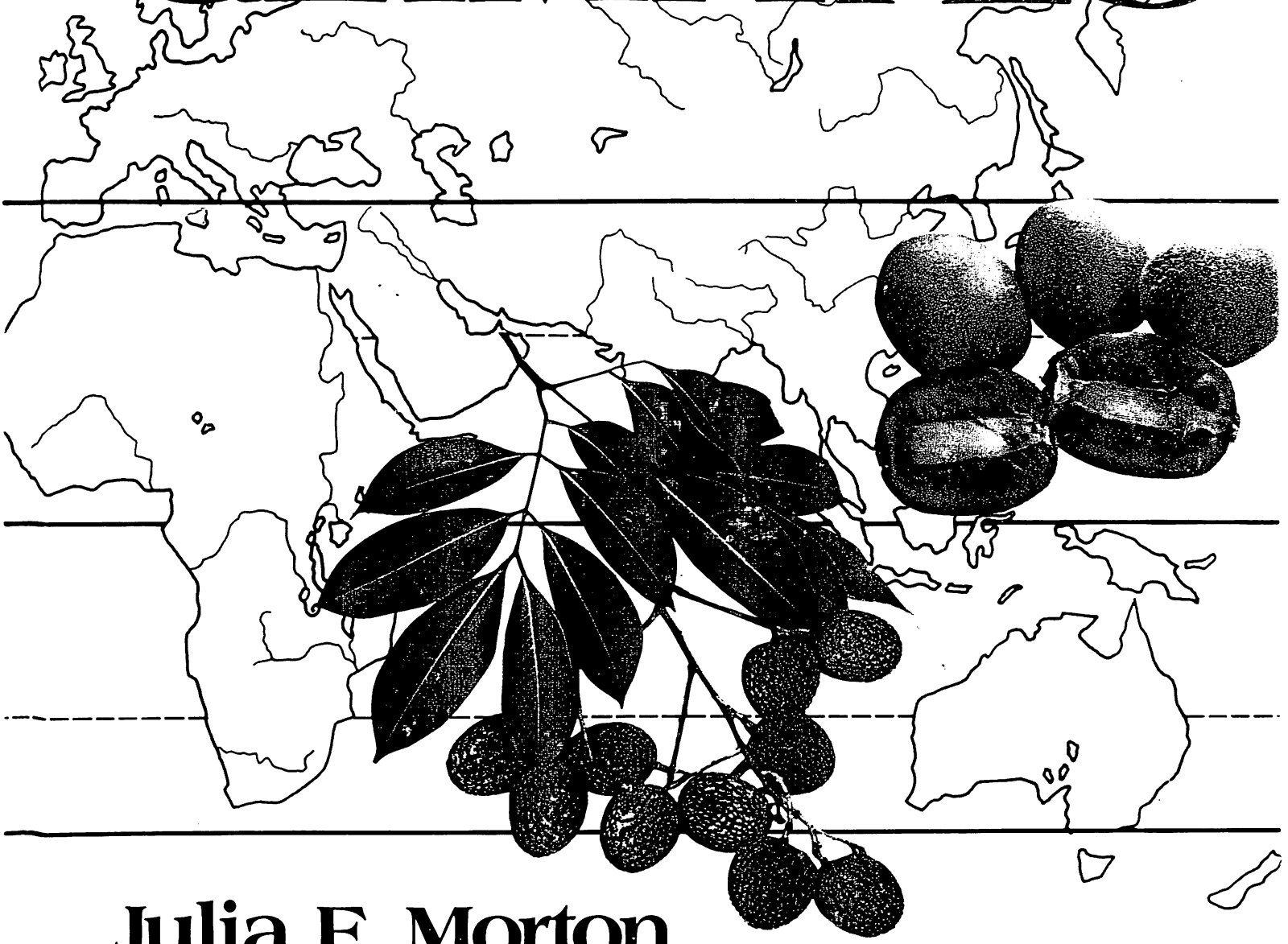
FRUITS OF WARM CLIMATES



Julia F. Morton

Lemon (Plate XX)

The leading acid citrus fruit, because of its very appealing color, odor and flavor, the lemon, *Citrus limon* Burm. f. (syns. *C. limonium* Risso, *C. limonia* Osbeck, *C. medica* var. *limonium* Brandis), is known in Italy as *limone;* in most Spanish-speaking areas as *limón, limón agria, limón real,* or *limón francés;* in German as *limonen;* in French as *citrónnier;* in Dutch as *citroen.* In Haiti, it is *limon France;* in Puerto Rico, *limon amarillo.* In the

Netherlands Antilles, *lamoentsji,* or *lamunchi,* are locally applied to the lime, not to the lemon as strangers suppose. The lemon is not grown there.

Several lemon-like fruits are domestically or commercially regarded as lemons wherever they are grown and, accordingly, must be discussed under this heading. These include: Rough lemon (*C. jambhiri* Lush.), Sweet lemon (*C. limetta* Risso), 'Meyer' (lemon X mandarin hybrid); 'Perrine' (lime X lemon hybrid); 'Ponderosa' (presumed lemon X citron hybrid), qq.v. under "Varieties".

Description

The true lemon tree reaches 10 to 20 ft (3-6 m) in height and usually has sharp thorns on the twigs. The alternate leaves, reddish when young, become dark-green above, light-green below; are oblong, elliptic or long-ovate, 2½ to 4½ in (6.25-11.25 cm) long, finely toothed, with slender wings on the petioles. The mildly fragrant flowers may be solitary or there may be 2 or more clustered in the leaf axils. Buds are reddish; the opened flowers have 4 or 5 petals ¾ in (2 cm) long, white on the upper surface (inside), purplish beneath (outside), and 20-40 more or less united stamens with yellow anthers. The fruit is oval with a nipple-like protuberance at the apex; 2¾ to 4¾ in (7-12 cm) long; the peel is usually light-yellow though some lemons are variegated with longitudinal stripes of green and yellow or white; it is aromatic, dotted with oil glands; ¼ to ⅜ in (6-10 mm) thick; pulp is pale-yellow, in 8 to 10 segments, juicy, acid. Some fruits are seedless, most have a few seeds, elliptic or ovate, pointed, smooth, ⅜ in (9.5 mm) long, white inside.

Origin and Distribution

The true home of the lemon is unknown, though some have linked it to northwestern India. It is supposed to have been introduced into southern Italy in 200 A.D. and to have been cultivated in Iraq and Egypt by 700 A.D. It reached Sicily before 1000 and China between 760 and 1297 A.D. Arabs distributed it widely in the Mediterranean region between 1000 and 1150 A.D. It was prized for its medicinal virtues in the palace of the Sultan of Egypt and Syria in the period 1174-1193 A.D. Christopher Columbus carried lemon seeds to Hispaniola in 1493. The Spaniards may have included lemons among the fruits they introduced to St. Augustine. They were grown in California in the years 1751-1768. Lemons were reported to be increasingly planted in northeastern Florida in 1839. Because of heavy imports from Sicily, commercial culture in Florida and California was begun soon after 1870 and grew to the point where 140,000 boxes were being shipped out of Florida alone. The small Florida industry was set back by a freeze in 1886, the susceptibility of the lemon to scab, and the unfavorable climate for curing the fruit, and also competition from California. Following the devastating freeze of 1894-95, commercial lemon culture was abandoned in Florida. Not until 1953 was interest in lemon-growing revived in Central Florida to take advantage of the demand for frozen concentrate and for natural cold-press lemon oil. At that time, Florida was importing lemons from Italy for processing. Plantings grew to 8,700 acres by 1975. Freezes caused 50% reduction by 1980. Still, in 1984, Florida exported $2 million worth of lemons.

In the meantime, Arizona had developed lemon orchards, though on a smaller scale than California. In the 1956-57 season, California produced 11 million gallons (42 million liters) of frozen lemon concentrate while Florida's output was still very small. California and Arizona became the leading sources of lemons in the western hemisphere. In recent years, California has produced nearly double the crop that can be profitably marketed fresh or processed. Foreign competition has increased and many California growers have destroyed their lemon groves or topworked the trees to oranges, but new cultural techniques making summer production possible may reverse the trend.

Guatemala has in the past 2 decades developed commercial lemon culture, primarily to produce the peel oil for its essential oil industry and secondarily for the purpose of dehydrating the fruit and preparing a powder for reconstituting into juice. Southern Mexico, too, is now a major grower of lemons, also primarily for lemon peel oil. Lemons are rarely grown for the fresh fruit market in Latin America. In South America, Argentina leads in lemon culture with Chile a distant second. Among the world's leading lemon growers and exporters are Italy, Spain, Greece, Turkey, Cyprus, Lebanon, South Africa and Australia. Lemons can be grown only at medium and high elevations in the Philippines.

Varieties

With the resumption of lemon-growing in Florida, workers at the Citrus Experiment Station, Lake Alfred, began a search for the most suitable cultivars, whether in dooryards, or in the United States Department of Agriculture planting at Orlovista, or the Lake Alfred collection. By late 1950, 200 selections had been brought together from various parts of the United States. Of these, 40 were budded onto 30-year-old grapefruit trees on rough lemon rootstock on the Minute Maid property at Avon Park. Two selections grown elsewhere were included in the studies—evaluation for thorniness, cold- and disease-susceptibility, sizes, juiciness, flavor, number of segments and seeds, yields, and quality of peel oil. The majority of the selections were judged undesirable; only a few showed promise for processing and fresh fruit marketing purposes. For processing, 'Villafranca' rated highest, followed by 'Eustis', 'Bearss', 'Perkin' and 'Avon'. Any of these, properly harvested and cured would be suitable for marketing fresh. Libby, McNeil & Libby, when planning for their lemon orchard at Babson Park, Florida, about 1948, tested varieties from all major lemon-producing areas of the world and chose 'Bearss' as rating highest in quality and quantity of juice, which was their chief concern at the time. In 1960, they added marketing of the fresh fruit and found the 'Bearss' equally desirable for this purpose.

The following are brief descriptions of most of the better known cultivars of true lemons and of lemon-like fruits that are accepted as lemons in home or commercial usage, and a few of the lesser-known.

'Armstrong' ('Armstrong Seedless')—a sport discovered in a private grove at Riverside, California, about 1909. Patented in 1936 by Armstrong Nurseries. Resembles 'Eureka' except that it usually bears seedless or near-seedless fruits. If planted among other lemon trees will occasionally have a few seeds.

'Avon'—first noticed as a budded tree in Arcadia, Florida. A budded tree propagated from the original specimen around 1934 was planted in the Alpine Grove in Avon Park; it produced heavy crops of fruits highly suitable for frozen concentrate. It, therefore, became the source of budwood for commercial propagation by Ward's Nursery beginning in 1940.

'Bearss' ('Sicily', but not the original introduction by Gen. Sanford in 1875, which has disappeared)—a seedling believed to have been planted in 1892, discovered in the Bearss grove near Lutz, Florida, about 1952. Closely resembles 'Lisbon'. It is highly susceptible to scab and greasy spot and oil spotting. The tree is vigorous and tends to produce too many water sprouts. Nevertheless, it has been propagated commercially by Libby, McNeill & Libby since 1953 because the peel is rich in oil. It constitutes 20% of Brazil's lemon/lime crop.

'Berna' ('Bernia', 'Verna', 'Vernia')—oval to broad-elliptic, with pronounced nipple, short neck; peel somewhat rough, medium-thick, becoming thinner in summer, tightly clinging. Seeds generally few or absent. Ripens mostly in winter; fruits keep well on tree until summer but become too large. Tree is vigorous, large, prolific. This is the leading cultivar of Spain and important in Algeria and Morocco. It is too much like the 'Lisbon' to be of value in California. In Florida, it has been found deficient in acid, low in juice, and too subject to scab.

'Eureka'—originated from seed taken from an Italian lemon (probably the 'Lunario') and planted in Los Angeles in 1858; selected in 1877 and budwood propagated by Thomas Garey who named it 'Garey's Eureka'. The fruit is elliptic to oblong or rarely obovate, with moderately protruding nipple at apex, a low collar at the base; peel yellow, longitudinally ridged, slightly rough because of sunken oil glands, medium-thick, tightly clinging; pulp greenish-yellow, in about 10 segments, fine-grained, tender, juicy, very acid. Fruits often borne in large terminal clusters unprotected by the foliage. Bears all year but mostly late winter, spring and early summer when the demand for lemons is high. Tree of medium size, almost thornless, early-bearing, prolific; not especially vigorous, cold-sensitive, not insect-resistant; relatively short-lived. Not suitable for Florida. Grown commercially in Israel. One of the 2 leading cultivars of California, though now being superseded by clonal selections with more vigor, e.g., 'Allen', 'Cascade', 'Cook', and 'Ross'. 'Lambert Eureka' is a chance seedling found in 1940 on the property of Horace Lambert in New South Wales. It is vigorous and productive.

'Femminello Ovale'—one of the oldest Italian varieties; short-elliptic with low, blunt nipple; slightly necked or rounded at base; of medium size; peel yellow, finely pitted, medium-smooth, medium-thick, tightly clinging; pulp in about 10 segments, tender, juicy, very acid, of excellent quality, with few, mostly undeveloped, seeds. Fruits all year but mainly in late winter and spring; ships and stores well. The tree is almost thornless, medium- to very-vigorous, but highly susceptible to *mal secco* disease. This is the leading cultivar in Italy, accounting for ¾ of the total lemon production, and ⅕ of the crop is processed as single-strength juice.

'Genoa'—introduced into California from Genoa, Italy, in 1875. Almost identical to 'Eureka'; ovoid or ovate-oblong with blunt nipple at apex; base rounded or slightly narrowed; of medium size; peel yellow, medium-thick, tightly clinging; pulp in 10-12 segments, melting, medium-juicy, with 29 to 51 seeds which are light-brown within. Tree is shrubby, nearly trunkless, spreading, very thorny, cold-hardy. Grown commercially in India, Chile and Argentina.

'Harvey'—of unknown parentage; was found by Harvey Smith on the property of George James in Clearwater, Florida. Fruit much like 'Eureka'. Tree highly cold-tolerant, compatible with several rootstocks. Commercially propagated by Glen St. Mary Nurseries Company, near Jacksonville, Florida, since 1943.

'Interdonato' ('Special')—a lemon X citron hybrid that originated on property of a Colonel Interdonato, Sicily, around 1875; oblong, cylindrical, with conical, pointed nipple at apex, short neck or collar at base; large; peel yellow, smooth, glossy, thin, tightly clinging; pulp greenish-yellow, in 8 or 9 segments, crisp, juicy, very acid, faintly bitter. Very few seeds. Earliest in season; mostly fall and early winter. Tree vigorous, usually thornless, medium-resistant to *mal secco*; of medium yield; accounts for 5% of Italy's crop.

'Lisbon' (perhaps the same as 'Portugal' in Morocco and Algeria)—originated in Portugal, possibly as a selection of 'Gallego'; reached Australia in 1824; first catalogued in Massachusetts in 1843; introduced into California about 1849 and catalogued there in 1853; introduced into California from Australia in 1874 and again in 1875. Fruit almost identical to 'Eureka'; elliptical to oblong, prominently nippled at apex, base faintly necked; peel yellow, barely rough, faintly pitted, sometimes slightly ribbed, medium-thick, tightly clinging; pulp pale greenish-yellow, in about 10 segments, fine-grained, tender, juicy, very acid, with few or no seeds. Main crop in February, second crop in May. Fruit is borne inside the canopy, sheltered from extremes of heat and cold. Tree large, vigorous, thorny, prolific, resistant to cold, heat, wind. Not well adapted to Florida. It is low-yielding and short-lived in India. Surpasses 'Eureka' in California. Has given rise to a number of clonal selections, particularly 'Frost', originated by H.B. Frost at the Citrus Research Station, Riverside, California in 1917 and released about 1950; also 'Prior Lisbon' and the more vigorous 'Monroe Lisbon'.

'Meyer'—a hybrid, possibly lemon X mandarin orange; introduced into the United States as S.P.I. #23028, by the agricultural explorer, Frank N. Meyer, who found it growing as an ornamental pot-plant near Peking, China, in 1908; obovate, elliptical or oblong, round at the base, occasionally faintly necked and furrowed or lobed; apex rounded or with short nipple; of medium size, 2¼ to 3 in (5.7-7.5 cm) wide and 2½ to 3½ in (6.25-9 cm) high; peel light-orange with numerous small oil glands, ⅛ to ¼ in (3-6 mm) thick; pulp pale orange-yellow, usually in 10 segments with tender walls, melting, juicy, moderately acid with medium lemon flavor; seeds small, 8 to 12. Tends to be everbearing but fruits mostly from December to April. Tree small, with few thorns, prolific, cold-resistant; produces few water sprouts, and is only moderately subject to greasy spot and oil spotting. It is easily and commonly grown from cuttings. Does well on sweet orange and rough lemon rootstocks; is not grafted onto sour orange because it is a carrier of a virulent strain of tristeza. Grown for home use in California; in Florida, both for home use and to some extent commercially for concentrate though the product must be enhanced by the addition of peel oil from true lemons, since that from 'Meyer' peel is deficient in flavoring properties. Has been fairly exten-

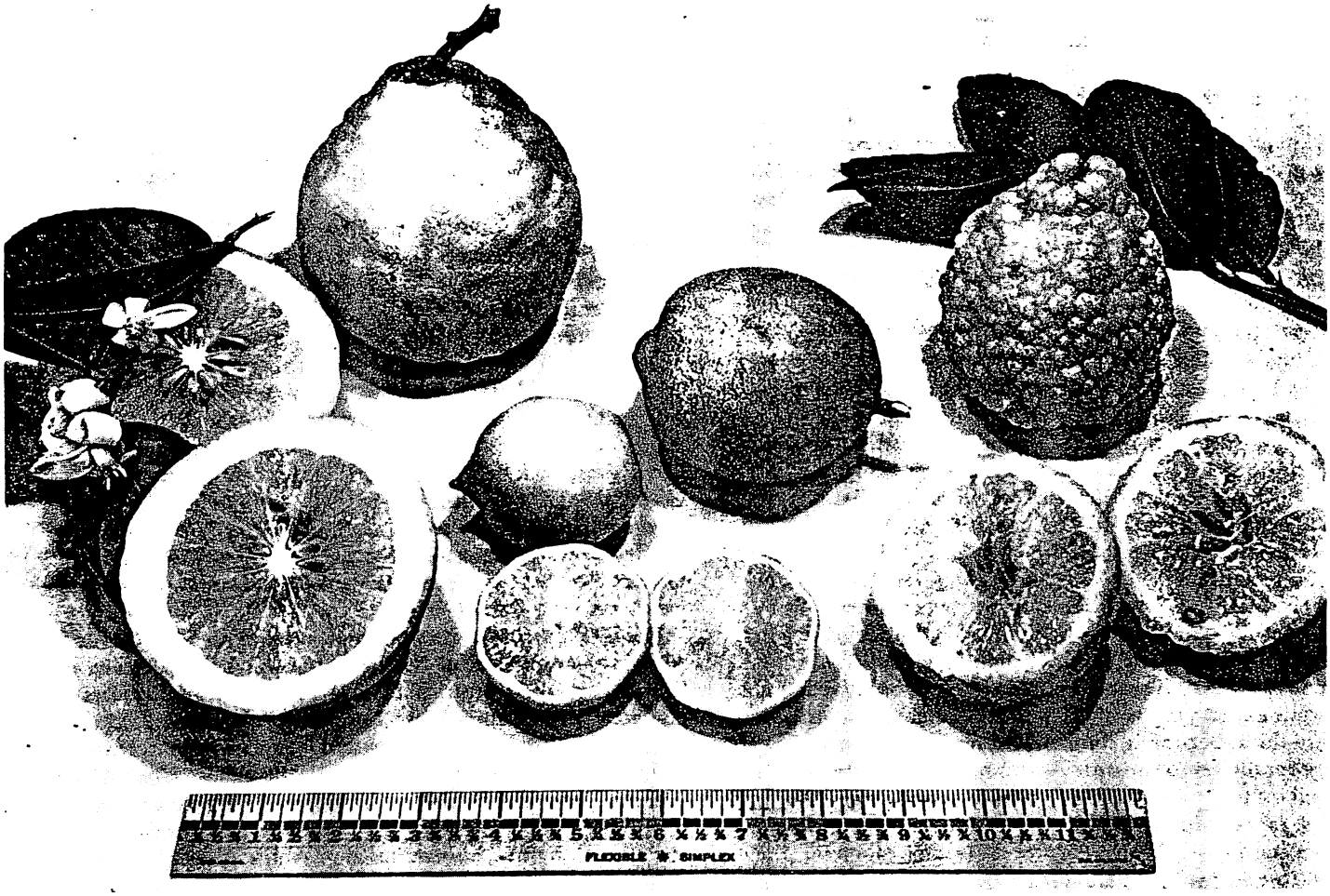


Fig. 41: Lemons: 'Ponderosa', perhaps a lemon X citron hybrid (left); 'Lisbon'-type commercial lemons (*Citrus limon*) (center); and rough lemon (*C. jambhiri*) (right).

sively planted in Texas and in Queensland, Australia, and New Zealand.

'Monachello' ('Moscatello')—suspected of being a lemon X citron hybrid; elliptical, with small nipple and no neck, merely tapered at apex and base; medium-small; peel yellow, smooth except for large, sunken oil glands, thin, clinging very tightly; pulp in 10 segments, tender, not very juicy, not sharply acid. Bears all year but mainly winter and spring. Tree not vigorous, slow-growing, almost thornless, with abundant, large leaves; bears medium-well, resistant to *mal secco*, and has been extensively planted in Italy in areas where the disease is common.

'Nepali Oblong' ('Assam', 'Pat Nebu')—originated in Assam; fruit resembles citron in some aspects; long-elliptic to oblong-obovate, with wide, short nipple; medium-large; peel greenish-yellow, smooth, glossy, medium-thick; pulp greenish-yellow in 11 segments, fine-grained, very juicy, of medium acidity, with few or no seeds. Everbearing. Tree large, vigorous, spreading, medium-thorny, prolific; foliage resembles that of the citron. Commercial in India.

'Nepali Round'—of Indian origin; round, without distinct nipple; juicy; seedless. Tree large, vigorous, compact, nearly thornless, medium-prolific. Successfully cultivated in South India.

'Perrine'—a Mexican lime X 'Genoa' lemon hybrid created by Dr. Walter Swingle and colleagues in 1909, but still a fairly typical lemon; it is lemon-shaped, with small nipple at apex, necked at base; of medium size; peel pale lemon-yellow, smooth, slightly ridged, thin, tough; pulp pale greenish-yellow, in 10 to 12 segments having thin walls; tender, very juicy, with slightly lime-like flavor but acidity more like lemon; seeds usually 4 to 6, occasionally as many as 12, long-pointed. Everbearing. Tree cold-sensitive but less so than the lime; resistant to wither tip and scab but prone to gummosis and other bark diseases. In the early 1930's, was extensively planted in southern Florida on rough lemon rootstock, but no longer grown.

'Ponderosa' ('Wonder'; 'American Wonder')—a chance seedling, possibly of lemon/citron parentage, grown by George Bowman, Hagerstown, Maryland around 1886 or 1887; appeared in nursery catalogs in 1900 and 1902; obovate, lumpy and faintly ribbed, slightly necked at base; large, 3½ to 4⅛ in (9-11 cm) wide, 3½ to 4¾ in (9-12 cm) high; peel light orange-yellow, with medium-large oil glands, flush or slightly depressed; ⅜ to ½ in (1-1.25 cm) thick; pulp pale-green, in 10 to 13 segments with thick walls; juicy, acid; seeds of medium size, 30 to 40 or more, brown within. Everbearing. Tree small, moderately thorny; buds and flowers white or barely tinged with red-purple. More sensitive to cold than true lemons. Grown for home use and as a curiosity in California and Florida and in small-scale commercial plantings since 1948. Rather widely cultivated as an indoor potted plant in temperate regions.

'Rosenberger'—a clone found in a grove of 'Lisbon' and 'Villafranca' trees at Upland, California; was planted in the

Rosenberger orchard and gained recognition as a superior cultivar. Tree closely resembles that of 'Villafranca'. Fruit is somewhat like 'Lisbon' but is shorter and broader and less tapered at base. Tree vigorous and prolific. Became popular in California in the 1960's.

'Rough Lemon' ('Florida Rough'; 'French'; 'Mazoe'; 'Jamberi')—perhaps a lemon X citron hybrid, but has been given the botanical name of *C. jambhiri* Lush. Believed to have originated in northern India, where it grows wild; carried in 1498 or later by Portuguese explorers to southeastern Africa where it became naturalized along the Mazoe River; soon taken to Europe, and brought by Spaniards to the New World; is naturalized in the West Indies and Florida; oblate, rounded or oval, base flat to distinctly necked, apex rounded with a more or less sunken nipple; of medium size, averaging 2¾ in.(7 cm) wide, 2½ (6.25 cm) high; peel lemon-yellow to orange-yellow, rough and irregular, with large oil glands, often ribbed; 3/16 to 3/8 in (5-10 mm) thick; pulp lemon-yellow, usually in 10 segments, medium-juicy, medium-acid, with moderate lemon odor and flavor; seeds small, 10 to 15, brownish within. Reproduces true from seeds, which are 96% to 100% nucellar. Tree large, very thorny; new growth slightly tinged with red; buds and flowers with red-purple. The scant pulp and juice limit the rough lemon to home use. It is appreciated as a dooryard fruit tree in Hawaii and in other tropical and subtropical areas where better lemons are not available. The tree has been of great importance as a rootstock for the sweet orange, mandarin orange and grapefruit. It is not now used as a rootstock for lemon in Florida because of its susceptibility to "blight" (young tree decline). It is also prone to Alternaria leaf spot (*Alternaria citri*) in the nursery, to foot rot (*Phytophthora parasitica*). Incidence varies with the clone and certain clones show significant resistance. In trials at Lake Alfred, 3 atypical clones showed immunity to leaf spot, while a typical rough lemon clone, 'Nelspruit 15', from South African seed, proved highly resistant to leaf spot and also extremely cold tolerant.

'Santa Teresa'—an old tree discovered to be disease-free in a 'Femminello Ovale' orchard in Italy that had been devastated by *mal secco*. Budded trees from the original specimen were being commonly planted in the 1960's wherever the disease was prevalent in Italy.

Sweet Lemon (*C. limetta* Risso)—a general name for certain non-acid lemons or limettas, favored in the Mediterranean region. In India, they are grown in the Nilgiris, Malabar and other areas. The fruits are usually insipid, occasionally subacid or acid. The seeds are white within and the tree is large, resembling that of the orange. One cultivar, called 'Dorshapo' after the plant explorers, Dorsett, Shamel and Popenoe, who introduced it from Brazil in 1914, resembles the 'Eureka' in most respects except for the lack of acidity. Another, called 'Millsweet', apparently was introduced into California from Mexico and planted in a mission garden. It was reproduced at the old University of California Experiment Station at Pomona. Neither is of any commercial value.

'Villafranca'—believed to have originated in Sicily; introduced into Sanford, Florida, from Europe around 1875 and later into California. Closely resembles 'Eureka'; of medium size. Tree is more vigorous, larger, more densely foliaged, and more thorny than 'Eureka' but becomes thornless with age. One strain is everbearing; another fruits heavily in summer. This was the leading lemon cultivar in Florida for many years; is cultivated commercially in Israel; is low-yielding and short-lived in India. It is little grown in California but has given rise to certain selections that are of importance, particularly 'Galligan Lisbon' and 'Corona Foothill Eureka'.

Climate

Because of its more or less continuous state of growth, the lemon is more sensitive to cold than the orange and less able to recover from cold injury. The tree is defoliated at 22° to 24°F (-5.56°--4.44°C). A temperature drop to 20°F (-6.67°C) will severely damage the wood unless there has been a fortnight of near-freezing weather to slow down growth. Flowers and young fruits are killed by 29°F (-1.67°C) and nearly mature fruits are badly damaged below 28°F (-2.22°C). On the other hand, the lemon attains best quality in coastal areas with summers too cool for proper ripening of oranges and grapefruit. Therefore, the lemon has a relatively limited climatic range. In Florida, lemons are produced commercially as far north as Ft. Pierce on the East Coast and Ruskin on the West Coast. The 'Meyer' lemon, as a dooryard tree, can be grown wherever oranges thrive, even as far west as Pensacola.

The fruits are scarred and the tree readily defoliated by winds, and benefit by the protection of windbreaks.

Lemons are grown in both dry and humid atmospheres, the latter being a disadvantage mainly in the processes of curing and storing. Over a large lemon-growing region in California, annual rainfall varies from 25 to 125 cm. In long, dry periods, the lemon must be irrigated.

Soil

The lemon tree has the reputation of tolerating very infertile, very poor soil. In Florida, groves are mostly on sand. In California, excellent growth is maintained on silty clay loam of high water-holding capacity. In Guatemala, recommended soils are sand, clay and sandy-clay—deep, with high permeability and good drainage. Black soils are also suitable if not lying over calcareous subsoil. Ph should be between 5.5 and 6.5. If acidity is high, it is necessary to apply lime to achieve the optimum level.

Propagation

The rough lemon is widely grown from seed. The 'Meyer' lemon is easily reproduced by rooting large cuttings in the nursery and planting them directly in the grove. They fruit 2 to 3 years sooner than budded trees and have a long life, remaining in full production for over 30 years, perhaps much longer.

In Florida, commercial lemons have been budded onto 'rough lemon', sweet orange, and 'Cleopatra' mandarin rootstocks. More recent practices are the utilization of sour orange, Volkamer lemon (*C. volkameriana*), and alemow (*C. macrophylla* Wester, an old Philippine lemon/pummelo hybrid). The latter is employed in California on soils containing an excess of soluble salts and boron. If citranges are used as rootstocks for 'Eureka', bud union crease will kill the tree.

Culture

Lemon trees should be spaced 25 ft (7.6 m) apart each way. If crowded or "hedged", production declines. The trees must be pruned when young and kept below 10 or 12 ft (3-3.6 m) in height. They are cut back severely after 12 years or replaced. Weeds must be controlled but lemon

Fig. 42: Flowers of the lemon (*Citrus limon*) are larger and showier than those of the orange.

trees are very sensitive to herbicides.

In Florida, fertilizing may be done 3 times a year between mid-November and the end of April, at the gradually increasing rate of 4 to 10 lbs (1.8-4.5 kg) per tree up to an age of 50 years. Nitrogen and potash are given in equal amounts under normal soil conditions. A nutritional spray with copper added is applied after spring bloom. Fertilizer and irrigation programs should be varied according to the desired goal: fresh fruit marketing or processing. High nitrogen steps up yield and peel oil content but also results in more scab infection and poor curing. Potash increases acidity. Heavy irrigation increases yield and peel oil, scab infection, size of fruit and accelerates maturity.

In California, foliar spraying of urea is preferred over ground application of nitrogen which can lead to accumulations of salts and also contamination of groundwater. Leaf analyses are made to determine the nitrogen requirements of each cultivar for maximum yield. 'Eureka', in a 6-year test, showed no response to increased levels of nitrogen. In New Zealand, mature trees (15 to 20 years old) are given 25 to 30 lbs (11.3-13.6 kg) of complete mixed fertilizer annually, also heavy dressings of organic manure or mulch.

In Sicily, growers have, for over 50 years, made a practice of withholding water in summer — for 35 to 60 days — until the trees begin to wilt. Then the trees are heavily irrigated and given high nitrogen fertilizer which induces a second bloom in August or early September, producing a crop the following summer when lemons are scarce and prices are high. This system, called the "Verdelli process", was adopted on a little over 1,000 acres (405 ha) in California in 1983. Adequate bloom did not occur on sandy or shallow soils, but 80% of the plantings on gradually dehydrating, fine-textured soil bloomed well. Nearly $3 million was expected from this extra crop of summer lemons in the Central Valley and the Riverside area in 1984. New horticultural techniques are needed to overcome the handicaps of higher use of fertilizer, increased insect and fungus problems, effects of moisture stress on fruit quality, and low temperature hazard to immature fruits in winter.

In 1965, a team of California horticulturists initiated experimental trellis culture of 'Prior Lisbon' lemon on *C. macrophylla* rootstock. It was found that the labor of training, and repeated pruning either manually or by machine hedging and topping, was excessive and uneconomic.

Guatemalan and Mexican growers interplant short-term crops such as beans, cassava, yautia (*Xanthosoma*), in the rainy season, and tomatoes and peppers during the winter when the lemon trees will be irrigated and fertilized.

Harvesting and Handling

The marketability of lemons depends on the stage at which they are picked. Italian lemons for export are harvested as early as possible and are naturally "cured" in transit. In early days, California and Florida lemons were allowed to remain on the trees until they became too large. It was realized that early picking is necessary and California and Arizona adopted the practices of picking at any time after the fruits reach a 25% juice content, and using rings to gauge the commercially acceptable size, and repeated spot-picking with clippers. Mechanical picking is impossible with lemons. The fruits are highly prone to oil spotting (oleocellosis) and cannot be handled roughly nor picked wet.

Formerly, Florida lemons were picked from mid-July to October for shipping fresh, and the balance in November was harvested for processing. Lemons under 2⅛ in (5.4 cm) are too immature to attain proper quality for marketing and fruits over 2½ in (6.25 cm) are too large. Manual spot-picking has been commonly practiced, but some producers have found it too costly, and are harvesting the entire crop at one time and grading for fresh sale or processing in the packing-house, discarding all undersized fruits. The lemons, after sorting according to color, washing and coating with a fungicide and a thin layer of wax are stored (cured) until ready for shipping.

Yield

Lemon tree yields vary considerably with the cultivar, the location and weather conditions. A yield of 3 boxes per tree is commercially satisfactory in Florida. In India, a 6-year-old tree bore 966 fruits and, at 9 years of age, had produced a total of 3,173 fruits.

Storage

Florida's climate is unfavorable for long-term curing. It has been claimed that a 10-day curing period is adequate and degreening of Florida fruit is not needed. A major producer keeps the newly harvested fruits for 48 hours at 60°F (15.56°C) and 95% humidity, then passes them through a pre-grading procedure to eliminate all that are unusable. The usable fruits are then treated with fungicide against stem-end rot and returned to the curing room. Those harvested early in the season need 3 weeks to color-up, the last may require less than a week. Finally, the fruits are washed, given a second fungicidal treatment, dried, waxed and packed.

Generally, lemons are cured at 56° to 58°F (13.33°-14.4°C) and 85-90% relative humidity. Green fruits may be held for 4 months or more, while the peel becomes yellow and thinner, the pulp juicier (6-80%) and the proportion of soluble solids higher (7-24%). Sometimes the degreening process is hastened by exposing the fruit to ethylene gas, ethephon, or silane, but this practice tends to stimulate decay, mainly through the shedding of the "button" (stem stub), the absence of which allows entry of *Diplodia natalensis, Phomopsis citri,* or *Alternaria* mycelium. Various auxins have been studied to determine which can be applied before storage to prevent button loss without delaying degreening. In 1982, Israeli investigators reported that decay losses from degreening procedures can be greatly reduced (from over 50% to 6.3%) by packaging the fruits in 10 micrometer-thick high-density polyethylene. This treatment makes it possible to store lemons with minimum damage for as long as 6 months.

In the past, New Zealand lemons for storage have been individually wrapped in diphenyl-treated paper after washing and dipping in a 200 ppm solution of 2,4,5-T and then waxing. The fruits were marketable after storing for 4 months at room temperature. Lemons can be kept for weeks in the home refrigerator if placed in a jar with a tight-fitting lid to prevent loss of moisture.

Lemons for export from Florida to Hawaii and Arizona must be fumigated with methyl bromide because of possible infestation by the Caribbean fruit fly. For sale within the state, other methods must be employed.

Pests and Diseases

In Southeast Asia, many species of ants attack the root system and the farmer times the opening of the water gates so as to force the ants to the surface of the beds, where he burns them with fire.

One of the 3 most serious arthropod pests of the lemon and other citrus trees in California is California red scale, *Aonidiella aurantii*. In the southern part of the state it is under biological control but it requires applications of pesticides in the San Joaquin Valley. In Florida, rust mites, purple mites and purple scale may at times be troublesome but they are all controllable with appropriate sprays.

Young lemon trees in California sometimes require protection from wild rabbits.

Diseases are the greater challenges. In Florida, the main lemon diseases are scab (*Elsinoe fawcetti*) on fruit, leaves and twigs; anthracnose of fruit (stylar-end-rot), leaves and twigs caused by both *Colletotrichum gloeosporioides* and *Glomerella cingulata;* greasy spot (*Mycosphaerella citri* or *Cercospora citri-grisea*); and gummosis (*Diaporthe citri*). The latter organism also causes melanose and dieback, and stem-end rot. Stem-end rot may also arise from attack by *Botryosphaeria ribis* and *Diplodia natalensis.*

Other lemon diseases recorded in Florida are branch knot (*Sphaeropsis tumefaciens*), damping-off (*Rhizoctonia solani*), leaf spot (*Mycosphaerella horii, Alternaria citri,* and *Catenularia* sp.; algal leaf spot or green scurf (*Cephaleuros virescens*); tar spot (*Cercospora gigantea*); felt fungus (*Septobasidium pseudopedicellatum*); charcoal root rot (*Macrophomia phaseolina*); root rot (*Fusarium oxysporum, Pythium ultimum,* and *Phytophthora parasitica;* heart-rot and wood rot (*Fomes applanatus* and *Ganoderma sessilis*); crinkly leaf and exocortis viruses; and green mold (*Penicillium digitatum*); blue mold (*P. italicum*); and pink mold (*P. roseum*). In 1955, the lemon budwood certification program was begun to provide virus-free stock for growers.

Red algae infests lemon trees and causes much dieback unless controlled with copper fungicide in the summer. Zinc deficiency causes stunting of twigs, reduced flowering, premature dropping of fruit, and yellow bands along the leaf veins. Manganese deficiency is evidenced by interveinal chlorosis and subsequent necrosis, shedding of leaves, flowers and young fruit. In India, fruit cracking occurs when dry periods are followed by heavy rains. Cracking can be largely avoided by frequent light irrigation during the dry period and early picking.

Stored lemons are subject to the stem-end rots and the molds listed above. The albedo may show small dark sunken areas even though this defect is not visible externally. Cultivars differ in their ability to resist decay.

Food Uses

Slices of lemon are served as a garnish on fish or meat or with iced or hot tea, to be squeezed for the flavorful juice. In Colombia, lemon soup is made by adding slices of lemon to dry bread roll that has been sautéed in shortening until soft and then sieved. Sugar and a cup of wine are added and the mixture brought to a boil, and then served.

Lemon juice, fresh, canned, concentrated and frozen, or dehydrated and powdered, is primarily used for lemonade, in carbonated beverages, or other drinks. It is also used for making pies and tarts, as a flavoring for cakes, cookies, cake icings, puddings, sherbet, confectionery, preserves and pharmaceutical products. A few drops of lemon juice, added to cream before whipping, gives stability to the whipped cream.

Lemon peel can be candied at home and is preserved in brine and supplied to manufacturers of confectionery and baked goods. It is the source of lemon oil, pectin and citric acid. Lemon oil, often with terpenes and sesquiterpenes removed, is added to frozen or otherwise processed lemon juice to enrich the flavor. It is much employed as a flavoring for hard candies.

Food Value Per 100 g of Edible Portion*

	Fruit (fresh, peeled)	*Juice (fresh)*	*Juice (canned, unsweetened)*	*Juice (frozen, unsweetened)*	*Lemonade (concentrate, frozen)*	*Peel (raw)***
Calories	27	25	23	22	195	
Moisture	90.1 g	91.0 g	91.6 g	92.0 g	48.5 g	81.6 g
Protein	1.1 g	0.5 g	0.4 g	0.4 g	0.2 g	1.5 g
Fat	0.3 g	0.2 g	0.1 g	0.2 g	0.1 g	0.3 g
Carbohydrates	8.2 g	8.0 g	7.6 g	7.2 g	51.1 g	16.0 g
Fiber	0.4 g	trace	trace	trace	0.1 g	-
Ash	0.3 g	0.3 g	0.3 g	0.2 g	0.1 g	0.6 g
Calcium	26 mg	7 mg	7 mg	7 mg	4 mg	134 mg
Phosphorus	16 mg	10 mg	10 mg	9 mg	6 mg	12 mg
Iron	0.6 mg	0.2 mg	0.2 mg	0.3 mg	0.2 mg	0.8 mg
Sodium	2 mg	1 mg	1 mg	1 mg	0.2 mg	6 mg
Potassium	138 mg	141 mg	141 mg	141 mg	70 mg	160 mg
Vitamin A	20 I.U.	20 I.U.	20 I.U.	20 I.U.	20 I.U.	50 I.U.
Thiamine	0.04 mg	0.03 mg	0.03 mg	0.03 mg	0.02 mg	0.06 mg
Riboflavin	0.02 mg	0.01 mg	0.01 mg	0.01 mg	0.03 mg	0.08 mg
Niacin	0.1 mg	0.1 mg	0.1 mg	0.1 mg	0.3 mg	0.4 mg
Ascorbic Acid	53 mg	46 mg	42 mg	44 mg	30 mg	129 mg

*Analyses of true lemons, as marketed.

***Lemon Peel Oil* consists mainly of terpenes, particularly limonene, also gamma terpinene and beta-phellandrene. There are small amounts of sesquiterpenes and aldehydes. Among the aliphatic aldehydes are n-octyl aldehyde, n-nonyl aldehyde, and citral.

Toxicity

The thorns of the lemon tree inflict painful punctures and scratches. Lemon peel oil may cause contact dermatitis, chronic in those who handle, cut and squeeze lemons daily. Parts of the body touched by contaminated hands may show severe reactions after exposure to the sun. People that suck lemons may suffer irritation and eruptions around the mouth. The wood of lemon trees and its sawdust may induce skin reactions in sensitive woodworkers.

Other Uses

Lemon juice is valued in the home as a stain remover, and a slice of lemon dipped in salt can be used to clean copper-bottomed cooking pots. Lemon juice has been used for bleaching freckles and is incorporated into some facial cleansing creams.

Lemon peel oil is much used in furniture polishes, detergents, soaps and shampoos. It is important in perfume blending and especially in colognes.

Petitgrain oil (up to 50% citral), is distilled from the leaves, twigs and immature fruits of the lemon tree in West Africa, North Africa and Italy. With terpenes removed, it is greatly prized in colognes and floral perfumes.

Lemon peel, dehydrated, is marketed as cattlefeed.

Lemonade, when applied to potted plants, has been found to keep their flowers fresh longer than normal. But it cannot be used on chrysanthemums without turning their leaves brown.

Wood: The wood is fine-grained, compact, and easy to work. In Mexico, it is carved into chessmen, toys, small spoons, and other articles.

Medicinal Uses: Lemon juice is widely known as a diuretic, antiscorbutic, astringent, and febrifuge. In Italy, the sweetened juice is given to relieve gingivitis, stomatitis, and inflammation of the tongue. Lemon juice in hot water has been widely advocated as a daily laxative and preventive of the common cold, but daily doses have been found to erode the enamel of the teeth. Prolonged use will reduce the teeth to the level of the gums. Lemon juice and honey, or lemon juice with salt or ginger, is taken when needed as a cold remedy. It was the juice of the Mediterranean sweet lemon, not the lime, that was carried aboard British sailing ships of the 18th Century to prevent scurvy, though the sailors became known as "limeys".

Oil expressed from lemon seeds is employed medicinally. The root decoction is taken as a treatment for fever in Cuba; for gonorrhea in West Africa. An infusion of the bark or of the peel of the fruit is given to relieve colic.