the period of water deficit, the soil at 60 cm depth around W0% trees had Ψm values of -129 kPa and -127 kPa depending on the season. In W25% soil at the same depth reached values of -59 kPa for 2004/05 and -64 kPa for 2005/06. At the end of July 2004, Long RDI treatment had values close to Ψm=-90 kPa at 60 cm depth, but rain fallen on July 25th modified briefly the trend of depleting soil water content. Nevertheless, at the end of August, when water deficit period finished for this treatment Ψm was -140 kPa. On season 2005/06, Ψm reached records of -125 kPa. Water content of soil around trees 50% irrigated (W50%) was similar to that observed for W25% (Ψm=-59kPa, and -77kPa, for season 2004/05 and 2005/06, respectively). Controls kept Ψm records between -10 and -20 kPa, both years. Reduction of soil water content had in turn effects on plant water status. Ψst and Ψpd were significantly and linearly related (r^2=0.83; $p<0.01$). For this reason, second year we only performed Ψst determinations. Values of Ψst=-0.52, -0.80 and -1.22 MPa were reached at the end of the water deficit period in 2004 for treatments W50%, W25% and W0%, respectively. Controls presented at this time values of Ψst=-0.38 MPa, whereas Long RDI reached Ψst=-2.03 MPa at the end of August. Second season controls and W50% presented similar stem water potential values at the end of July (Ψst=-1.07 MPa for controls versus -1.37 fro W50%). More negative records were reached at the end of the treatments W25%, W0% and extended RDI (Ψst=-1.74, -2.07 and -1.77; respectively). Differences were significant between these two groups.

The alteration of soil and plant water status modified reproductive phenology of 'Algerie' loquat. At this regard, all deficit irrigation treatments promoted earlier flowering when compared with control fully-irrigated trees (Fig. 1). The greatest advancement in full bloom date was achieved when water savings reached 75% (season 2004/05) or 100% (season 2005/06), during a period of stress limited to six weeks. W25% treatment caused an anticipation of full bloom of 27 (2004/05) and 21 days (2005/2006) with respect to controls. Complete suppression of watering (W0%) during six weeks anticipated full bloom 25 and 27 days, seasons 2004/05 and 2005/06, respectively. Trees under long RDI advanced full bloom date in a lesser extent (12 and 18 days, 2004/05 and 2005/06, respectively); despite that water stress integral in these trees was higher due to the prolongation of the period of water deficit. A water cut of 50% produced an anticipation of full bloom of only 13 and 10 days, depending on the year. Deeper water cuts allowed also a desirable concentration of bloom (Figs. 1 and 2).

Contrary to beneficial effects on bloom date, water restrictions significantly diminished the size of the blossoms both seasons (Tables 1 and 2). The greater the water shortage was, the slighter the flowers were produced. Therefore, control full-irrigated trees produced the heaviest flowers, whereas trees suffering extended RDI formed the slightest ones; between them, treatments with a shorter period of water deficit in which trees showed a gradual dry weight loss in flowers formed in main panicles (with the exception of W50% values second season) as well as in flowers from secondary panicles (Table 1). Flower size diminution on both kinds of panicles had no significant effects on flower fertility (Tables 1 and 2). Nevertheless, first season, the capacity of setting fruits seemed to be partially reduced for flowers in main panicles (Table 1). This season (2004/05) p value was close to reach significance in the analysis performed in main panicles (p=0.12). Second season, this trend was not observed (Table 2).

On the other hand, RDI treatments seemed to promote greater blooming intensity. The prolongation of the water deficit period for three months significantly increased the number of flowers in main panicles first season and the percentage of lateral shoots forming inflorescences the second season. Minor, no significant, effects were observed on the percentage of lateral shoots developing panicles first year, and on the number of flowers per secondary panicle. The limitation of water stress to only six weeks had a lower impact promoting blooming. Significant effects were only observed on late forming panicles (secondary shoots) and only the second season. Main shoots developed a high proportion of fruitful panicles in all treatments, since most of the tagged twigs formed terminal panicles both seasons (data not shown). No differences, therefore, can be expected at this regard among treatments.

DISCUSSION

RDI anticipates loquat flowering. This response coincide with our previous research (Hueso and Cuevas, 2004; Cuevas et al., 2003), although a more precise determination of the stress period and an elevation of the water shortages in this experience has permitted to increase bloom earliness when compared with previous results. Water-stressed trees from mid-June to the end of July consistently reached full bloom before than control trees (Figs. 1 and 2). The greatest advancement in full bloom date was achieved when water savings reached 75% (season 2004/05) or 100% (season 2005/06). Given the small differences in precocity between these two treatments other factors might determine final choice. For instance water availability and the easiness for implementation, but also the magnitude of flower size loss and its effects.

As previously observed (Cuevas et al., 2003), trees suffering water stress during August (here Long RDI) advanced bloom date in a lesser extent. Rodríguez et al., (this volume) have observed that first indication of flower commitment in 'Algerie' loquat occurs in Spain at the end of July. Hence, stress during August might trim bloom anticipation by slowing down normal flower development. Mild water deficit (as the provided by W50%) produces minor advancements of full bloom and also an undesirable prolonged blooming season. Reduced water savings and scarce bloom advancement make this treatment clearly less valuable. On the contrary, deeper water cuts derived in shorter blooming season (Figs 1 and 2), making easier and more effective fruit thinning.

Contrary to beneficial effects on reproductive phenology, water cuts reduced flower size. Finding non-critical periods for deficit irrigation is a recurrent aspiration in RDI studies. In that search, many authors focus on postharvest. However, when adopting postharvest deficit irrigation the negative effects that may have on flowers differentiating concomitantly inside the bud must be considered. Early work made in apricot by Brown (1953) and Uriu (1964) has demonstrated that water stress after harvest has profound implications in flower development next season. Recently, Torrecillas et al (2000) also in apricot observed a reduced fruit set after early postharvest RDI due to a greater fruitlet abscission which suggests damages to pistils during flower differentiation. Lamp et al. (2001) cited work done by Goldhamer and colleagues where it was found that, in almond, water stress during flower development (previous summer) reduced next season's crop yield because of a reduced flower quality. Nonetheless, in our study the negative effects on flower quality had no translation into the number of fruit initially set (Tables 1 and 2).

In short, the complete suppression of watering during six weeks from mid-June to end of July appears at present at the most promissory RDI schedule to promote early bloom in 'Algerie' loquat. Earlier bloom led to earlier harvest. So far, negative effects on flower size have not compromised neither yield nor fruit set and size at harvest. A more precise determination of critical levels of stress may allow us to relieve trees from water stress in an earlier date, and therefore maximize blooming date advancement. Such determination is still in progress.

ACKNOWLEDGEMENTS

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Tables

Table 1. Effects of Regulated Deficit Irrigation on flower quality and bloom intensity. Season 2004/05.

	Flower dry weight		Initial set (fr/panicle)		Flowers per panicle		Reproductive shoots (%)
Treatments	Main axes	Secondary axes	Main axes	Secondary axes	Main axes	Secondary axes	Secondary
Control	57 a[1]	54 a	12.0 a	7.7 a	160 b	100 a	88 a
W50%	54 ab	52 ab	8.7 a	6.6 a	156 b	108 a	78 a
W25%	53 bc	49 bc	6.8 a	6.1 a	146 b	90 a	80 a
W0%	50 cd	46 c	7.1 a	5.7 a	151 b	96 a	82 a
Long RDI	46 d	46 c	6.8 a	5.7 a	209 a	121 a	98 a
P	0.0001	0.005	NS[2]	NS	0.05	NS[x]	NS

[1]Different letters in each column indicate significant differences at 5% level. Duncan test.
[2]NS, not significant (P>0.05). Percentage data were previously arc-sin transformed

Table 2. Effects of Regulated Deficit Irrigation on flower quality and bloom intensity. Season 2005/06.

	Flower dry weight		Initial set (fr/panicle)		Flowers per panicle		Reproductive shoots (%)
Treatments	Main axes	Secondary axes	Main axes	Secondary axes	Main axes	Secondary axes	Secondary
Control	53 a[1]	47 a	12.2 a	10.4 a	265 a	164 ab	74 b
W50%	46 b	41 b	11.8 a	10.5 a	232 a	182 a	89 a
W25%	50 a	39 bc	11.2 a	9.4 a	237 a	175 a	98 a
W0%	46 b	37 c	12.7 a	9.6 a	230 a	138 bc	93 a
Long RDI	45 b	38 c	11.9 a	8.2 a	292 a	118 c	98 a
P	0.005	0.001	NS[2]	NS	NS	0.005	0.05

[1]Different letters in each column indicate significant differences at 5% level. Duncan test.
[2]NS, not significant (P>0.05). Percentage data were previously arc-sin transformed

Figures

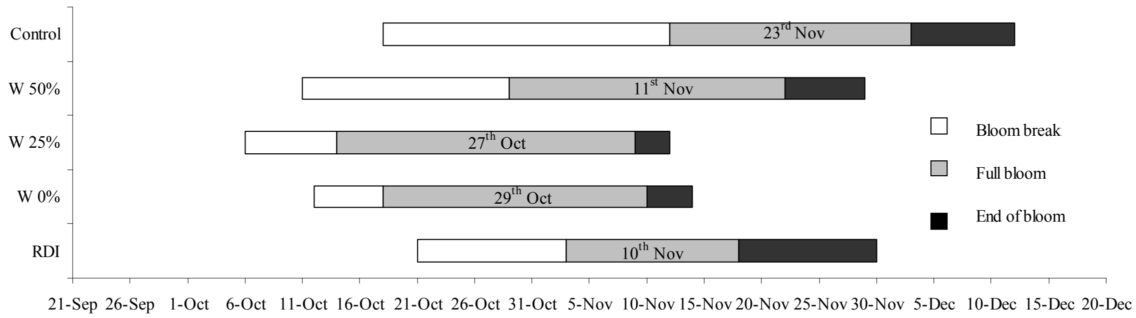

Fig. 1. Blooming course of control full irrigated trees and trees suffering different levels of water deficits (see text for legend). Season 2004/05.

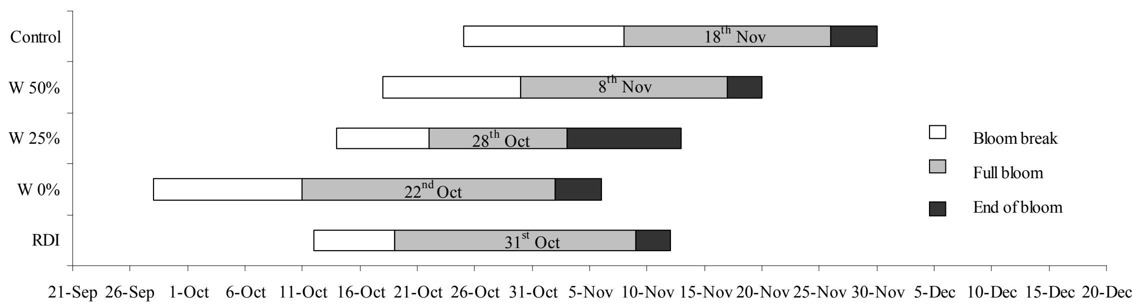

Fig. 2. Blooming course of control full irrigated trees and trees suffering different levels of water deficits (see text for legend). Season 2005/06.