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Loquat Production in Turkey: Problems and Solutions

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ABSTRACT

The objective of this study was to determine the current status and problems of loquat (*Eriobotrya japonica* Lindl., *Rosaceae*, *Maloideae*) production in Turkey and to provide solutions and alternatives. Globally, loquat production was 566,031 t in 2006, 12,310 t (~2%) of which originates from Turkey. Turkey is thus an important world producer of loquat. Traditional loquat culture in Turkey consists of isolated trees located in gardens, family orchards or small plantings destined for local consumption. Until the last decade, loquat growing was carried out only in isolated home gardens for local consumption. After its economical value had been realized, demand for its commercial production rapidly increased. The total production in 1980 (3,000 t) increased more than four-fold by 2006 and reached about 12,310 t produced from 243,429 trees. The Mediterranean region of Turkey has the most suitable ecological conditions for growing loquat. According to 2006 statistics, 97% of total loquat production of Turkey is from the coastal Mediterranean zone. The existing organised orchards are small, each ranging from 0.1 to 6.0 hectares. The spacing is 6-8 m × 6-8 m. Soil cultivation, irrigation, pruning, fertilization and control of scab (*Spilocaea eriobotryae*) are carried out in organized orchards but not always for scattered trees. Fruit thinning, for the improvement of fruit quality, is not practiced. In Turkey, loquat is consumed as an early season fresh fruit. Improvement in handling and transportation efforts may help solve some of the present problems in loquat production in Turkey. Research must focus on high-density plantings, protected cultivation, and dwarf rootstocks. Future studies to find solutions to these problems should increase loquat production and may therefore increase both domestic consumption and export.

Keywords: cultivar, cultivation, fruit thinning, loquat, Mediterranean region, pruning

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INTRODUCTION

Loquat (*Eriobotrya japonica* Lindl., *Rosaceae*, *Maloideae*) is a subtropical evergreen fruit tree that blooms in fall and early winter. Most authorities now believe loquat originated in China (Lin *et al*. 1999). Although loquat originated in China (Zhang *et al*. 1993), it was introduced to Europe from Japan in the 18th century as an ornamental tree. Later, in the 19th century, selections of cultivars with large fruits were used for fruit production. Loquat is cultivated mainly in China, Japan, India, Pakistan, Madagascar, Reunion Island, Mauritius Island, the Mediterranean countries (Spain, Turkey, Italy, Greece, Israel), United States (mainly California and Florida), Brazil, Venezuela, and Australia. This species has adapted well to the Mediterranean climate and grows in the same areas where citrus species are cultivated (Bedenes *et al*. 2000). Generally, loquats are found between latitudes 20° and 35° North or South, but can be cultivated up to latitude 45° under maritime climates (Lin *et al*. 1999). This species was introduced to Anatolia 150 to 200 years ago, possibly from Algeria or Lebanon (Demir 1987).

Presently, most production is for the fresh market. Loquat fruits are consumed largely as fresh fruit, although small amounts are used in jams, jellies, syrups, and pies (Shaw 1980). Loquat may be eaten fresh without the peel, combined with other fruits in fruit salads, used as a pie filling, and made into sauces and gelatin desserts, jams, and jellies. Fruit may also be canned, dried, frozen, and made into syrup. Loquat fruit are a good source of vitamins and minerals (**Table 1**) (Crane and Caldeira 2006).

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Invited Review

Table 1 Nutrient value of loquat fruit (3.5 oz or 100 g of fruit)[1].

Constituent	Approximate Value
Water Content	87%
Calories	47 kcal
Protein	0.4 g
Fat	0.2 g
Cholesterol	0 mg
Carbohydrate	12.0 g
Total Dietary Fiber	1.7 g
Calcium	16 mg
Iron	0.3 mg
Magnesium	13 mg
Phosphorus	27 mg
Potassium	266 mg
Sodium	1 mg
Vitamin C	1 mg
Vitamin A	1528 IU

[1] Data source: USDA-ARS, Nutrient Data Laboratory, Database for Standard Reference, Release 18 [website: http://www.nal.usda.gov/fnic/foodcomp/].

The objective of this review is to determine the current status and problems of loquat production in Turkey and to provide solutions and alternatives.

THE CURRENT SITUATION OF LOQUAT PRODUCTION

The world loquat production was 566.031 tons and China stands out as the main producer and Spain as the prime exporter (**Table 2**).

Turkey is one of the most important producers of loquat in the world. In 2006, Turkey ranked fourth in production in the world with approximately 12,310 t. Until the last decade, loquat growing was carried out only in isolated home gardens for local consumption. After its economical value had been realized, demand for its commercial production rapidly increased. The total production in 1980 (3,000 t) increased more than three-fold by 1990 (9,000 t), four-fold by 2006, and reached about 12,310 t which was produced from 243,429 trees (**Table 3**). However, there are significant yearly fluctuations in terms of tree numbers because of frost damage, pulling out orchards established by seedlings, and establishment of more intensive orchards with new cultivars (i.e. 'Akko XIII', 'Gold Nugget', 'Tanaka' and 'Hafif Cukurgöbek', 'Ottowiani', 'Champagne de Grasse') bearing abundant and high quality fruits (Polat and Calıskan 2007).

In Turkey, loquat is produced in certain parts of the Mediterranean, Aegean, and Black Sea regions which have subtropical climate. The Mediterranean region has the most suitable ecological conditions for growing this fruit (Polat 1996); 91.2% of plantations in 2006 were located in the Mediterranean region lying in the southern part of the country with 97% of total loquat production of Turkey from the costal zone (Anonymous 2006). Specifically 91.2%, 4.4%, 4.2% and 0.2% production in the Mediterranean, Aegean, Black Sea and Marmara, respectively. In addition, from that study, 97%, 2.0%, 0.9% and 0.1% of the total number of loquat trees could be found growing in these four areas, respectively. Loquat production in this region increased by 300% in the last decade. Alanya, in Antalya, and Tarsus, in Icel provinces, are the major loquat growing areas. In the Aegean Region, loquat growing is limited only in microclimates, mainly in Sultanhisar and Aydın (Polat and Calıskan 2007).

Investigations on loquat are centered at Mustafa Kemal University in Hatay, Cukurova University in Adana, and Citrus Research Institute in Antalya. Investigations on cultivar trials, resistance of cultivars to winter cold and spring frost, resistance to scab, various propagation methods, rootstocks, parthenocarpy, fruit thinning, storage, high density, and protected cultivation have been conducted (Demir 1983; Erdogdu 1987; Demir 1989; Polat and Kaska 1991; Paydas *et al*. 1992; Polat and Kaska 1992a-h; Kılavuz and Eti 1993; Polat and Kaska 1993; Yalcın and Paydas 1995; Polat *et. al*. 1995; Demir and Durceylan 1998; Tepe 1999; Polat 1999; Polat *et al*. 2002; Erkan *et al*. 2005; Ertürk *et al*. 2005; Polat *et al*. 2005; Polat and Calıskan 2006).

Table 2 Area, production and exports of loquat in main countries(1).

Countries	Area (ha)	Production (T)	Exports	Percent in total production (%)
China	118,270	453,600	+	80.14
Japan	2,420	10,245		1.81
Pakistan	11,000	28,000	+	4.95
Israel	330	3,000		0.53
Egypt	33	440		0.08
Greece	300	2,750		0.49
Morocco	385	6,400		1.13
Portugal	243	950		0.17
Italy	663	4,412		0.78
Turkey	9,856	12,310	+	2.17
Chile	138	37		0.01
Brazil	300	2,400		0.42
Spain	3,230	41,487	+	7.33
Total	147,168	566,031		100.00

[1]: There are no FAO statistics available for loquat production; therefore the present data come from that published in journals and mostly from personal communications by researches from the producing countries. There are some countries where loquat is an important commercial crop and other countries where the crop is located in family orchards and isolated trees. **Table 2** shows those countries where the acreage of loquat as a regular crop is higher than 30 ha.

Table 3 Loquat production and number of trees in Turkey in different years (1980-2006). Source: Agricultural Structure (Production, Price, Value). State Institute of Statistics Prime Ministry Republic of Turkey.

Year	No. trees			Production
	Bearing	Non bearing	Total	(t)
1980	136,000	23,000	159,000	3,000
1985	165,000	30,000	195,000	6,500
1990	220,000	41,000	261,000	9,000
1995	238,000	78,000	316,000	9,800
2000	340,000	37,000	377,000	11,500
2001	245,500	41,500	287,000	11,500
2002	244,000	42,000	286,000	11,800
2003	246,000	40,000	286,000	12,000
2004	243,000	37,000	280,000	9,250
2005	251,000	37,000	288,000	12,000
2006	243,429	39,873	283,302	12,310

In Adana, the varieties of loquat under the experiment generally ripened at the end of April and in May. During the experimental years, Baffico, Champagne de Grasse and M. Marie appeared to be the most productive cultivars. Largest fruits were obtained from Ottawianni and Gold Nugget. Sayda and Hafif Çukurgöbek were found as the sweetest. The highest flesh/seed ratio and the lowest number of seeds per fruit were determined in Tanaka. The lowest acidity values were found in Champagne de Grasse and Victor. According to the evaluations of both growing period's parameters by weighed ranking tests, the highest points were obtained from M. Marie, Champagne de Grasse, Baffico, Gold Nugget and Akko XIII (Yalçın 1996).

Based on the results of several adaptation studies (Demir 1983; Erdogdu 1987; Paydas *et al*. 1992; Yalcın and Paydas 1995; Polat and Calıskan 2006) six cultivars ('Akko XIII', 'Gold Nugget', 'Tanaka' and 'Hafif Cukurgöbek', 'Ottowiani', 'Champagne de Grasse') were recommended for production.

Chip, patch, and T (shield) buddings performed at 15-day intervals from 15 January to 15 May were evaluated in Adana, Turkey (Polat and Kaska 1991). March was the most suitable month for budding, with 95% bud take. Patch budding was more successful than T and chip budding, but the strongest scion shoots were obtained with chip budding. Polat and Kaska (1993) determined the bud take rates using 'Gold Nugget', 'Tanaka' and 'Champagne de Grasse' loquat cultivars. T, patch and chip buddings were conducted on 25 March 1991. The bud take was found as 98.99% in 'Gold

Nugget', 94.35% in 'Champagne de Grasse' and 88.94% in 'Tanaka'. The successful bud take was 94.10% with T, 95.23% with patch and 92.95% with chip buddings. In another study by Polat and Kaska (1992a) 'Gold Nugget' budded 5 times at 1-month intervals between December 15 and March 15 and on April 1st. Buddings were conducted in heated greenhouses and outside conditions and successful budding rates were compared. No significant differences were revealed between these treatments. In another study, a budding experiment was carried out on the loquat seedlings grown in the open and in a heated greenhouse. The bud sticks of 'Gold Nugget' were used. The buddings (T, chip and patch) were done on the 15th of December, January and February. The success rate of buddings was 85.55% in the greenhouse and 67.72% in the open air (Polat and Kaska 1996).

A series of experiments on the propagation of loquats by air layering were carried out for two years (Polat and Kaska 1992b). To stimulate the rooting 2000 to 30000 ppm IBA solutions were tested. The highest rate of rooting (40%) was obtained from Yuvarlak Çukur Göbek (YÇG) variety girdled in December and treated with 10,000 ppm IBA. Girdling stimulated rooting of air-layered branches. Rings 0.5 cm wide rooted better than those 1.0 cm wide, as evaluated by root number and length. Higher rooting percentages were obtained from the February and March air-layered branches as compared to December. IBA at 10,000 ppm resulted in higher rooting than all other IBA concentrations. It was observed that the success rate of propagation by air layering in loquats is rather low. Therefore, these methods were not recommended for the commercial propagation of loquats.

Polat and Kaska (1992c) evaluated cuttings of 'Gold Nugget', 'Tanaka' and 'Yuvarlak Çukur Göbek' (YÇG) taken by approximately one month intervals between February and June and two months interval between August and December for two years. The lengths of cuttings were arranged as 15 to 20 cm having one or two leaves. The cuttings were treated with 1000 to 4000 ppm IBA and they were planted in the mist propagation beds where volcanic tuff was kept as rooting media. At the end of experiments, it was observed that none of the cuttings were rooted.

To assess the success of budding of loquats on Quince-A rootstock and the effect of this rootstock on the growth of the nursery plants Polat and Kaska (1992d) carried out a budding experiment. In the study, loquat seedlings were used as control. 'Akko-XIII' and 'Armut Şekilli' were used as experimental varieties. T (shield), chip and patch budding methods were studied. The budding were performed in spring and autumn. The key results of the experiment included: 1) in spring budding, loquat seedling rootstock has yielded more budding success (85.12%) than the Quince-A rootstock (54.82%); 2) success rate of budding on Quince-A rootstock was better in April than in May; 3) in dormant buddings made in fall, loquat seedlings were successful than the Quince-A rootstock, 48.28% and 36.05%, respectively; 4) Quince-A rootstock have had about 20% dwarfing effect on the saplings compared to the seedling rootstock.

Polat and Kaska (1992e) also conducted histological studies for the 'Akko-XIII' and 'Armut Şekilli' cultivars that were budded on Quince-A by shield (T), patch and chip budding methods. Formations of bud union on different buddings were studied on the microtome sections of the unions. In these histological studies the following results were obtained: in the first examinations of the bud unions, it was shown that callus formation started particularly at the sides of the unions. Along the surfaces of the union both at the scion and stock sides necrotic layers were observed. The callus cells which were formed from both stock and scion had torn the necrotic layers and filled the gap between the stock and scion and consequently formed a bridge between these two parts. After the formation of a callus bridge, differentiation in the cambium took place. In the loquat/Quince-A combination the cambium tie had not yet formed even after 100 days of budding. However, after 160 days of budding the formation of a cambium tie was observed. Although there was normal development just after budding, in parallel to the increase of leaf surface the development slowed down, and chlorosis on the leaves and die-back on the shoots were observed. It was concluded that in the loquat/Quince-A budding combination there may be incompatibility. However, this conclusion requires further work.

For the same loquat cultivars, 'Akko-XIII' and 'Armut Şekilli', Polat and Kaska (1992f) also determined the success rate of several budding types using Quince-C rootstock. T, patch and chip buddings were studied. Buddings on loquat seedling (70.42%) were more successful than those on Quince-C (56.67%). The bud take was 61.25% on T, 63.37% on patch, and 65.00% on chip buddings.

To determine tree size on 'Akko-XIII' and 'Armut Şekilli' budded on the loquat seedling and Quince-A rootstocks, the growth of the loquat nursery plants were investigated (Polat 1995). Loquat seedlings were taken as control. 'Akko-XIII' and 'Armut Şekilli' loquat varieties were budded on these two rootstocks and were planted in 3 × 3 m plots. From 1993 to 1995, 18.240 mm, 30.148 mm and 36.391 mm diameters and 72.304 cm, 120.200 cm and 124.400 cm heights were obtained from the loquat plants on Quince-A rootstock. In plants in which the rootstocks were loquat seedlings, 20.01 mm, 37.361 mm and 47.242 mm diameter and 81.075 cm, 141.400 cm and 164.000 cm height values were obtained. Thus, trees on Quince-A rootstock were 15.25% smaller than those on loquat rootstock.

Tepe (1999) determined the effect of tree, flowering and fruit characteristics and maturation dates of fruit; resistance to low climatic conditions of loquat, Quince A and pyracantha (*Crataegus oxyacanthus*), rootstock on 'Gold Nugget', 'Akko XIII', 'Hafif Çukurgöbek', 'Sayda' loquat varieties. Rootstock characteristics varied depending on the loquat variety although similar data for several characteristics was observed: tree growth (rootstock and bud), habitus growing, flowering and fruit characteristics (largest fruit, seeding rate, fruit firmness), fruit maturation, resistance to poor climatic conditions.

Polat *et al*. (1995) studied the effects of several treatments on seed germination. Seeds of loquat cultivars ('Akko-XIII' and 'Armut Şekilli' and 'Tanaka') were stratified for 45 days while others that were left untreated and kept for 45 days after harvesting were sown in seedbeds. Germination tests on other lots of the same seeds were also carried out under laboratory conditions. In field conditions, the germination rate in 60 days after sowing seed, and maximum germination rates of varieties were statistically analyzed. 'Tanaka' seeds had the highest germination rate; germination rates after 60 days of 'Tanaka', 'Armut Şekilli' and 'Akko-XIII' were 47.11%, 33.56% and 23.30% and the maximum germination rates of these three loquat varieties were 88.00%, 84.20% and 67.43%, respectively. Germination of seeds was found to be affected by different treatments. The highest averages results were obtained from the treatment of stratification followed by the control and treatment of storage of seeds in polyethylene bags. Germination rates after 60 days of stratified seed, stored seed in polyethylene bags and control seed were 42.41%, 20.89% and 40.67%, respectively; maximum germination rates were 92.87% in 82 days, 86.00% in 106 days and 61.53% in 85 days, respectively.

Kılavuz and Eti (1993) investigated the effects of flower thinning by hand, NAA on the fruit set, growth rate and size of the fruits of some loquat varieties. The loquat cultivars 'Hafif Çukurgöbek', 'Akko XIII', and 'Gold Nugget' were thinned with 25, 50 or 100 ppm NAA or napthalenacetamide (NAAm) or by hand by 50%, 70% or 90%. With NAA and NAAm applications, thinning percentage increased with an increase in concentration; however, the optimum level of thinning on fruit growth varied with cultivar. In general, fruits on thinned branches developed more rapidly than non-thinned controls in all cultivars. Thinning did not have any effect on fruit shape.

Paydas *et al*. (1995) assessed the effects of hand thin-

ning of small fruits by 30%, 50%, 70% and 90% as branch applications on loquat fruit quality characteristics (fruit weight, fruit index, seed number, seed weight, flesh/seed ratio, acidity and TSS). Hand-thinning of fruits by 70% and 90% in 'Akko XIII' and 'Ottawianni', by 50%, 70% and 90% in 'Baffico' and 'Kanro' gave positive results. However, since 90% fruit thinning may negatively impact yield, 50% and 70% of small fruit thinning were recommended.

Demir and Durceylan (1998) determined the various characteristics of several loquat varieties including 'Akko XIII', 'Champagne de Grasse', 'Gold Nugget', 'Hafif Çukurgöbek', 'Uzun Çukurgöbek' and 'Sayda' in term of earliness, resistance to *Venturia ineaqualis* var. *eriobotryae* and flowering time of their combination hybrids under Mediterranean conditions. The results indicated that some 'Akko XIII' × 'Uzun Çukurgöbek' hybrids had superior flowering time, TSS, fruit taste and fruit color. Some 'Gold Nugget' × 'Champagne de Grasse' hybrids had superior flowering time, percentage seed and acid while some 'Gold Nugget' × 'Sayda' hybrids had superior index, number of seed and TSS/acid ratio. Fruit weight, seed weight and subjective fruit taste were found to be superior in some 'Gold Nugget' × 'Uzun Çukurgöbek' hybrids.

A study by Polat *et al*. (2002) showed that the highest cumulative yield/unit area was obtained with 3 × 3 m density (7165 kg/ha), followed by 3 × 6 m (4056 kg/ha), then 6 × 6 m (2200 kg/ha). On the other hand, Polat *et al*. (2005) stated that protected cultivation increased earliness 13-20 days compared to the open field.

Erkan *et al*. (2005) assessed the effects of different packaging materials on the storage of 'Gold Nugget' loquats. After harvest, fruit were divided into three groups for different postharvest treatments. The first group of loquats was placed in foam trays and they were covered by cling film. The second group of fruit was also placed in foam trays and they were covered by polyethylene (PE) plastic films. The third group of loquats was considered as the control group without any treatment. The loquats were stored 0°C with 90-92% relative humidity for 2 months. During storage, weight loss, titrable acidity, total soluble solid and skin color changes were determined on the fruit taken from storage at 15-day intervals. Furthermore, the changes in O_2 and CO_2 when using different materials were recorded. Packaging loquats in cling films and PE plastic films were very effective in reducing weight loss compared to unwrapped fruit. Results indicated that Modified Atmosphere-packaged loquat fruit could be stored at 0°C and 90-92% RH for 60 days without much loss of quality.

'Hafif Cukur Gobek' loquat fruits were overwrapped with 12.5 µm, 14 µm or 16 µm thick PVC films and kept at 0°C for 60 days. Percent weight loss, skin color (L*, a*, b*), fruit flesh firmness (kg force), total soluble solids (%TSS), titratable acidity (%), physiological and fungal disorders were determined immediately after harvest and at 15-day intervals. Packaging with 12.5 µm or 14 µm thick PVC films could keep fruit at 0°C for up to 45 days (Ertürk *et al*. 2005).

In Turkey, loquat is consumed as an early season fresh fruit. Although production is not adequate for domestic consumption there are exports to Saudi Arabia, Iraq, Kuwait, Jordan, Russia, Sweden, Germany, and other European countries. Although export is not stable, total loquat export was 111 t (67% to Saudi Arabia and 27% to Jordan) in 2001, 373 t (78% to Saudi Arabia and 13% to Jordan) in 2002, 89 t (71% to Saudi Arabia and 24.5% to Kuwait) in 2003, 208 t (88% to Saudi Arabia and 6% to Kuwait) in 2004, 163 t (81% to Saudi Arabia and 9% to Russia) in 2005, 293 t (64% Iraq and 33% Saudi Arabia) in 2006 and 512 t (53% Iraq and 38% Saudi Arabia) in 2007 (IGEME 2001- 2007).

PROBLEMS IN LOQUAT PRODUCTION

Cultivars

Cultivar selection is a very important aspect of loquat culture. Most importantly, the cultivar should be desirable to the markets. The early varieties are sold with higher prices

Fig. 1 Views from several adaptation studies carried out at different parts of the Mediterranean region of Turkey.

Table 4 Some important loquat cultivars which are growing in Turkey and their various characteristics (Polat and Calıskan 2007).

Cultivar	Ripening period	Yield (kg/tree)	Fruit weight (g)	Seed Number	Flesh/seed ratio	TSS (%)	Color
Hafif Çukur Gobek	20 Apr-10 May	41.66	34.52	4.09	3.85	11.54	Orange
Sayda	20 Apr-10 May	42.00	31.02	4.84	3.69	11.90	Orange
Gold Nugget	20 Apr-21 May	35.16	39.68	4.15	4.90	10.12	Orange
Tanaka	30 Apr-20 May	34.00	31.85	1.76	5.31	9.74	Orange
Akko XIII	30 Apr-16 May	63.83	36.76	5.57	4.40	10.47	Clear Orange
Champagna de Grasse	20 Apr-10 May	70.00	25.90	3.43	4.44	12.04	Clear Yellow
Ottowianni	24 Apr-16 May	31.00	49.78	6.58	4.71	10.66	Clear Orange
Baffico	20 Apr-19 May	66.33	30.02	2.94	5.15	11.47	Orange
Kanro	30 Apr-27 May	24.50	37.67	3.07	5.90	9.75	Clear Orange
Taza	24 Apr-16 May	35.33	31.15	4.58	5.58	10.45	Clear Yellow
Victor	30 Apr-16 May	45.33	25.40	3.60	5.32	11.67	Yellow
Dr. Trabut	5 May-18 May	30.00	36.67	4.51	5.09	12.26	Orange

than mid-season cultivars in both local and global markets. Thus, early cultivars should be produced in the Mediterranean region, given that this area has suitable ecological conditions for early production (Polat 1997). Also, late-ripening cultivars are very important for the markets. However, our studies (Polat 1996, 1997) indicated that the importance of choosing late-ripening cultivars was not well understood among the producers.

Most of the scattered loquat trees are seedlings while the trees of the organized orchards are grafted with the desired cultivars on loquat seedlings. The existing cultivars have been selected by researchers or farmers from seedlings cultivated locally. There are many local varieties originating from seedling trees (Polat 1997). These have been selected according to the quality of the fruit (number of seeds per fruit, large fruit size, early maturity). The local cultivars are grouped in two categories, those with round fruits and those with oval fruits. The most common local cultivars are known by 'Uzun Cukurgobek', 'Hafif Cukurgobek' and 'Yuvarlak Cukurgobek' and 'Armut Sekilli'. These cultivars are now in collection and are in evaluation in different experimental fields at different locations of the country to compare them with the new varieties introduced from abroad (**Fig. 1**).

In our study (Polat 1996, 1997), we found that producers purchased plant materials from nurseries and did not question whether the varieties were suitable for their area, and were even unfamiliar with the cultivars that they had in their orchards. In the end, several problems regarding cultivars used are a result of a lack of scientific data. For example, the cultivars currently grown in some areas are not productive and have small fruit. Therefore, among the productive, high quality cultivars, those that are well adapted to their region must be chosen. To do this, selection studies should be initiated among the seed-grown genotypes of orchards and adaptation studies should also be conducted. In such studies priority should be given to previous research conducted in the Mediterranean Region.

A loquat trial was established at the Citrus Research Institute (Ministry of Agriculture and Rural Affairs) based in Antalya between 1968 and 1981 with 12 local selections and 5 introductions. 'Akko XIII', 'Gold Nugget', 'Tanaka' and 'Hafif Cukurgöbek' were selected as the most suitable cultivars and pollination requirements and suitable pollinators were determined. An adaptation trial was replicated in 7 different locations, 6 being in the Mediterranean and 1 in the Aegean region with the selected cultivars together with 6 new introductions from Corsica ('Ottowiani', 'Baffico', 'Victor', 'Taza', 'Kanro', 'Champagne de Grasse') (Demir and Yalcınkaya 1991). Several adaptation studies (Demir 1983; Erdogdu 1987; Paydas *et al*. 1992; Yalcın and Paydas 1995; Polat and Calıskan 2006) were carried out at different locations of the Mediterranean region and important results were obtained to improve loquat cultivation. As a result, six cultivars ('Akko XIII', 'Gold Nugget', 'Tanaka' and 'Hafif Cukurgöbek', 'Ottowiani', 'Champagne de Grasse') were recommended for production.

A list of important loquat cultivars which are grown in Turkey and some of their characteristics are shown in **Table 4**. The currently grown cultivars are harvested in April-May. Harvest dates can be even earlier if novel early genotypes are identified.

Rootstocks

The rootstock used depends on the area. **Table 5** shows the most common cultivars and rootstocks used in the Mediterranean countries. Data come from the First Meeting of the CIHEAM Cooperative Working Group on Underutilized Fruit Crops in the Mediterranean Region (Llácer *et al*. 1995) (after Llácer *et al*. 2003).

In all Mediterranean countries, the rootstocks used are loquat seedlings; they are very well adapted to calcareous soils which are very abundant in the Mediterranean basin. Trails of quince trees (A, C, BA 29) have often been studied in some countries. This species allows to obtain smaller and more compact trees, a shorter juvenile period and bigger fruits, with high sugar content and nice color. However, quince trees are very sensitive to calcareous soils and they show graft union incompatibility with many varieties (Llácer *et al*. 2003). On the other hand, in China which is the main loquat producing country, the most used rootstock is loquat seedlings while in some areas, quince is used as dwarfing rootstock (Lin 2007).

The use of loquat seedling rootstock usually results in a comparatively large tree with a high canopy. Cultivars grown on quince rootstock produce a dwarfed tree of early bearing character. The smaller tree has no effect on fruit size and gives adequate fruit production with the advantage of easier picking (Crane and Caldeira 2006).

Commonly, trees are grafted onto loquat seedlings, occasionally on *Eriobotrya deflexa*, and *Photinia serrulata*, and may be grafted onto dwarfing rootstocks of quince (*Cydonia oblonga* Mill.) and pyracantha (*Pyracantha* spp.).

Table 5 Most common cultivars and rootstocks used in some Mediterranean countries (Llácer *et al*. 2003).

Country	Cultivars	Rootstocks
Cyprus	Morphou; Karantoki	Loquat seedlings
Egypt	Early suckary; Large round; Advance; Premier; Late Victoria	Loquat seedlings, Quince
Greece	Rozenon; Troulotis; Koilarato	Loquat seedlings
Israel	Akko 1; Akko 13	Loquat seedlings
Italy	Nespolone di Trabia; Nespolone Bianco; Vainiglia; Sanfilippara, Virticchiara	Loquat seedlings, Quince
Morocco	Tanaka; Saint Michel; Algerie	Quince
Portugal	Tanaka; Algerie; Golden Nugget	Loquat seedlings, Quince
Spain	Algerie; Magdal; Golden Nugget; Tanaka	Loquat seedlings, Quince
Turkey	Akko 13; Golden Nugget; Tanaka; Hafif Çukurgöbek	Loquat seedlings

Fig. 2 Tree shape (top) and fruit set (bottom) on loquat/Quince-A combination.

Fig. 3 Quince-A rootstock (B, C) has 25% of dwarfing effect when compared to loquat seedling (A, D) (Polat 1990).

Loquat seedlings are preferred over apple, pear, quince or pyracantha rootstocks under most conditions. Quince and pyracantha may cause extreme dwarfing – to less than 8 ft (2.5 in). Quince rootstock tolerates heavier and wetter soils than loquat but is apt to put out numerous suckers (Crane and Caldeira 2006).

At present, the rootstocks used are loquat seedlings in Turkey. However, the dwarfing clonal rootstocks are very important in loquat culture. The utilization of the dwarfing rootstocks will not only enable high density plantings and therefore higher yields, but also will have other advantages such as easier and more effective cultural applications (Polat and Kaska 1992d, 1992f). We suggest dwarfing, clonal rootstocks such as Quince-A and BA-29 for loquat production. This species allows growers to obtain smaller and more compact trees (**Fig. 2**). Trails of quince trees (A, C, BA-29) have been studied much in Turkey. In some of our studies (Polat and Kaska 1992d; Polat 1995), Quince-A rootstock had a 25% dwarfing effect compared to loquat seedlings (**Fig. 3**). Polat and Calıskan (2007) recommended that nurseries should initiate grafting loquat onto quince rootstock. Further studies on these rootstocks should be conducted.

Nursery production

Growers either purchase their nursery plants from nurseries (usually from private nurseries) or produce their own nursery plants by taking buds from trees in nearby orchards that they believe are of high quality. We observed many incorrect applications from the selection of budding material, the budding process, care of budded trees, and planting of the young tree and consecutive care. For this reason, emphasis should be given to supplying high quality, true-to-type, dwarf nursery plants to growers and making sure that accurate management techniques are applied. To fulfill this purpose, an area should be chosen where correct and novel techniques could be demonstrated to the growers.

The most convenient period for budding is the beginning of March to mid-May and patch budding (**Fig. 4**), which proved to be more satisfactory than shield and chip budding (Polat and Kaska 1991; Polat 1999). Polat and Kaska (1992h) and Polat *et al*. (1995) report that stratification and storing seeds at 4°C increased the germination rate.

Orchard establishment

Loquat is a 1ong-lived tree and orchards over 30 years old remain productive. Thus, location and site selection are important in planning orchards. In China and India, loquats are grown at elevations up to 2000 m. In Japan, loquats are grown on hillsides to obtain the benefit of good air flow (Kozaki *et al*. 1995). In more tropical regions, the tree thrives and fruits well at elevations between 900 and 1200 m, but bears little or not at all at lower levels (Campbell and Malo 1986; Morton 1987).

Winter temperature should be higher than -3°C, and summer temperature not over 35°C. The tree requires 1000-1200 mm of rainfall annually and a suitable level of humidity. Soil should be deep and well drained, with an adequate content of organic matter. Sand loams or clay loams with a pH of 5.0 to 8.0 are considered appropriate, with pH 6.0 being optimum (Lin *et al*. 1999).

Nursery plants must be transplanted before the growth of spring buds, depending on climate. In China, leaves on the base of nursery plants are removed and the root system is often dipped in mud. Before planting, well-fermented manure is added to planting holes (Lin *et al*. 1999).

Loquats are planted at a density of about 500-600 trees/ha, but some cultivars with vigorous and spreading character are established at about 450 trees/ha (about 5 m between rows and 4 m between trees). In Japan, standard plant distance is 5 to 7 m (Sato 1996). In Brazil, a spacing of 7 × 7 m is recommended on flat land, 8 × 5 (or 6) m on slopes. In Putian county, Fujian province of China, loquat is spaced 6 m between rows and 3 m between trees with longan, a tree with a long juvenile period, interplanted 6 × 6 m. Loquat produced the same yield as the normal orchard from the third to the tenth year and then was removed to encourage longan (Lin *et al*. 1999).

In Turkey, standard plant distances are 6 × 6 m, 7 × 7 m or 8 × 8 m. However, it is recommended that high density planting by using dwarf rootstocks produce higher yield per unit area in a shorter time (Polat and Kaşka 1992d, 1992f;

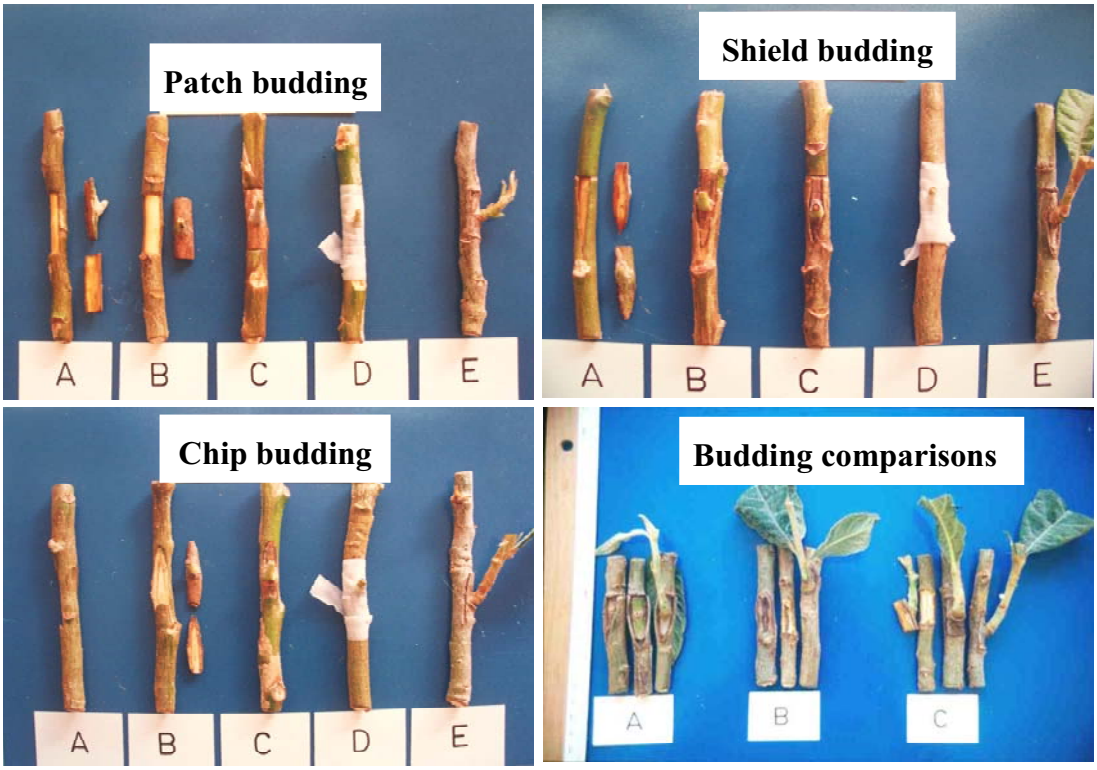

Fig. 4 Budding methods used in loquat propagation.

Fig. 5 (Top) Loquat trees trained in open-centre system. (Bottom) Regular loquat orchards are established with a spacing of 6-8 m.

Polat 1995, 1996). As a matter of fact, positive results were obtained from studies that aimed to find out the success of budding of loquats on Quince-A and Quince-C rootstocks and the effect of these rootstocks on the growth of nursery plants (Polat and Kaşka 1992d, 1992f; Polat 1995). According to these results, Quince-A rootstock had one quarter of the dwarfing effect than loquat seedlings (Polat 1995).

Traditional loquat culture in the Turkey consists in isolated trees located in gardens, family orchards or small plantings destined to local consumption. The older loquat orchards were mainly established by seedlings but new and more intensive orchards are being established on seedling rootstocks. The mistakes made during the establishment of orchards affect all of the following production and cultural techniques. During the establishment of orchards, young trees should be planted in well-aligned patterns at set distances. Otherwise, when the young trees develop, cultural practices such as soil management and pruning will be difficult to carry out and application of automated techniques will not be possible. We observed some of the growers did not pay attention to the correct ways to established orchards and thus mechanization could not be applied to their orchards.

In general, the regular loquat orchards are small in size and each range from 0.1 to 6.0 ha. The existing organized orchards are established with a spacing of 6-8 m × 6-8 m (**Fig. 5**) and with more than one cultivar. Recently, protected cultivation and high-density systems are increasingly popular in Turkey due to increased yield per unit area. Highest yields were obtained from 'Hafif Çukurgöbek' (3.05 kg/tree, 1882 kg/ha), averaging three years. The highest cumulative yield/unit area was obtained with 3 × 3 m density (7165 kg/ha), followed by 3 × 6 m (4056 kg/ha), and 6 × 6 m (2200 kg/ha) (Polat *et al*. 2002). Protected cultivation increased earliness 13-20 days compared to the open field (**Fig. 6**) (Polat *et al*. 2005).

Soil management

Soil management in fruit and nut planting is aimed primarily at weed control, but also is control concerned with retaining good soil structure by preventing compaction, and with the possible use of cover crops to improve fertility and prevent erosion. Weed control may be achieved by mechanical means (tillage, flailing, mowing, etc.) use of chemical herbicides, planted cover crops, or a combination of 2 or more of the above. The choice of method is determined by the nature of any critical problem in the specific planting.

Cover crops are not often used in nonirrigated plantings because they compete with the fruit plant for moisture. However, where irrigation is done, a permanent cover crop may be used to prevent erosion and to provide a firm base

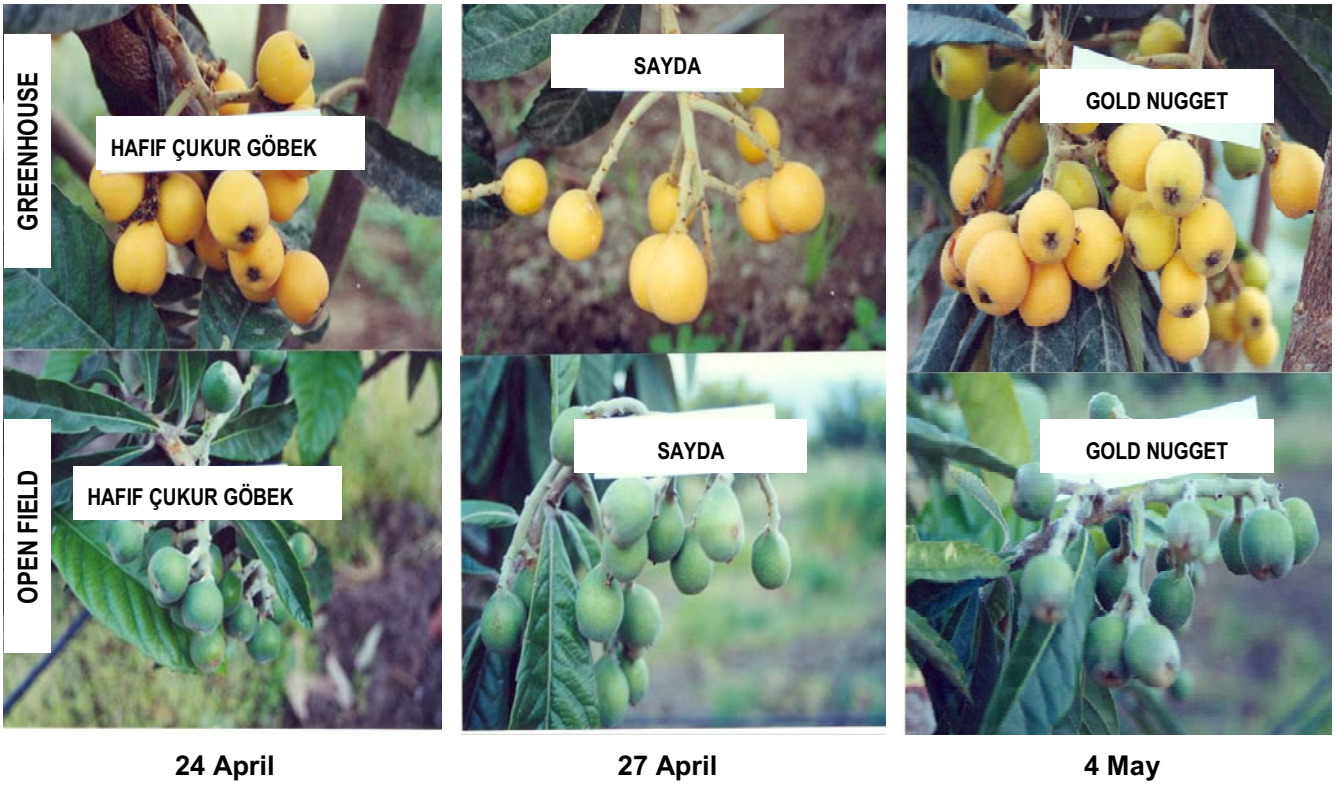

Fig. 6 Fruit maturities of some loquat cultivars in greenhouse and open field.

for orchard equipment when the soil is wet. Clover, alfalfa, or other legumes can be used to enrich the soil with nitrogen.

Loquat is usually grown under sod culture in Asia. Orchards are mowed two to three times per year and mowed grass clippings are spread under the trees as mulch. Growers improve the soil by providing manure and other organic substrates (Shinkai *et al*. 1982). Film mulch was found to increase hardiness of loquat in Zhejiang, China. The soil temperature increased by 2°C in a 12-year-old loquat orchard mulched with brown-black or transparent polyethylene film from November to June. Soil moisture, nutrient status, and soil bulk density were improved by mulching and available soil N, P, and K, as well as yield also increased (Xia 1986) (after Lin *et al*. 1999).

We observed (Polat 1996, 1997) that most Turkish growers understood the importance of soil management. However, overly deep cultivation of the soil is a common mistake among loquat growers. Soil culture is conducted with tractors where applicable.

Generally partial-cover soil cultivation is applied in Turkey. During winter the soil is covered with green fertilizer plants such as clover, alfalfa, or other legumes or weeds which are removed from the surface in spring without damaging the roots and should be maintained throughout the growing season.

Pruning

Loquat trees grow upright and too tall when proper training is neglected, often resulting in damage by strong winds and lower labor efficiency (Lin *et al*. 1999; Lin 2007). The objective of pruning is to lower the bearing surface to facilitate fruit thinning and harvest. Pruning should also remove crossing branches and thin dense growth to let light in to the center of the tree. Loquats respond well to more severe pruning (Shih 2007). There are different ideas about loquat pruning in the literature, some of which are summarized below.

In China, loquat trees had been traditionally trained as a modified central leader, but are recently trained into an open-center system, where branches are pulled down by string to allow light penetration into the crown to promote fruit set. Loquat may also be trained into a vase-shape. Pruning is carried out after harvest usually in summer when flower buds become visible. Overgrown branches of the tree crown are removed with shears or handsaws, and sprouts are removed or cut back. Pruning is indispensable to reduce the number of bearing shoots and to secure sufficient flower buds (Lin *et al*. 1999; Lin 2007).

During the first 1 to 2 years after planting, pruning young trees by tipping shoots in excess of 2 to 3 ft, tipping will increase branching. Trees may be trained to a modified central leader or open center configuration. Mature trees may be selectively pruned to maintain trees at 6 to 12 ft in height. This will make care of the tree and harvest easier (Crane and Caldeira 2006).

To encourage good fruit development on loquat, it is also necessary to occasionally prune out some branches throughout the canopy of the tree. This thinning will open the tree up to allow light in and increase fruit production. Loquat should be pruned after danger of frost has passed but prior to spring bud-break (Begeman 1999).

After planting, trunks of the survival trees were shortened at 20-30 cm above the graft union and 3 to 4 lateral buds were allowed to develop into main branches in different directions. The main branches were tied down so as to grow horizontally. The shoots developed were then trained, maintaining one main shoot and two side shoots, so that a bi-layered, open and dwarf canopy was formed. When such a canopy was well-shaped, one main shoot and one side shoot were maintained at each flush growth. Pruning was mainly conducted after harvest by removing the dead, weak, overlapping and diseased twigs and by shorting the vigorously growing shoots, so as to maintain a evenly distributed dwarf branch and light penetrating canopy (Zheng and Lin 2007).

In Turkey, the most common production mistake is the ignorance of pruning. The growers do not either understand the importance of pruning or do not know proper pruning techniques. In some regions, pruning is restricted to taking off dead branches. As a result, the trees overdevelop and the canopies are mixed. Therefore, sunlight cannot penetrate the plant canopy very well, causing problems in fruit set

Table 6 Recommendation of optimal irrigating schedule for Antalya, Turkey (Demir 1987).

Yearly irrigation water needed (mm)	Irrigation times for different structure of soil			Water dose for each irrigating (mm)		
	Light (Sandy)	Middle (Loam)	Heavy (Clay)	Light (Sandy)	Middle (Loam)	Heavy (Clay)
1130	10-11	8-9	6-7	110-100	140-130	190-160

and quality. Finally, the fruiting branches die. It is highly important to educate growers on proper pruning techniques. Pruning is applied regularly in intensive orchards but not always for scattered trees. Generally, loquat trees are trained in open-centre system (**Fig. 5**, top) (Polat and Calıskan 2007).

To train the loquat trees to open-centre, after one year from planting, the middle apical branch should be removed from the bottom and then a good shape should be given to the other 3-4 scaffold branches which emerge from the main trunk. It is best to select 3 to 4 scaffolds that are uniformly spaced around the tree, with wide branch angles, and not directly across from another scaffold. Other branches, not selected, should be removed. The lowest scaffold should be 24 to 32 inches above the soil surface to avoid interfering with cultural work under the tree, such as harvesting and weed control.

The scaffold branches on the tree should be shorted to 35-40 cm in the same year. After the first year of growth, 2-3 new lateral branches should be maintained from each main branch to give a balanced shape to the tree. In the following year, interference with the tree should be limited to taking dead or diseased branches.

Judicious pruning should be done either just between flowering and fruit-setting or after harvesting, otherwise terminal shoots become too numerous and cause a decline in vigor which may result in biennial bearing (Morton 1987; Shih 2007).

Irrigation

Loquat, which can tolerate drought, is hardier than orange but not as hardy as fig. In general, loquat does not require irrigation, but when the fruits are maturing, sprinkler irrigation is carried out to reduce sunburn (Lin *et al*. 1999). Loquat trees are drought tolerant, but they will produce higher quality fruit with regular, deep watering. The trees should be watered at the swelling of blossoms and 2 to 3 waterings should be given during harvest. The trees can not tolerate standing water (Morton 1987).

Newly planted loquat trees should be watered at planting and every other day for the first week or so and then 1 to 2 times a week for the first couple of months. For the first 3 years, they should be watered once a week during prolonged dry periods (e.g., 5 or more days of little to no rainfall). Once the rainy season arrives, watering should be reduce or stopped. Once loquat trees are 4 or more years old, watering should occur during fruit development and prolonged dry periods. Over-watering may cause trees to decline or be unthrifty (Crane and Caldeira 2006).

Like all trees, loquat need frequent watering during the first few months after planting. But once established they have good drought tolerance. Only occasional watering is needed to keep them attractive. Regular watering, however, is necessary to produce good fruit (Begeman 1999).

Although loquat is remarkably drought-resistant for a broadleaved evergreen, it needs moisture at all times, particularly in summer. After the tree is established, irrigation water should be kept away from the trunk. As the tree matures, irrigate closer than half the distance between the trunk and the outer reach of the branches should not take place. If the tree is 6 to 8 feet from a lawn or other irrigated area, it does not usually need special irrigation (Tous and Ferguson 1996).

The importance of irrigation is well understood and most orchards are irrigated in Turkey. The most common irrigation techniques are basin, furrow and drip irrigations, and some growers bring their irrigation water from distant sources (up to 15-20 km away). Use of drip irrigation in all orchards would increase the benefits of irrigation.

Loquat saplings are irrigated from April to October in 7-10 day intervals depending on climate and soil conditions. Irrigation is applied adequately to moisturize 30-50 cm as active root depth by the basin method. For the irrigation of a mature loquat orchard the most common method is basin irrigation. In these orchards, irrigation is practiced between the end of the rainy season in spring and the start of the rainy season in fall. Depending on the climatic conditions the irrigation interval is between 15-20 days. Light soil should be irrigated frequently with less water and heavy soil should be irrigated rarely with much water. The optimal irrigating schedule for Antalya, the major loquat growing area, is provided in **Table 6**.

Fertilization

Fertilization is one of the most important management practices for healthy tree development, high yields, and quality fruits (Polat and Calıskan 2007). Nutrient availability in the soil is the net effect of several interacting factors, some of which are incompletely understood. The interaction between tree and soil is even more complex, and leaf and soil analyses are merely tools for estimating the kinds and amounts of fertilizer to apply in a particular situation. Unfortunately, fertilizer use worldwide is more related to economic status than to the needs of crops (Westwood 1995).

The types of fertilizer used and application rates are related to plant age and soil nutrient content. For young, juvenile trees, fertilizer is applied every two months. In orchards with low fertility, 195 kg N, 165 kg P, and 210 kg K/ha are applied each year; in orchards with higher fertility, 150 kg N, 94 kg P, and 112 kg K are applied. In Japan, standard applications are 170 kg N, 115 kg P, and 125 kg K/ha for 10-year-old trees of 'Mogi' (Sato 1996), and 240 kg N, 190 kg P, and 190 kg K when a yield of 10 t/ha is expected (Fujisaki 1994). Fertilizer schedules in China are discussed by Lin *et al*. (1999; **Table 7**). Pit disorder (black fruit disease) was associated with low soil Ca and was corrected with soil applications of 100 kg/ha Ca (Huang and Lin 1996).

For good fruit production trees require ample fertilization and irrigation. In the tropics, animal manure is often used. A good formula for applications of chemical fertilizer is 45 kg 6-6-6 NPK three times a year during the period of active growth for each tree 8 to 10 ft in height (Morton 1987).

A month after planting, 113 g per tree of a young-tree fertilizer, such as 6-6-6 (6% nitrogen, 6% phosphate, 6% potassium) with minor elements is spread. Twenty to 30% of the nitrogen should come from organic sources (**Table 8**). This is repeated every 8 weeks for the first year. Then, the amount of fertilizer is gradually increased to 227 g, 341 g, 454 g, etc. as the trees grow. Four to 6 dry fertilizer applications per year may be made up to the third year. A foliar fertilizer mix composed of magnesium and minor nutrients (manganese, zinc, boron, and molybdenum) may be applied 2 to 3 times per tree per year any time from April to November. In acid to neutral soils, apply iron sulfate at 7-28

Table 7 Fertilizer application time for loquat in China (Lin *et al*. 1999).

Stage of growth	Percentage of total	Function
After harvest	50	Resuming vigor
Prior to flowering	15	Increasing cold resistant
After fruit set	25	Lowering fruit drop
Growth of fruit	10 (foliar spray)	Increasing fruit growth

Table 8 Suggested fertilizer recommendations for loquats for Florida (Crane and Caldeira 2006).

Year	Times per year	Amount/tree /application (lbs)[1]	Total amount/tree/ year (lbs)	Minor element sprays (times/ year)[2]	Iron chelate drenches (oz/tree/year) [3]
1	4-6	0.25-0.5	1.5-3.0	2-3	0.5-0.75
2	4-6	0.5-1.0	3.0-6.0	2-3	0.75-1.0
3	4-6	1.0-1.5	6.0-9.0	2-3	1.0-1.5
4	2-3	1.5-2.5	9.0-10.0	2-3	1.5-2
5	2-3	2.5-3.5	10.0-14.0	2-3	2-4
6	2-3	3.5-4.0	14.0-16.0	2-3	2-4
7+	2-3	4.0-4.5	16.0-18.0	2-3	2-4

[1] Use 6-6-6, 8-3-9, or a young-tree or slow-release fertilizer.
[2] The spray should contain zinc, manganese, boron, and molybdenum; it may also contain iron. Foliar sprays are most efficient from April to September.
[3] Iron chelate soil drenches (iron plus water) will prevent iron deficiency; foliar sprays are generally not effective. Apply soil drenches from June to September.

Table 9 After 4 years recommended doses and application times of N, P, K for loquat in Turkey (Demir 1987).

Age of tree	Nitrogen		Phosphorous		Potassium	
	Pure N (g/tree)	Ammonium sulfate application time and dose	Pure P_2O_5 (g/tree)	Triple super phosphate application time and dose	Pure K_2O_5 (g/tree)	Potassium sulfate application time and dose
4-6	120-240	July 400-800 October 100-200 February 100-200	55-90	August-September 135-225	60-120	August-September 120-240
7-12	460-700	July 1300-2000 October 500-750 February 500-750	110-130	August-September 275-325	180-270	August-September 360-540
After 12 years old	400 200 200	July 2000 October 1000 February 1000	160	August-September 400	300	August-September 600

g/tree to the soil 2 to 3 times per year. In alkaline soils with a high pH, the soil is drenched with iron chelate 2 to 3 times a year from June through September. To make a soil drench, mix 14-21 g of iron chelate with 14-19 liters of water and pour onto the soil next to the tree trunk. For mature trees, fertilize trees 2 to 3 times per year. The fertilizer should be applied just before or at bloom, perhaps during late fall, again in March, and once during the summer. The fertilizer mix should also include phosphate (P_2O_5) and potash (K_2O) by use of a 6-6-6, 8-3-9 or similar material (Crane and Caldeira 2006).

Following many years of practice, the following rates of fertilizer application are recommended for loquats: for 1-to-3–year-old trees, N fertilizers should be mainly applied and 10-15 kg straw manure + 30-50 kg compost + 1-1.5 kg lime per tree; for 4-to-6–year-old trees 0.4 kg N per tree, and an N:P:K ratio of 1: 0.4-0.5:0.6-0.8: for adults (over 7-year-old) trees, 1.0 kg N per tree and an N:P:K ratio of 1: 0.5-0.6:0.8-1.0. fertilizers should be applied 3 times a year. The following foliar fertilizers should also be applied: 0.3-0.4% urea, 0.2-0.3% KH_2PO_4 and 0.1 % Borax sprayed before flowering (Zhi and Ya 2005).

The recommended amount of fertilizers applied for a fruit load of over 20 kg/tree is sheep manure at 50-60 kg and compound chemical fertilizers at 1 kg, applied in mid-late September as basic manure plus supplementary chemical fertilizers in the vegetative season (Chun *et al*. 2000).

Loquats benefit from regular, light applications of nitrogen fertilizers, but too much nitrogen will reduce flowering. A good formula for applications of chemical fertilizer is three times a year just before the period of active root growth. The first application is made in August using 0.3 kg of (elemental) 12N-5P-10K-1Mg-0.5Ca for each tree; the second is December to use 0.2 kg of 6N-5P-7K-1Mg-0.5Ca-0.5S and the third is the end of April to use 0.1 kg of 10N-2P-4K-1.5Mg-0.5Ca. In "special cases" of excessive growth, fertilizing only once a year in midwinter is recommended. Organic matter is needed once during summer with fermented compost such as cow dung, charred rice husk, bagasse, or sesame residues. The amount used depends on the organic matter content in the soil (Shih 2007).

In some areas of Turkey, farmyard manure is the sole source of fertilizer, and the timing of fertilization and amount applied is not standard. Therefore, the benefits of fertilization were not as great as they could be. To determine the macro- and micronutrient needs of loquat trees, leaf and soil analyses should be carried out. In loquat orchards, the optimal leaf and soil sampling time is March. Leaf examples can be taken from one-year-old branches bearing fruits. If such an analysis can not be utilized, a general fertilization program (Demir 1987) could be as follows. 1st year: For each sapling 30 g pure N (150 g ammonium sulphate) per year given as 25 g with each irrigation; 2nd year: For each sapling 60 g pure N (300 g ammonium sulphate) from February to July is given 4 times (75 g with each irrigation) with irrigation; 3rd year: For each sapling 100 g pure N (500 g ammonium sulphate) from February to July is given 4 times (125 g each irrigation) with irrigation; For loquat trees over 4 years old: KPN should be given as necessary. Macroelement needs of 4-year-old loquat trees is summarized in **Table 9**. In addition chemical fertilizer for each 3-4 years can be supplied by providing 30-40 t farmyard manure/ha to the soil and is useful for improving the soil's physical state and organic content. Farmyard manure can be provided together with potassium and phosphorus.

Pest and disease management

In Turkey, two diseases that sometimes create problems are fireblight (*Erwinia amylovora*) and loquat scab (*Spilocaea eriobotryae*). The most common problem of disease management is loquat scab. Control of loquat scab is carried out in organized orchards but not always for scattered trees. To get high quality fruits from infected trees is very difficult. The infected branches cannot grow normally. Leaves of infected trees senesce earlier than healthy trees and the tree may drop a significant amount of leaves. In otherwise healthy trees, fertility decreases and trees become unproductive.

In loquats, scab management can be carried out with some pesticides in addition to cultural precautions. Before starting to spray with pesticides, the old infected parts of trees (i.e. branch, leaf, fruit) should be removed from the tree. Having good air circulation is also important for scab management. The first spray is conducted in autumn when new flower wisps are produced with 1.5% Bordeaux mixtures. The second spray is made before flowering. For pre-flowering spraying Bordeaux mixtures are preferred. After the end of the 3rd and 4th flowering, spraying should be con-

ducted at 10-15-day intervals until 20 days before harvest. For these sprayings Bordeaux mixtures and some other fungicides which contain copper oxyfluoride can be used. In sprayings, trees canopy should be almost wet with pesticides (Demir 1987).

The most common pests on loquat orchards are *Zeuzera pyrina* and Aphides. Pest management should start at the end of June. Tree should be completely washed with pesticides. If there are some maggots on branches, these should be pruned from the tree. Aphids are also a problem in some years for especially in young trees. Black or green aphids, which can be seen in spring, cause damage to new branches and leaves. To kill aphids some insecticide with organic phosphate should be used (Demir 1987).

The most important problem reducing loquat fruit quality is purple spot, a physiological disorder that affects loquats. Purple spot incidence varies from year to year and depends on location and harvest time (Gariglio *et al*. 2003), suggesting that environmental factors can influence purple spot appearance.

Harvest, ripening, and storage

Loquat fruits should be allowed to ripen fully before harvesting. They reach maturity in about 90 days from full flower opening. Determination of ripeness is not easy, but it is important because unripe fruits are excessively acid. Full development of color for each cultivar is the best guide. Since loquat fruits are easily injured, fruits should be handed carefully. The fruits are difficult to harvest because of the thick, tough stalk on each fruit which does not separate readily from the cluster, and the fruits must be picked with stalk attached to avoid tearing the skin. Clusters are cut from the branch with a sharp knife or with clippers (Morton 1987; Lin 2007). Great care is taken to avoid blemishes. Major Japanese growers have monorail systems for conveying the picked fruits and equipment from their hillside plantations (Morton 1987).

Loquats generally will keep for 10 days at ordinary temperatures, and for four weeks to 60 days in cool storage (Morton 1987; Lin 2007). After removal from storage, the shelf-life may be only 3 days. Treatment with the fungicide, benomyl, makes it possible to maintain loquats for one month at 15.56°C with a minimum of decay. Other fungicides tried have proved much less effective. Cold storage of loquats in polyethylene bags alters the flavor of the fruit, promotes internal browning and the development of fungi (Morton 1987). Controlled atmosphere (CA, low O_2) did not influence the quality of fruits stored at 25 ± 5°C. Low temperature (3 ± 1°C) prolonged storage life, especially when combined with CA; losses of soluble sugar, TS, titratable acidity and ascorbic acid slowed, enabling fruits to be stored for longer than 40 days. Furthermore, respiration rate, ethylene production, and fruit rots were kept low by low temperature and low O_2 (Lin 2007).

In Turkey, loquat is consumed as an early season fresh fruit. The currently grown cultivars are harvested in April-May. The early varieties are sold with higher prices than mid-season cultivars in both local and global markets. Due to this, most growers use early cultivars, and harvesting of unripe fruits is common among growers. For the fresh market they should not be picked before full maturity; otherwise they are too acid. Fruit should be of proper size and color when they picked. Fruit color development increases and firmness decreases during the last 4 to 5 weeks of development. Loquat fruit should be picked at nearly full to full color development. Tasting a few fruit before harvest will indicate which color fruit are harvestable. Depending upon the variety, peel color when ready to pick may be yellow to orange (**Table 4**). Harvesting is by hand. Cut clusters of fruit from terminal branches and then clip individual fruit from the cluster. Since loquats are harvested early when even the local markets cannot be adequately supplied, there is no problem with fruit storage. However, pre-cooling (hydrocooling) and refrigerated transportation is required when the fruit is shipped to distant locations.

Ripe loquat fruit may be stored in plastic bags in the refrigerator for several weeks. Experiment results which in Turkey showed that, MA packaged loquat fruit could be stored 0°C temperature and 90-92% RH for 60 days without losing much of their quality (Erkan *et al*. 2005); Hafif Cukur Gobek packaged with 12.5 µm or 14 µm thick PVC films could be kept at 0°C until 45 days (Ertürk *et al*. 2005).

Marketing

The international trade in loquat is very low (7.4% of total production). However, Spain accounts for 84% of international trade (Caballero and Fernandez 2003). Although some growers market their own production, most growers are organized in associations. In these associations, individual growers bring their production classified and packed. The product is then reviewed and regarded in the packing house to meet quality standards. Spain exports 36 to 47% of total production. While production is exported to many countries, more than 80% of the export is destined for Italy, Portugal and France (Soler *et al*. 2007).

Whole clusters are not particularly attractive on the market, therefore individual fruits are clipped from the cluster, the stalk is detached from each fruit and the fruits are graded for size and color to provide uniform packs (Morton 1987; Lin *et al*. 1999; Lin 2007).

An exception is that the whole cluster may be displayed in Spain. In India, usually two grades of fruit are considered, although three grades can be made, with the poorest fruits (undersized or misshapen) sold for manufacture of jams, jellies, and other by-products (Randhawa and Singh 1970). In Japan, fruits are separated into three to four grades according to quality and four to five grades by size, and packed in a 300-g or a 500-g bag, 1-kg or 2-kg carton box. Almost all of these procedures are performed manually. As harvesting and packing are highly labor-intensive operations, this limits the area of loquat production for each grower (Fujisaki 1994).

In China, in recent years, loquat fruits are carefully picked, classified into three grades, packed into various types of boxes, and then shipped to market. Almost all of these procedures are performed manually. Thus, harvesting and packing are highly labor-intensive operations. The crop is most1y located in family orchards in high-density plantings. Loquat is a very demanding fruit crop. Loquat fruits are mostly consumed fresh and sold at high prices. Production of high quality fruits, according to market demand, requires large investments of labor. Labor represents 66% of total costs, the highest for horticultural crops in Spain. Most of the labor cost is for thinning and harvesting. In China marketing by individual growers has some importance; however growers are more and more organized into associations. Experience has demonstrated that scattered management by individual household tends to be unsuccessful. Thus, the loquat industry can only be well developed with leadership, such as the “dragon head enterprise” in China. This system has created good developmental opportunities for local farmers and officials (Lin 2007).

In Turkey, fruit is consumed fresh in spring when it ripens early. Small quantities are exported (between 89 and 512 t, i.e. 0.74 and 4.2% of total production) to countries in the Middle East, and Central and Northern Europe. The fruits are sorted, but the process is not adequate. Also, the fruit are carried in too large containers (up to 15-20 kg) (**Fig. 7**), resulting in bruising, especially genotypes with soft flesh. Recently, some farmers could get higher prices by grading the fruits in sizes and selling them in small trays of 1 kg (**Fig. 8**). Currently, fruit is carried in primitive conditions on local vehicles. In some areas, the growers market the fruit themselves daily. Therefore, because of the undesirable transportation and marketing of a small amount of the fruit, loquats are sold at lower prices then they could be. Due to this, growers should be organized into associations for better income.

Fig. 7 The loquat fruits are carried in large containers (up to 15-20 kg).

Fig. 8 Some producers can get higher prices by grading the fruits in sizes and selling them in small trays of 1 kg.

FUTURE PROSPECTS

Loquat fruits appear in the Turkish market in early spring and are sold at high prices since there are not many other fruit species in the market at that time. As production increases due to high yielding cultivars and more intense plantings, production costs can be reduced to increase domestic consumption and the chance of exportation. Introduction and adaptation studies along with breeding are underway to obtain high yielding cultivars with large and high-quality fruits, resistant to diseases mainly to scab, and adapted to handling and transportation. These efforts could solve problems in loquat production. The main remaining factor limiting production is climate since minimum temperature and the risk of frost is a hazard.

Protected cultivation can increase earliness by 15-20 days, and with early cultivars, earliness can be extended to 30 days. A high-density cultivation system can be utilized in the near future and it may increase yield per area three-to-four–fold (Polat *et al*. 2002). Nurseries should initiate grafting loquat onto quince rootstock. Further work should be conducted to use dwarf rootstocks such as BA-29 and also research should be continued to determine the mutual effect of high-density and protected cultivation using dwarf rootstock.

CONCLUSIONS

Loquat is an important fruit that can be marketed for a high price if required care is taken from the selection of the cultivar to handling of the fruit (harvest, sorting, packing and transportation). Loquat production is currently restricted to a few regions in Turkey, but the Mediterranean region has great potential for loquat growing, especially for the early season. To realize this potential, growers should be educated on modernization of their production techniques by training courses.

As a result, Turkish loquat germplasm is open for international researcher and co-operation. Collaborative research should be implemented for collection and protection of loquat germplasm, determining the effects of loquat consumption on human nutrition and on human health.

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