High-Density Loquat Orchards: Plant Selection and Management. First Results

J.J. Hueso
Estación Experimental de Cajamar 'Las Palmerillas', El Ejido, Almería, Spain.

M.L. Cañete and J. Cuevas
Departamento de Producción Vegetal.
Universidad de Almería, Almería, Spain.

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Abstract
High production costs represent the most limiting factor for loquat. Further expansion of loquat in Spain depends on reducing costs, increasing productivity and extending the offer with early, more profitable products. High density orchards of semi-dwarf trees of extra-early varieties represent an attractive approach to solve once all these challenges. To check suitability of loquat to extreme intensification we have designed a high density orchard of 'Magdal' grafted on quince C at a distance of 2.5 X 1.7 m (2353 trees per ha). Cultivar was selected considering its earliness; rootstock due to their dwarfing ability and capacity to induce early bearing. On February 2001, rootstocks were planted in the field; T-budding was carried out in situ on September at 20 cm off the ground level. Budding success was high (86% of the scion developed). On October 2002, some trees formed the first flowers that were removed to allow tree growth and training as a modified central leader. First tier of scaffold branches was formed on season 2003/2004 at 0.5 m height. First yield reached an average of 2.8 kg/tree on season 2003/04. Most trees have completed the second tier of scaffold branches after 2004 harvest. Second yield on April 2005 reached a worthy level of 10.8 kg per tree (25 t per ha). Third yield, still not fully harvested, can be roughly estimated about 30 t per ha. At present, trees have occupied the space allotted and have formed the third, last, tier of limbs. Average height reaches now 1.87 m. Small size of the trees has substantially reduced labor costs in flower and fruit thinning. Earlier bearing, greater productivity, and reduced costs suggest that high density orchards represent a more profitable way to cultivate loquat as long as we are able to maintain tree size. So far, crop and dormant pruning seem to control tree size satisfactorily. Regulated deficit irrigation would be of help to reduce vegetative growth.

INTRODUCTION
Loquat is considered indigenous of Zhejiang, southeastern China (Lin et al., 1999), although it has become well adapted to warm Mediterranean climates. Spain is the second world producer and the first exporting country (MAPA, 2004). Main cultivation areas of Spain are the Comunidad Valenciana and Andalusia, regions located at the East and South of the country, respectively; both areas benefit of close proximity to Mediterranean Sea. Most popular cultivars in Spain are 'Algerie', a variety selected by Spaniards in North Africa, and the North American 'Golden Nugget'; 'Tanaka' (Japanese) and 'Magdal' (autochthonous) follow. In Spain, loquat is usually grafted on seedlings of the same species, although several quince genotypes are increasingly used due to their dwarfing capacity.

Main season in Spain is mid-April and May. Early production reaches high prices, taking advantage of the consumer demand for spring fruits. Although loquat enjoys so far of a good commercialization, heavy concentration of the product in the second half of May causes an abrupt price drop. Fruit size and earliness are, therefore, the two most important parameters in Spanish loquat markets. High production costs represent, on the other hand, the most limiting factor for loquat in Spain. Labor accounts for more than 75% of total costs due to the high need of labor in this species for fruit thinning and harvesting. Higher profitability for Spanish loquat producers will depend on reducing costs, increasing productivity and extending the offer with early, more profitable products. High density orchards of semi-dwarf trees of extra-early varieties represent in fact an attractive approach to solve once all these challenges. To check suitability of loquat to extreme intensification we have designed a high density orchard of 'Magdal' grafted on quince C at a distance of 2.5 X 1.7 m (2353 trees per ha). Here, we present the first promissory results.

MATERIALS AND METHODS

A small scale experimental orchard of 'Magdal' grafted on quince C was established at the Experimental Station of Cajamar 'Las Palmerillas', near to the city of El Ejido (Almería, SE Spain). The Station has the following coordinates: 2º43'W longitude, 36º48'N latitude. Climate of the area is classified as a subtropical semi-arid Mediterranean type. Annual rainfall in the area is 231 mm whereas evaporation from an "A" pan located in the Experimental Station reaches average values of 1922 mm per year. The soil is a well-aerated sandy-loam (72.4% sand, 14.6% loam, and 13.0% clay), pH 7.8. Field capacity of the soil is 13.4%, while its wilting point is 5.1%.

For the experience of intensification loquat orchards we selected 'Magdal' mainly based on its early-producer condition and its inherent precocity in harvest date (it fruits ripen 17 days before 'Algerie', the leader and reference loquat cultivar in Spain). 'Magdal' adult trees are medium-sized, bloom profusely and produce heavily, elongated-shaped, yellow fruits (Martínez-Calvo et al., 2000). As rootstock, we chose quince C due to its dwarfing ability and its capacity to induce early bearing. In pear, where quince C is quite common, it has the reputation to promote heavy production and good fruit quality (Westwood, 1982). Our trees were 2.5 X 1.7 m spaced (2353 trees per ha), N-S orientated, and trained according to a modified central leader (Fig. 1). Rootstocks were directly planted on February 2001 and T-budded on September at 20 cm above ground.

A homogenous block of 72 trees was used for budding success and initial growth. Bloom phenology was followed on six trees during seasons 2004/05 and 2005/06 based on phenological stages previously described by Cuevas et al. (1997). From first yield (season 2003/04) to present, we have determined the number and dates of harvesting operations, the yield as kg·tree^{-1}, productivity as kg·ha^{-1}, and cumulative yield on a sample of 36 trees distributed in four consecutive rows. At harvest, a sample of 20 fruits was randomly selected from the most representative harvesting operation to determine the most relevant parameters of fruit quality. Income (€·ha^{-1}) received by farmers was calculated based on yield and prevalent prices for each harvesting operation. Finally, during the last two seasons we have estimated labor cost for flower and fruit thinning.

RESULTS AND DISCUSSION

Budding success was high (86% of the scion developed next spring), coinciding with previous reports using the same rootstock (Polat and Kaşka cit. by Polat et al., 2004).

From the buds that sprouted from the scion we selected the best one to constitute the central leader (Fig. 1 a,b,c). In the same operation any growth below 0.5 m was removed. First tier of scaffold branches was formed on season 2003/2004 (Fig. 1 d,e). To do so, we selected at 50 cm height the four best oriented secondary shoots (90º apart one of the other). Tipping was achieved on these twigs to favor the growth of the central leader. Wide crotch angles (about 60º) were preferred. Most trees have completed the second tier of scaffold branches after 2004 harvest, at 90 cm height (Fig. 1 f,g). Narrow crotch angles initially predominated in these limbs. No modification of the angles was initially executed, however, crop load has widen them to a degree of 45º or close.

Initial tree growth can be considered rapid, but crop and pruning seem to achieve so far good control of tree height and volume. At present, most trees are just about to completely occupied the space allotted (average canopy is 11.2 m^3) and have formed the third, last, tier of branches at 130 cm height. To limit height, the central leader (1-year-old section) was periodically headed to a side bud by removing less than ¼ of the past season growth. Average height reaches at present 1.87 m, while TCSA is now 38.66 cm^2 (Fig. 1 h,i). To regulate crop load and, in addition to pruning (performed after harvest) and hand fruit thinning, we have removed part of the lateral shoots emerging late in the season, because they produce less and lighter fruits. Heavy pruning and intense fruit thinning is not advisable since trees will respond with more vigorous growth. Growth regulators as paclobutrazol were not used. However, regulated deficit irrigation started early in the life of the tree could be very convenient to keep trees in a reduced size (Hueso, 2005; Hueso et al., this volume) as it has been proven in peach and pear (Chalmers et al., 1981; Mitchell and Chalmers, 1982).

First year after budding (on October 2002) some trees were able to form some flowers; these flowers were removed to allow tree growth and training as a modified central leader. First bloom occurred on October 2003. On season 2004/05, full bloom took place on October 25th and lasted for 40 days. On season 2005/06 bloom was earlier (full bloom occurred on October 23rd) and shorter (it prolonged during 30 days) (Fig. 2). First yield was picked on season 2003/2004, two years after budding. First yield reached an average of 2.8 kg/tree that is to say 6.6 $t \cdot ha^{-1}$ distributed as follow: March 13rd (7%), March 26th (25%), April 12nd (56%) and April 27th (12%) (Table 1). Second yield on April 2005 reached a worthy level of 10.8 kg per tree (25 t per ha) (Table 1). Timetable distribution of yield was April 13rd (31%), April 21st (26%), April 27th (25%) and May 3rd (18%). Cold temperatures during January (-3 ºC were briefly reached) delayed harvest this season. On current season (2005/06) harvesting was initiated on March 14th. Total yield is roughly estimated in about 30 t per ha. Parameters defining fruit quality were within the correspondent to this cultivar (Martínez-Calvo et al., 2000; Insero et al., 2004) (Table 2).

Only three references of high density loquat orchards have been found in the literature. Insero et al. (2004) compared ten cultivars (among them 'Magdal') grafted on BA-29 quince and spaced 4 x 2 m. 'Magdal' was rated among the less productive cultivars. Average Cumulative yield from 4th to 8 th season was about 45 t per ha. With similar tree density but spacing loquats at 3 x 3 m, Polat et al. (2004) have compared 'HÇG', 'Sayda' and 'Golden Nugget' grafted on loquat seedlings. They obtained a mean productivity of 7165 $kg \cdot ha^{-1}$ during the three first harvests. After two more years Polat et al. (2005) have published that orchard productivity has raised to 9311 $kg \cdot ha^{-1} \cdot year^{-1}$. From our preliminary results we may deduce greater interest in selecting quince C as rootstock for high density orchard, since allow greater intensification and heavier production (Table

1). Sustentability can not at this time be assured, although quince C vigour is lower that that induced by BA-29 and loquat seedlings as rootstocks.

On the other hand, reduced size of the trees has substantially trimmed labour costs for flower and fruit thinning. Flower thinning in our orchard required 176 hours per ha during season 2004/05; 392 hours more were employed for fruit thinning. On season 2005/06 labor needs for thinning were 176+376 hours per ha (flower and fruit thinning, respectively). For comparative purposes it can be stated that, in the area, mature 'Algerie' orchards grafted on 'Provence' quince with a density of 400 trees per ha and a production of 30 t per ha precise 624 hours per ha (392 for flower thinning plus 232 additional hours per ha for fruit thinning) (Esteban, 2001). When grafted on loquat seedling average time needed for thinning is 856 hours per ha (Caballero et al., 1992). Comparisons could be more favourable if we estimate differences in total yield.

Earlier bearing, greater productivity, and reduced costs all suggest that high density orchards represent a more profitable way to cultivate loquat as long as we are able to maintain tree size. So far, crop and dormant pruning seem to control tree size satisfactorily. Regulated deficit irrigation would be of help to reduce vegetative growth.

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Tables

Table 1. Yield, productivity and average price for 'Magdal' loquat of high-density orchard from first to third season.

	2003/04	2004/05	2005/06[1]	Cumulative[2]
Yield (kg tree^{-1})	2.8	10.8	4.8	13.6
Productivity (kg ha^{-1})	6588	25412	11224	32000
Price (€ kg^{-1})	1.63	1.66	-	1.65

[1] Yield until March 28th.
[2] Cumulative to season 2004/05.

Table 2. Fruit quality parameters of 'Magdal' loquat grown in high density orchard.

	2003/04	2004/05	2005/06
Weight (g)	48.83±3.12	55.10±2.21	52.00±2.01
Length (mm)	62.04±1.85	62.90±1.69	60.18±1.63
Diameter (mm)	39.48±0.55	41.82±0.51	39.39±1.08
Seed number	3.10±0.12	2.70±0.35	3.15±0.44
Pulp weight (g)	39.33±3.17	46.45±1.89	42.74±1.30
Seeds weight (g)	9.02±0.23	7.88±0.84	9.27±1.23
Color "a"	5.97±0.66	12.34±1.73	8.97±0.82
SST (ºBrix)	11.05±0.33	12.35±1.15	11.70±0.37
Acidity (g·l^{-1}malic acid)	18.06±2.58	9.82±2.60	12.18±1.60
Pulp/seed ratio	4.49±0.43	6.94±1.19	4.83±0.45

Figures

Fig.1. Successive steps of high density orchard of 'Magdal' loquat. a) In situ grafting; b) Leader selection; c) First scaffold; d) First bloom; e) First harvest; f) Second scaffold in formation; g) Second harvest; h) Bloom break; i) Current condition.

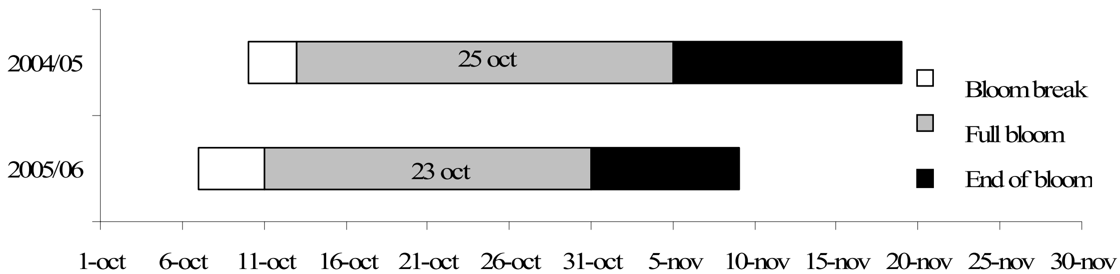

Fig. 2. Bloom course of 'Magdal' loquat in high density orchard.