Deficit irrigation effects on flowering of loquat

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SUMMARY – In the tropics and subtropics, natural episodes of drought trigger flower induction in many woody plants. Bearing in mind such effect, we have applied deficit irrigation strategies on loquat with the aim of obtaining earlier bloom and harvest that favours better prices. The experiment was carried out during three consecutive years on trees of cultivar 'Algerie'. Three treatments have been selected: (i) Control, receiving about 40% of Epan measured with a Class A pan placed in the orchard; (ii) Continuous Deficit Irrigation (CDI), with stress uniformly applied throughout the year and 20% saving of water; and (iii) Regulated Deficit Irrigation (RDI), with the same reduction in irrigation, but stress concentrated on postharvest, from May to August, when reduction reached 55% of the amount of water received by controls. Both deficit irrigation treatments caused earlier flowering. Under RDI, full bloom was advanced between 11 and 30 days depending on the year. CDI caused minor but progressive effects on bloom date. Advancement of full bloom under CDI was only of 1 day the first year, but 9 days in the third year. Earlier flowering led to earlier harvesting. Deficit irrigation did not affect the number of flowers per panicle, but a higher proportion of secondary shoots formed flowers under RDI. Deficit irrigation affected also flower quality. At this respect control trees formed heavier flowers than deficit irrigation treatments. However, so far flower dry weight had no impact neither on quantity nor on quality of the fruits harvested. After three years of treatments, deficit irrigation has been proved to be a feasible and a more profitable strategy to produce loquat.

Key words: Loquat, deficit irrigation, earliness, flowering, harvesting.

***RESUME –** "Effets d'une irrigation déficitaire sur la floraison des néfliers". Dans les régions tropicales et subtropicales, des épisodes naturels de sécheresse ont provoqué la floraison dans un grand nombre d'arbres. En considérant ces effets, on a appliqué des stratégies d'irrigation déficitaire chez les néfliers du Japon dans l'objectif d'obtenir une floraison et une récolte plus précoces qui favorisent un meilleur marketing. Des expériences ont été développées pendant trois années consécutives sur des arbres du cv 'Algérie'. Trois traitements ont été sélectionnés : (i) le témoin, qui a reçu approximativement 40% de l'Epan mesurée avec un évaporimètre classe A placé dans le verger ; (ii) l'irrigation déficitaire continue (CDI), avec une économie d'eau de 20%, et un stress appliqué uniformément pendant toute l'année ; et (iii) l'irrigation déficitaire contrôlée (RDI), avec la même réduction d'irrigation, mais le stress étant concentré après la récolte, depuis le mois de mai jusqu'au mois d'août, lorsque la réduction était de 55% de la quantité d'eau reçue par les arbres témoins. Les deux traitements d'irrigation déficitaire ont provoqué une floraison plus précoce. Sous RDI, la floraison complète a été avancée de 11 à 30 jours selon l'année. Le CDI a provoqué des effets plus faibles mais progressifs sur la date de floraison. L'avancement de la floraison complète sous CDI a été seulement d'un jour la première année de traitement, mais de 9 jours la troisième année. Une floraison plus précoce a conduit à une récolte plus précoce. L'irrigation déficitaire n'a pas affecté le nombre de fleurs par panicule, mais une proportion plus grande de rameaux secondaires a formé des fleurs sous RDI, et cela a conduit à une floraison plus grande. L'irrigation déficitaire a affecté aussi la qualité de la fleur. A cet égard les arbres témoins présentèrent des fleurs plus lourdes que les traitements d'irrigation déficitaire. Cependant, le poids sec n'a montré aucun impact sur la quantité et la qualité des fruits récoltés. Après trois ans de traitement, l'irrigation déficitaire s'est montrée être une stratégie viable et plus rentable pour produire le néflier.*

***Mots-clés :** Néflier, irrigation déficitaire, précocité, floraison, récolte.*

Introduction

Loquat (*Eriobotrya japonica*, Rosaceae, Maloideae) is a subtropical evergreen fruit crop that 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 marketing. In this sense, prices are very high at the beginning of the season (March and April), but fall sharply on May and June when cherries, peaches, plums and other spring fruits arrive market. For above reasons, any culture practice able to improve loquat earliness may have a significative impact on payments returns, increasing loquat profitability. As proved below, orchard water management could bring us such a target.

In 1984, Mitchell *et al*. coined the concept of regulated deficit irrigation (RDI) as a water management strategy that reduces the amount of water available for the crop during non-critical phenological stages, while fully covers crop water demand the rest of the year. RDI main objective is to save water but trying to reduce the impact of water shortage on productivity and fruit quality. Proper selection of non-critical phenological periods is the key for successful RDI. Behboudian and Mills (1997) in a recent review emphasize the principle of economic profit behind any deficit irrigation strategy. They define deficit irrigation as a water management system that deliberately provokes a period of water deficit in the plant or in the soil seeking any economic benefit. In this experience, we have combined both considerations trying to obtain better returns for loquat yield by appropriately selecting a period of water deficit linked to flower induction promotion. In its center of origin, loquat bloom date is probably controlled by natural episodes of rainy and dry weather. As happens in other subtropical woody plants flower induction is often triggered by a rest condition imposed by drought. Current theories sustain that bud rest is needed before vegetative meristem evolve into a reproductive structure. Shortage of water perceived in root apex seems to initiate hormonal changes leading to flower induction. Moderate water stress appears, therefore, as a tool for promoting bloom and advance harvest in loquat. Main objective of this work is to cause earlier flowering by deficit irrigation with permissible effects on bloom density and quality.

Materials and methods

Trials were performed during three consecutive campaigns on a solid block of cultivar 'Algerie' located in "Las Palmerillas" Experimental Station near El Ejido (Almería, SE of Spain). Trees are grafted on 'Provence' quince and spaced 2.5 × 5 m. At the beginning of the trial, the trees presented a uniform canopy volume of 2.67 m^3, 2 m height. Orchard soil is sandy loam with low water retention capacity (field capacity = 13.4%, wilting point = 5.1%). Two lines of 2.3 l/h drip emitters per tree row were used to apply water. Emitters are pressure compensating and extruded into the tubing every 0.5 m. Water schedule was programmed with AGRONIC 4000 and a system of electric valves. Average precipitation in the area limits to 220 mm, mainly during fall and spring. Eto reaches 1726 mm with extreme values 2.4 mm/day on December and January and 8.7 mm/day on July. Fertilizers have been applied trough water system at a rate of 160 FU/ha N, 120 FU/ha P_2O_5 and 120 FU/ha K_2O.

Three treatments were selected: (i) Control, receiving about 40% of Epan measured with a Class A pan placed in the orchard; (ii) Continuous Deficit Irrigation (CDI), with 20% saving of water, and stress uniformly applied along the year; and (iii) Regulated Deficit Irrigation (RDI), with the same reduction, but stress concentrated on postharvest from May to the end of August, when saving reached 55% of the amount of water received by control trees. Effects of deficit irrigation treatments on reproductive phenology, flower intensity and quality were analyzed. Phenology was followed according to procedure reported by Barranco *et al*. (1994) from summer bud to initial fruit set using phenological stages described by Cuevas *et al*. (1997). Date and advancement of full bloom were calculated based on observations. Flower quality was estimated by flower dry weight using 100 king flowers from 10 different trees. Flowers were sampled at late balloon stage, their bracteoles removed and finally cut at gynoecium level. Flower dry weight was recorded after several days at 70ºC. Bloom density as number of flowers per panicle and proportion of buds evolving into reproductive structures was also determined. The number of flowers was counted on four terminal panicles per tree on four trees per treatment every year. On 2000/01 campaign we followed evolutions of 25 terminal and 25 lateral shoots on four trees per treatment. On 2001/02 we did the same with 10 main and 10 lateral shoots on six different trees per treatment.

Results and discussion

Control trees reached full bloom between November 23rd and 25th depending on year. RDI made trees bloom 13 days earlier on 1999/00, 19 days earlier on 2000/01 and 20 days earlier on 2001/02. CDI had minor, but progressive effects on bloom date. First year, full bloom was advanced only three days; on 2001/02 CDI trees reached full bloom 10 days before controls. Earlier flowering in response to water deficit has been often reported in subtropical crops (Sánchez-Blanco *et al*., 1989; Nakajima *et al*., 1993; Galán, 1999). *Forzatura* or restriction of water available for lemon trees is used since long in Spain and Italy for producing out of season, summer crop. That technique, in fact, inspires our experimental approach. Our results also coincide with observations of earlier flowering season in loquat during dry years (Rodríguez, 1983). This author recommends a reduction in irrigation rates during June, July and August with the idea of promote flowering.

Deficit irrigation treatments diminished dry weight of flowers. Flowers from RDI trees were the lightest with significant differences with respect to control and CDI (Table 1). CDI trees formed lighter flowers than control trees, with significant differences on 1999/00 and 2001/02 (Table 1). These results suggest that although water stress was implemented solely for advancing flower induction process, it had collateral negative effects on subsequent flower development. Lower dry weight of flowers, expressed every year, may reflect plant water status during formation of panicles. No interaction among years and treatments was detected on flower dry weight (p=0.25).

Table 1. Quality of flowers expressed by dry weight (g). In bold means for treatments and years

	Dry weight of single flower (g)†			
	1999/00	2000/01	2001/02	Mean
Control	0.521a	0.508a	0.490a	0.506
CDI	0.475b	0.500a	0.432b	0.469
RDI	0.429c	0.414b	0.395c	0.413
Mean	0.475	0.474	0.439	

†Values with the same letter do not differ significantly.

Intensity of flowering was estimated by the number of flowers per panicle and also for the proportion of terminal and lateral shoots developing panicles. The number of flowers per panicle showed a large variability among years (Table 2), but did not show any change in response to treatments. No interaction was either detected between treatments and years. Bloom intensity resulted very high regardless of treatments. Almost 100% of main shoots developed flowers in all treatments (Table 3). No differences were either found in the number of lateral shoots sprouted below terminal panicles. However, some effects were caused by deficit irrigation on the fate of these lateral shoots. Under RDI a higher proportion of them formed a panicle; differences were significant only first year (Table 3). Positive effects of deficit irrigation on bloom density have been reported in subtropical (Sánchez-Blanco *et al*., 1989; Nakajima *et al*., 1993) as well as in temperate fruit crops [Raese *et al*., 1982; Mitchell *et al*., 1984; Chalmers *et al*., 1985; Degman *et al*., 1932; Proebsting *et al*., 1977 (cited both by Behboudian *et al*. (1997)]. However, some other authors have documented no effects or lower bloom density when deficit irrigation is implemented (Brun *et al*., 1985; Caspari *et al*., 1994; Mills *et al*., 1994). Discrepancies must be due to the moment and intensity of water stress (Behboudian and Mills, 1997). Moderate water deficits on postharvest has often led to an increase in bloom density next year (Mitchell *et al*., 1984; Larson *et al*., 1988; Li *et al*., 1989).

Table 2. Number of flowers for panicle. In bold means for treatments and years†

	Number of flowers for panicle			
	1999/00	2000/01	2001/02	Mean
Control	194.5	198.9	179.3	190.9
CDI	174.2	240.2	212.3	201.6
RDI	186.3	218.3	199.4	208.7
Mean	185.0	219.2	197.0	

†Differences no significative.

Table 3. Percentage of main and lateral shoots developing flowers, and number of lateral shoots

	2000/01			2001/02		
	% panicles on main shoots	Lateral shoots per main shoot	% panicles on lateral shoots[†]	% panicles on main shoots	Lateral shoots per main shoot	% panicles on lateral shoots
Control	100	0.31	30.4b	100	0.22	58.3
CDI	97.7	0.34	20.0b	100	0.38	51.7
RDI	100	0.58	96.4a	100	0.24	86.7

[†]Values with the same letter do not differ significantly.

Conclusions

In short, our results confirmed that loquat responds to moderate summer water stress with earlier and more intense flowering that in turn lead to earlier harvesting season. Negative effects on flower quality caused by water stress did not have, so far, a significant impact on fruit set or fruit quality. We focus now in timetable modifications of water stress date and intensity with the idea of maximize advancement in bloom and eliminate negative effects on flower quality.

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