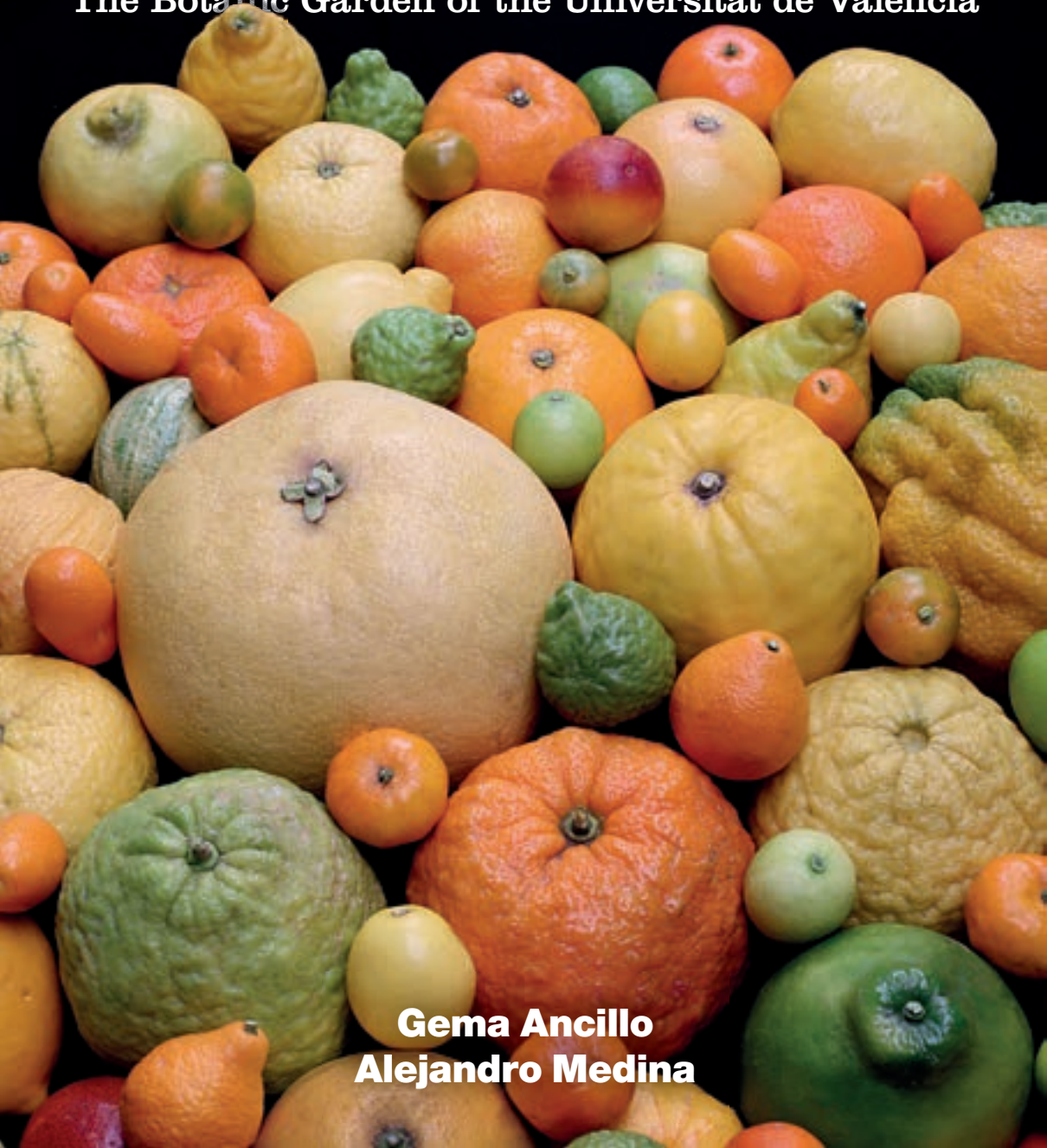


Botanical monographs

CITRUS

The Botanic Garden of the Universitat de València



Gema Ancillo
Alejandro Medina

Botanical Monographs
CITRUS

Gema Ancillo and Alejandro Medina

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Introduction

Botanic gardens have traditionally been involved in the acclimation of plants. It was here that they brought species collected in remote places to experiment with them before introducing them to local farmers as new crops or plants with a variety of uses such as medicinal and industrial application or for making dyes.

Since its foundation, the Jardín Botánico de la Universitat de València (Botanical Garden of the University of Valencia, referred to as the Jardín Botánico hereon) has played an important role in this respect, which reached a peak in the second half of the nineteenth century. José Pizcueta, the director of the Botanic Garden between 1829 and 1867, conducted an in-depth study of plant breeding in collaboration with the Spanish Royal Society known as Real Sociedad Económica de Amigos del País, of which he was chairman. He made land available at the Jardín Botánico to test and develop agricultural practices, which were subsequently expanded by the director José Arévalo Baca.

The region known as Comunidad Valenciana (Valencia, Alicante and Castellón) is recognized worldwide for its great citrus-growing tradition. In the late eighteenth century, Cavanilles assessed the extent of orange cultivation as 400 *tahúllas*, equivalent to about 50 hectares. This surface area was considered remarkable at the time but pales compared to the 170,000 hectares devoted to citrus growing nowadays. This rise in production was a result of increased consumption of fresh citrus fruits from the eighteenth century onward.

The Jardín Botánico has a collection comprising nearly 50 species of citrus, which range from the most well known and commonly grown such as oranges, mandarins, lemons and grapefruit, to others used as rootstock or used widely in perfumery, such as bergamot, or some with important religious significance, such as citron. The collection also holds others that are not cultivated for commercial purposes, illustrating the huge variety of citrus species.

The collection is divided into two parts. One is located in the Plaza de Carlos Pau showing the great diversity mentioned above, and another next to the *huerta* (vegetable plot), demonstrating the origin of the most well known and commonly



grown citrus according to the present state of knowledge. Both plots are the result of collaboration between the Jardín Botánico and the Instituto Valenciano de Investigaciones Agrarias (Valencian Institute for Agricultural Research, referred to as IVIA hereon) which started more than twenty years ago and continues with the preparation of this monographic work.

This citrus collection, which dates from the restoration of the garden beginning in 1987, also includes a citrus specimen opposite the Caseta del Romero. This specimen is notable for several reasons, first of all because it is located in an area devoted to succulents, where it is out of context. But even more striking is that it has two types of fruits and, above all, the large size of the tree, which experts say is an indisputable indicator that it is around 100 years old or more. This is a noteworthy characteristic because it is probably the oldest specimen in the Comunidad Valenciana, and thus in Spain as a whole. As for the fruit,



some branches bear bitter orange (*C. aurantium*) while others (although similar to grapefruit) bear pummelo also known as shaddock (*Citrus maxima*), one of the species giving rise to grapefruit (*C. x paradisi*) when crossed with orange. The fact it bears two types of fruit is a result of grafting, which is a common agricultural practice. Although we lack specific data on the experiments carried out on citrus in the Garden, both the age of the specimen and the fact that pummelo is grafted on sour orange rootstock would indicate that our Jardín Botánico, home to the School of Agriculture at that time, experimented with citrus. It has yet to be revealed whether or not these practices were exported to agriculture on a wider scale and to what extent they have influenced the development of citriculture in Valencia.

The publication of this second volume in the Botanical Monograph series provides the opportunity to thank the efforts made by this institution and the various people who have made it possible: Luis Navarro, Gema Ancillo, Alejandro Medina and José Antonio Pina. The graphics represent an important part of this monograph and we would like to thank José Plumed, Gema Ancillo, Alejandro Medina and José Juárez for the wonderful photographs illustrating the texts. The graphic design has been carried out by MÉTODE journal's specialised team, whose professional commitment is reflected in the excellent quality of their work. Text edition is an inconspicuous part of the preparation of a book but is essential for the clarity and correctness of any publication; our thanks to José Manuel Alcañiz for performing this task.

Our thanks once again to all the gardeners, curators and directors who have conserved and improved the collections of this garden, whose professional devotion is reflected by the survival of our one-hundred-year-old citrus tree.

Isabel Mateu

Director of the Jardín Botánico de la Universitat de València



The subfamily *Aurantioideae*

In 1737, Linnaeus grouped all the citrus species he knew within the *Citrus* genus. The Latin term *citrus* comes from the Greek word *kedros*, used to describe trees such as cedar, pine and cypress. The term was used because the smell of citron leaves and fruits are reminiscent of cedar. This distinctive scent comes from essential oils contained in oil glands located under the skin, characteristic of these plants.

General description

The aerial part of the citrus trees is formed by the trunk and main branches, with further branching. Leaves, flowers and fruits are located on these secondary branches. Many varieties have branches bearing thorns, which may be of considerable size, and vary depending on the age of the specimen. Trees can reach a height of between 3 and 15 meters. In cultivated citrus, the lower part of the trunk corresponds to the rootstock on which the variety is grafted.

Tree growth habit differs depending on the angle between the main branches and the trunk. Some varieties can be distinguished by their erect growth habit



On the left, orange grove in Valencia. On the right, plot with different citrus varieties at different stages of development.



On the left, *Clementina fina* tree from the collection held at the IVIA Citrus Germplasm Bank. On the right, longitudinal section of a tree trunk at the point of union between the graft and rootstock.

(such as Ellendale or Salustiana), or by their spreading growth habit (such as Navel or Navelina) or by their drooping growth habit (such as Clemenules or Fortune).

In citrus, growth flushes depend on weather conditions. Rainfall determines tree growth and development in the Tropics, while seasonal changes and temperature do so in subtropical conditions. In the climatic conditions of Valencia, with the exception of lemon trees, citrus are dormant in winter and flush in spring, summer and early autumn. The spring is the most important season, as it is then that blossoms develop, which will give rise to fruit production. In summer and autumn there are only vegetative shoots, which are longer, fewer in number and bear larger leaves.

Trunk

Citrus plants have a single brownish stem with variable branching. Young trunks are green and tender and have a ridge that extends below the base of each petiole, thus the cross-section is initially triangular but later becomes circular as the trunk grows thicker. Therefore, one can distinguish two types of growth: in length and in thickness.

The stem bears leaves, both apical and axillary buds, thorns, flowers and fruits.

The leaf blades are arranged spirally around the stem, and the direction of the spiral switches with each individual growth flush. The phyllotaxy of most species is $3/8$, as well as some related genera such as *Fortunella* and *Poncirus*. In pummelos and grapefruits, phyllotaxis is $2/5$.

Axillary buds sprout at the leaf-stem junction (axil), whereas apical buds sprout at the end of the stem. Normally a main bud and several accessory buds are formed but only the largest one sprouts and develops; only if this one withers do the others develop. A thorn also usually grows in the axil, although there are thornless species. The size of the thorn may vary according to species, vigour of the sprouting and above all on the age of the plant.

Root

The root is the underground part of the plant and has great vertical and horizontal distribution. In general, the roots are deep, depending on the species and soil characteristics, but most of the root mass is close to the surface.

The root system is composed of the main taproot, which grows downward and directly serves to anchor the plant, and lateral or secondary roots. Secondary roots branch outward and bear root hairs, which are responsible for the absorption of water and nutrients.

There are two types of secondary roots: thin and fibrous, which form a dense mass known as a “beard”, and other long and sturdy ones. The bearded ones form bundles measuring 20 to 30 cm in length, from the main root in the case of young plants or lateral roots in adult plants.



From left to right: *Carrizo citrange* trunk; axillary shoots on a navel orange tree; example of phyllotaxis in citrus; thorns on *Poncirus*.



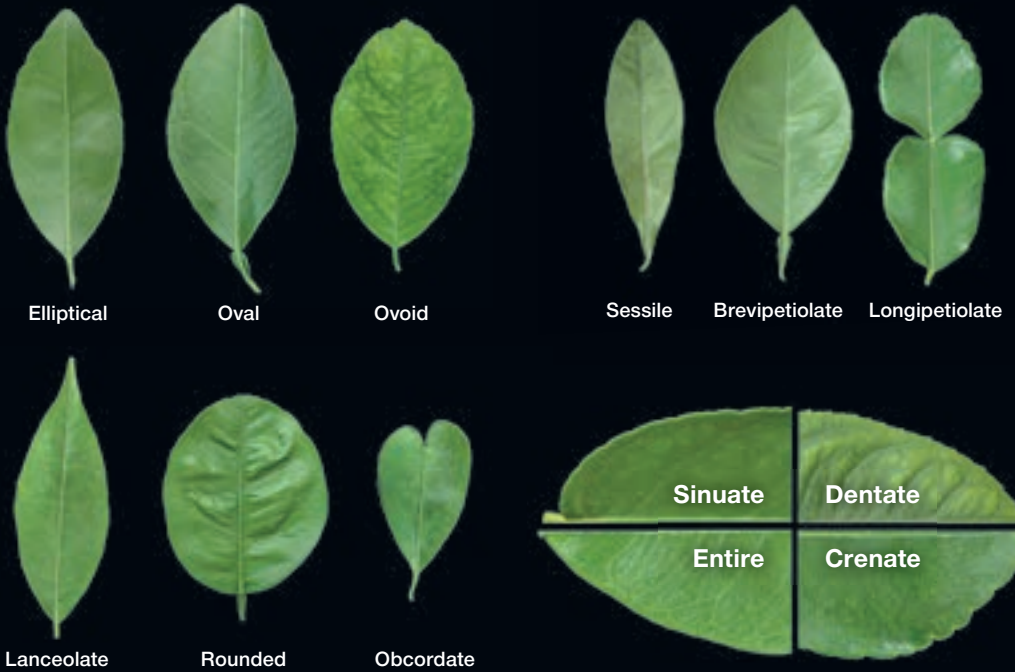
Uprooting a clementine tree.

As in the aerial part, root growth is not continuous but alternating with aerial shoots arising, although growth in adult trees may be almost continuous.

It is very common that under normal growing conditions, citrus roots harbour mycorrhizal fungi, forming effective symbiotic partnerships.

Leaf

Citrus trees are evergreen, except *Poncirus trifoliata* which is deciduous. However, the leaves have a fixed term and are renewed over time. The half-life of productive leaves is about fifteen months, while those located on vigorous vertical shoots may last up to four years. The period of greatest leaf fall is spring, mainly after flowering. The leaves separate from the stalk at abscission zones, which are located at the junctions both of the petiole and stem, and at the base of the leaf blade (also known as the limbus).



Citrus leaf shape, margin and petiole development.

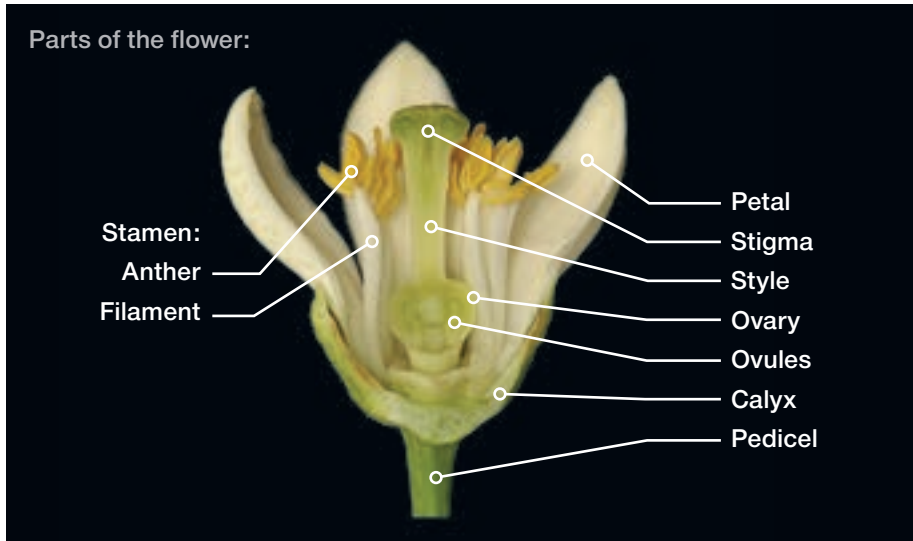
The leaf is compound, imparipinnate, though it appears to be simple, because in most cases only the terminal leaflet is retained. Proof of this can be seen in the joint between the leaf blade and petiole, although in some species the latter may be absent. The petiole may be shorter than the leaf blade, in which case the leaf is called *brevipetiolata*, or may be longer than the blade, in which case it is called *longipetiolata*. In many species, the petioles are winged. The wings can be very prominent, as in the case of the pummelo, grapefruit and sour orange, or may be barely visible as in satsumas.

The leaf blade is dark green on top (adaxial) and light green on the underside (abaxial). The young leaves are a lighter green than adult leaves, – except in lemons and citrons, which are purplish – and only darken when shoot growth ceases.

The shape varies from oblong to oval and there is great variation in size from one species to another. Venation is reticulate. The midrib is prominent and becomes more diffuse as it approaches the apex. The adaxial side of the leaves hold oil glands near the surface.



Citrus flower diversity.



The leaf blade margin varies depending on the species, and may be entire, serrate or dentate, sinuate or crenate.

Flower

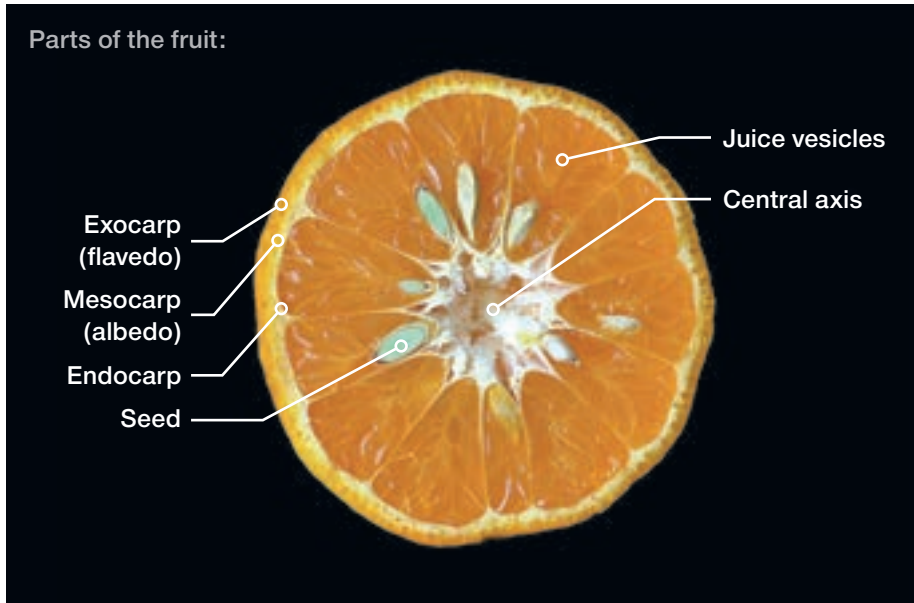
The flowers, known as orange blossom, or *azahar* in Spanish, emit a pleasant fragrance because the sepals and petals have oil glands beneath the lower skin (abaxial epidermis). They are white in most cases, but can also be purple, as in the case of lemon and citron. They are usually hermaphroditic and vary in size. The largest are found in the sour orange and grapefruit, while the smallest are in mandarins and limes. They may be isolated or grow in clusters to form a corymbus or cyme. The flowers are attached to the stem by a small peduncle measuring about 1 cm in length, which gives rise to the receptacle at the top.

Citrus flowers are formed by:

a) A dense green calyx, consisting of five fused sepals, whose free portion forms five small projections. Together with the disc and part of the peduncle, it is attached to the fruit, forming a nipple-like projection.

b) The corolla has five somewhat overlapping white or pinkish petals, curving inwards. These petals are thick and long, and they have a leathery appearance due to the waxy cutin covering their surface.

c) The stamens (20-40), white filaments, are joined to the base of the corolla forming a circle within it, and whose anthers, white or yellow, have four loculi.



The floral disc appears just above the point where the stamens join the flower, between the stamens and carpels, and is called the nectar disc or nectary because it secretes aqueous nectar until the petals fall.

d) The pistil consists of an ovary formed by 10 carpels, style and stigma. The ovary is supported on the nectar disc and is generally ellipsoidal. The style is cylindrical in shape and smaller in diameter than the stigma, which is located at its end and is shaped like a somewhat oblate sphere.

Fruit

The citrus fruit is a specialized berry called a hesperidium, divided into multiple sections or segments, each enclosed by a membrane. It arises from growth of the ovary and is characterized by having about ten fleshy carpelar units (segments) connected around a central axis, where the seeds are arranged radially in the centre of the fruit.

Fruit size and colour vary among species and variety, as does the shape, which may be oval, pear-shaped or spherical (oblate or not).

The fleshy part or endocarp consists of juice sacs or vesicles, usually thin and filamentous structures which contain mostly sugars, organic acids and water, constituents of juice. Vesicles are composed of a thick body and a filamentous

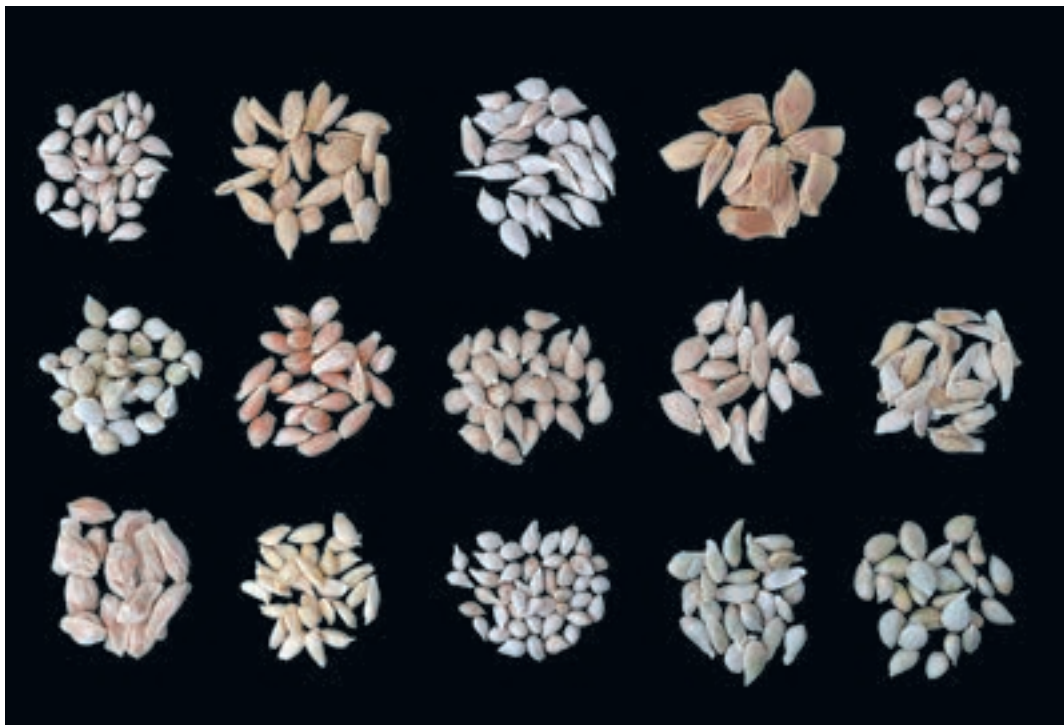


Citrus fruit diversity.

stem that attaches the vesicle to the wall segment, and which is longer or shorter depending on vesicle position.

The pericarp or shell, also called rind, comprises the following:

- a) The exocarp or flavedo, which is the outermost part of the fruit, the colour of which depends largely on the temperature at which it develops. It contains essential oil glands produced by the fruits. It is thick and may be more or less smooth or rough.
- b) The endocarp, which is the innermost part of the pericarp and forms part of the locular membrane.
- c) The mesocarp or albedo, which is the intermediate portion, is white and pithy.



Citrus seed diversity.

Seeds

Seeds derive from ovules through various developmental processes. They exhibit a wide variation in size, weight, shape, colour and homogeneity. However, there are common characteristics within species; for example lemon seeds are typically small, rounded and pointed. There is also a variety in the number of seeds per fruit, a factor that may change slightly from year to year depending on pollination and other external factors.

Seeds consist of three main parts with specific functions:

- a) The embryo is composed of a hypocotyl, plumule and radicle; the last two are the rudiments of the stem and root.
- b) The cotyledons are storage organs, used by the seed in cellular differentiation during germination.
- c) The seed coats are composed of an outer shell called the testa, and an inner covering called the tegmen. These provide a defence against possible external attack.



Cross section of a zamboa fruit showing its seeds.

Apomixis is a very common phenomenon in citrus, whereby embryos form without fertilization having taken place, i.e., they form asexually, developing from the nucellus. Therefore, the seeds produce plants containing the same genetic information as the parent plant. In apomictic citrus, sexual and asexual reproduction occur simultaneously, forming seeds with a zygotic embryo (fertilized) and one or more nucellar ones. Zygotic embryo growth is often slower than nucellar embryo, so these seeds do not develop fully and are aborted. Instead the nucellar embryos remain, thus perpetuating the genetic characteristics of the parent plant. In citrus, polyembryony (occurrence of two or more embryos in a seed) almost always occurs apomictically. It is very rare that two or more zygotic embryos are produced in the same seed.

Some citrus varieties, such as satsumas are parthenocarpic, which means they are capable of forming fruit in the absence of pollination. Unfertilized ovules do not develop and shrink to produce seedless fruits.

Citrus seeds become unviable sooner than other types of seed. They can be affected by pre-harvest factors such as prolonged drought, frost or other factors,

and also post-harvest factors such as excessive exposure to heat, sun or drying as well as prolonged storage of the fruit. Therefore, conservation of citrus germplasm is not based on seed storage but mainly on the conservation of whole trees in orchards or in special protected field installations.

Historical Background

There are different hypotheses as to the origin of citrus, as it is a controversial and complex issue. In general, there seems to be agreement that they originated in tropical and subtropical regions of Southeast Asia and the Malay Archipelago and from there spread to other continents.

The citron was the first citrus known in Europe. It was introduced around the year 300 BC and although it is no longer commercially important, it played a key role in plant propagation, being widely used as a source of rootstocks onto which the desired varieties have been grafted. In Spain, the citron was the first citrus to be introduced, dating back to about the seventh century, and second were the sour orange, which was introduced by the Arabs around the tenth or eleventh centuries, and the lemon tree. The first records of pummelo date back to the late eleventh or early twelfth century, while the sweet orange did not arrive until the fifteenth century through the trade routes with the East. The last to arrive were the mandarin, in the nineteenth century, and the grapefruit, in the early twentieth century.

In the early sixteenth century, citrus cultivation, mainly of sweet orange, became more popular. The first plantations were established in the eighteenth century; although they contained only isolated trees, citrus growing became increasingly important. Until the mid-nineteenth century, seeds were used for propagation, and thus the plants took a long time to start producing, four to ten years depending on the variety, and had thorns that damaged fruit and hindered harvesting. For this reason, growers started grafting buds from adult trees. The sour orange was one of the first rootstock used in Spain together with citron. Since the late nineteenth century, however, sour orange became the most commonly used due to its good yield and resistance to gummosis. This disease, caused by the fungus *Phytophthora* sp., appeared in Spain around 1862 and spread rapidly. Its effects were devastating, killing all trees except those grafted on sour orange. Unfortunately, the latter rootstock is sensitive to the citrus tristeza virus. The disease caused by this virus kills trees grafted on sour orange, and in the 1960s Spanish citriculture was seriously endangered, suffering major losses. Consequently, in 1968, drastic legal measures were taken, these included banning the use of sour orange as a rootstock, prohibiting the importation of varieties to avoid the risk of introducing new pests or diseases, the





From left to right: illustrations of citron, bitter orange and zamboa by Pierre Antoine Poiteau (1818).

full and mandatory restructuring of citrus nurseries and then, in the mid-1970s, implementation of a Sanitation Programme, involving citrus Quarantine and Certification to ensure varietal identity and optimal health status of plants grown in Spain. The year 1979 witnessed the first delivery of pathogen-free buds of some varieties to authorized nurseries and the first commercial plantations were started with material developed within this programme. The material was grafted onto tristeza-tolerant rootstock. Initially Cleopatra mandarin (*C. reshni* Hort. Ex Tan) and Troyer citrange (*C. sinensis* (L.) Osb. x *Poncirus trifoliata* (L.) Raf.) were used as they were considered the most suitable. Today, only 4% of the cultivated area still comprises trees on Troyer citrange and 8% on Cleopatra mandarin. Most trees (75%) are now grafted on Carrizo citrange due to its agronomic advantages: it ensures greater productivity and is more resistant to fungi and nematodes, in addition to growing better in calcareous or waterlogged soils.

Systematics

The taxonomy of citrus is very complex and botanists have not reached total agreement on this issue. The problem is that citrus hybridize very easily, even between different genera, spontaneous mutations frequently occur and,

TRIBE	SUBTRIBE	GENUS		
Clauseneae	<i>Micromelinae</i>	<i>Micromelium</i>		
	<i>Clauseneae</i>	<i>Glycosmis</i>		
		<i>Clausena</i>		
		<i>Murraya</i>		
	<i>Merrillinae</i>	<i>Merrillia</i>		
Citreae	<i>Triphasilineae</i>	<i>Wenzelia</i>		
		<i>Monanthocitrus</i>		
		<i>Oxanthera</i>		
		<i>Merope</i>		
		<i>Tripashia</i>		
		<i>Pamburus</i>		
		<i>Luvunga</i>		
		<i>Paramingnya</i>		
		<i>Wenzelia</i>		
		<i>Citrinae</i>	Primitive citrus fruits	<i>Severinia</i>
				<i>Pleiospermium</i>
	<i>Burkillanthus</i>			
	<i>Limnocitrus</i>			
	Fruits closely related to citrus		<i>Hesperethusa</i>	
			<i>Citropsis</i>	
			<i>Atalantia</i>	
			True citrus fruits	<i>Fortunella</i>
	<i>Eremocitrus</i>			
	<i>Poncirus</i>			
	<i>Clymenia</i>			
	<i>Microcitrus</i>			
<i>Balsamocitrinae</i>	<i>Citrus</i>			
	<i>Swinglea</i>			
	<i>Aegle</i>			
	<i>Afraegle</i>			
	<i>Aeglopsis</i>			
	<i>Balsamocitrus</i>			
	<i>Feronia</i>			
<i>Feroniella</i>				

Table 1. Classification of the subfamily *Aurantioideae* (according to Swingle and Reece, 1967).

moreover, because of apomixis, most of these mutations are likely to be passed down. These phenomena have given rise to a huge number of varieties, with varying degrees of commercial interest, which are often very difficult to identify.

Citrus and related genera belong to the order *Geraniales*, suborder *Geraninas* and family *Rutaceae*. The *Rutaceae* family includes many genera and species and six subfamilies, with citrus and related genera belonging to the *Aurantioideae* subfamily (which most authors consider monophyletic).

The *Aurantioideae* subfamily is divided into two tribes: *Clauseneae*, with five genera, and *Citreae*, with 28 genera. The first comprises the most primitive genera (remote citroides) and the second the most recent (citroides and citrus). The subtribe *Citrinae* belongs to the latter tribe, which is again subdivided into three groups: plants with primitive citrus fruit (six genera), plants with citrus-like fruits (two genera) and plants with true citrus fruit, encompassing six genera among which *Citrus* are included.

Due to its complexity, the *Citrus* genus gives rise to widely varied views among botanists. The two most important classification systems are the Swingle system, which considers 16 species within the genus, and Tanaka, which considers 162, but no system of nomenclature is universally accepted as yet. The species of most interest from the agricultural point of view are:

- Key lime or Mexican lime (*C. aurantifolia* (Christm.) Swing)
- Persian lime or Tahiti lime (*C. latifolia* L.)
- Sour orange (*C. aurantium* L.)
- Pummelo (*C. maxima* (L.) Osb.)
- Lemon (*C. limon* (L.) Burn.)
- Grapefruit (*C. paradisi* Macf.)
- Mandarin (*C. reticulata* Blanco)
- Sweet orange (*C. sinensis* (L.) Osb.)
- Clementine (*C. clementina* Hort.)
- Satsuma (*C. unshiu* (Mak.) Marc.)

The common name mandarin refers to a very heterogeneous citrus group and, without doubt, one with the greatest genetic diversity. Therefore, it is a very controversial group and its classification is not yet clear. Swingle, for example, considers mandarins as a single species (*C. reticulata*), while Tanaka establishes as many as 36 species within this group (*C. reticulata*, *C. deliciosa*, *C. tangerina*, *C. restini*, *C. unshiu*, *C. nobilis*, etc). Currently, *C. reticulata* is not grown commercially and what we buy as mandarins on the market are actually hybrids of mandarin crossed with other species.

Origin

Currently, the hypothesis most widely accepted by the scientific community regarding the phylogenetic origin of citrus is that most species of the *Citrus* genus are probably direct or successive hybrids branching from four ancestral species: *C. medica* L. (citron), *C. reticulata* (mandarin), *C. maxima* (Burm.) Merr. (pummelo) and *C. micrantha* Wester (papeda).

As for secondary species, both sour orange and sweet orange originated from hybridizations between pummelo and mandarin. The sour orange would correspond to direct hybridization, while the sweet orange would come from successive hybridizations, in other words, crosses of mandarin with hybrids of mandarin and pummelo. Grapefruit comes from pummelo and sweet orange, while clementines are a cross between mandarin and sweet orange. Finally, lemons are hybrids of sour orange and citron, and limes come from the citron and the papeda (*C. micrantha* Wester).

Ecology

At present, the cultivation of citrus spans most tropical, subtropical and temperate regions located between parallels 44° N and 41° S. They thrive in deep soils that facilitate root development and provide good aeration and circulation, providing a good water status and avoiding excessive humidity.

Climatic conditions are critical. The optimum temperatures for development of citrus are between 25 °C and 30 °C. As previously mentioned, in the tropics citrus trees bloom continuously while in the subtropics, with well-defined seasons, blossoming depends on seasonal changes in temperature. Fruit colour is also closely related to temperature since the change in colour, which is due to the degradation of chlorophyll and subsequent synthesis of carotenes, takes place at temperatures below 13 °C. Thus oranges and mandarins grown at high temperatures stay green in colour. In blood oranges, the deep red colouration of the pulp is due to anthocyanin synthesis, and is inversely related to temperature. By contrast the reddish colour of grapefruit, caused by lycopene, is darker at high temperatures, provided they do not exceed 35 °C. The temperature is also important in determining fruit acidity. The higher the day/night temperature contrast, the lower the concentration of acids.

With respect to atmospheric humidity, citrus thrive within a wide range of values and can grow as well in subtropical desert regions with near zero relative humidity as in tropical regions with relative humidity of up to 70% during the day and saturation at night. With respect to precipitation, the water requirements of citrus, estimated in terms of evapotranspiration-related losses, are equivalent



Damage caused by frost in a Mexican lime tree.

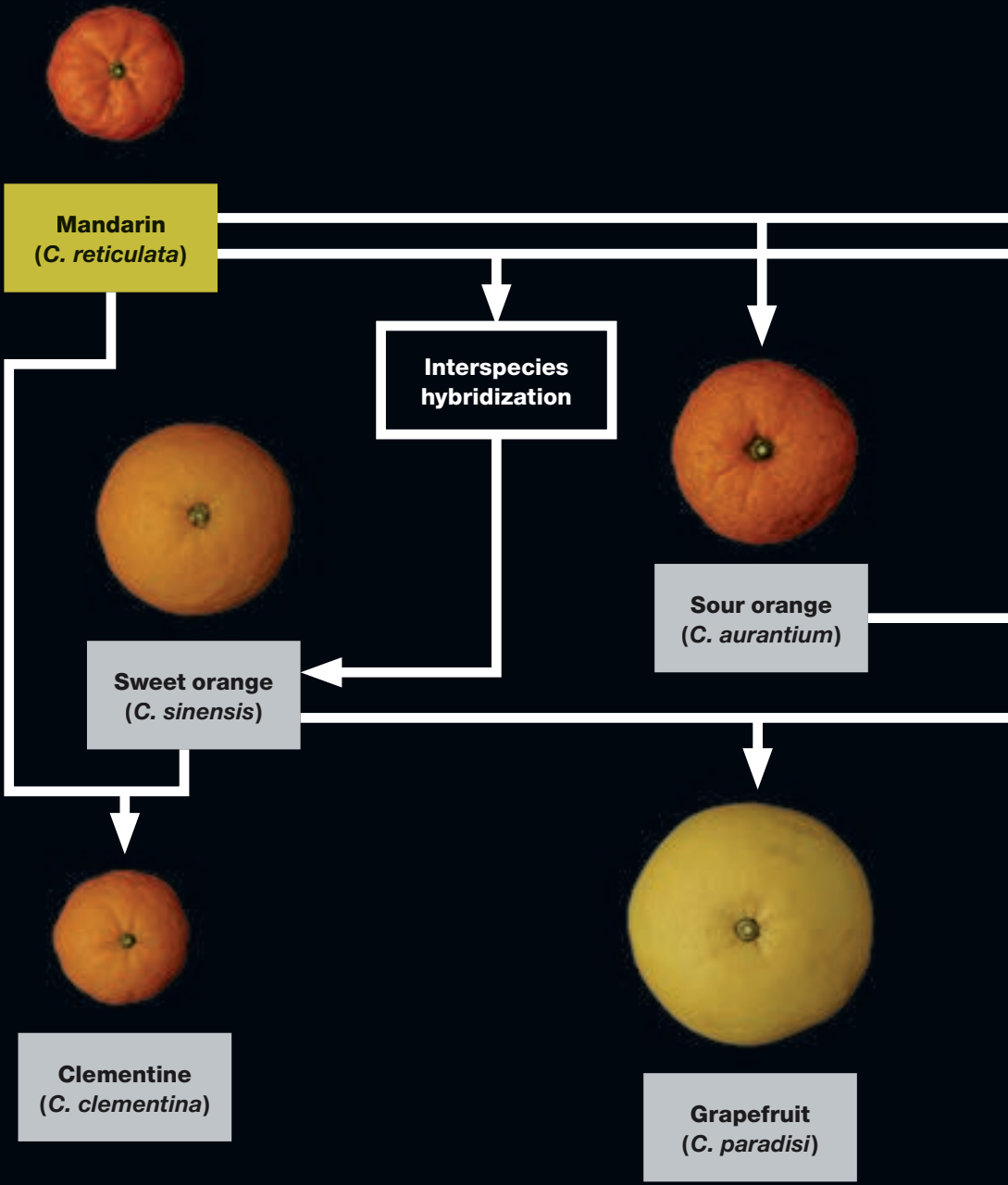
to an annual rainfall of between 750 and 1200 mm, and should preferably be suitably distributed.

Citriculture in Spain

Trade

Citrus is the main fruit crop in the world, ahead of apple, banana or grapes. World production of citrus reached 124 million tonnes in 2010, with the cultivated area exceeding 8.6 million hectares (FAOSTAT data, 2010). Spain, with more than six million tonnes and 306,000 hectares (MAGRAMA data, 2010), is the sixth largest producer, behind China, Brazil, USA, India and Mexico, but is the leading exporter of fresh citrus.

Genetic origin of the main commercial citrus species.





Pummelo
(*C. maxima*)



Citron
(*C. medica*)

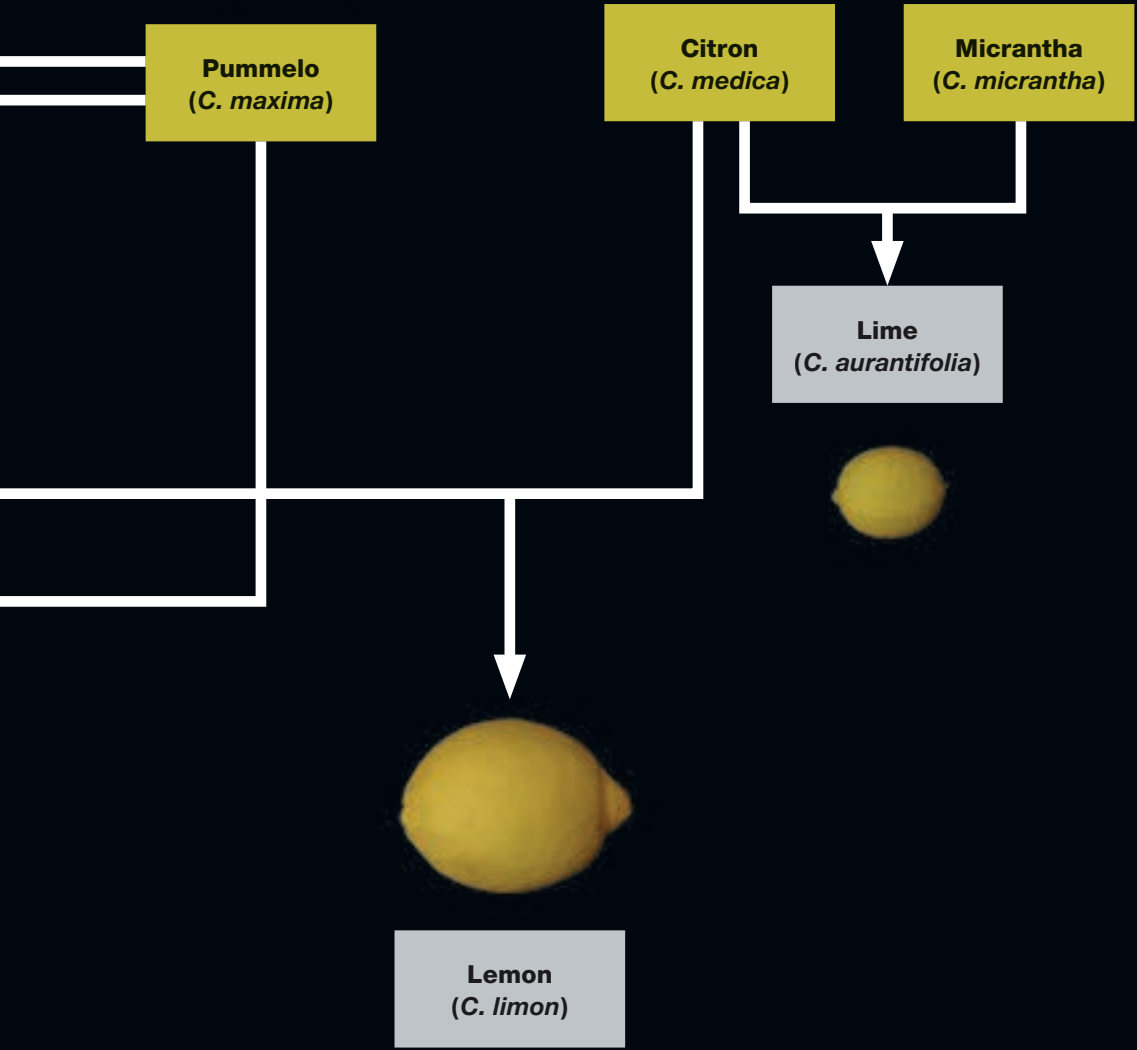


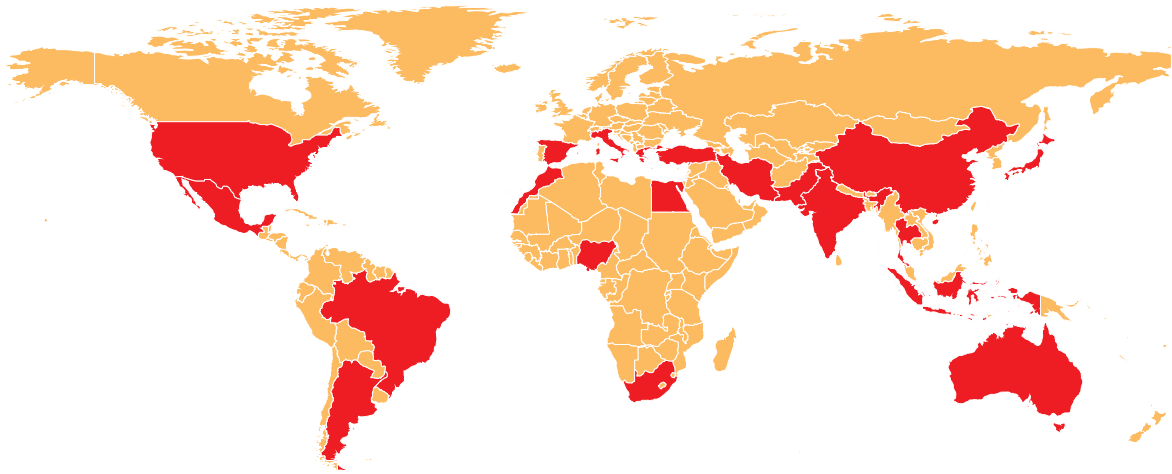
Micrantha
(*C. micrantha*)

Lime
(*C. aurantifolia*)



Lemon
(*C. limon*)





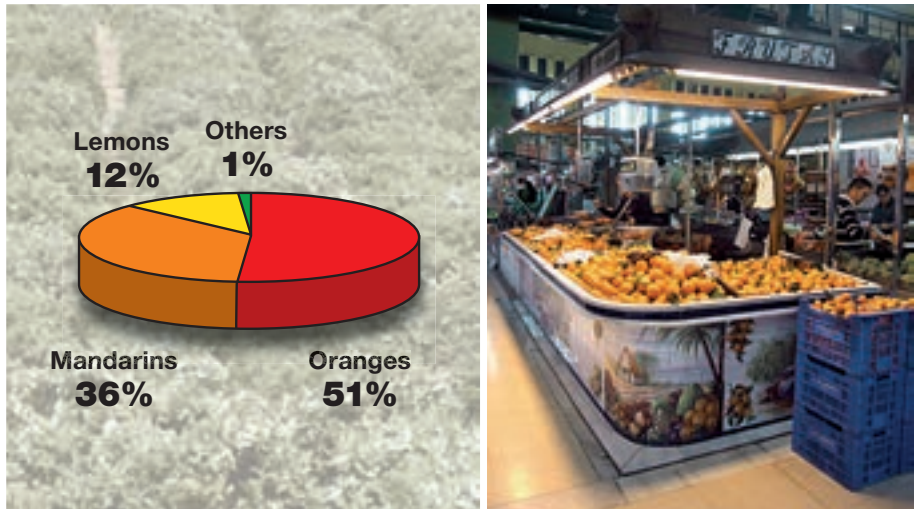
Red shading shows the major citrus-growing countries in the world.

The breakdown of citrus production in Spain is as follows: orange 51%, with Navel being the main type. Mandarins represent 36% of total production, within which clementines would represent 68%. Lemons reach almost 12% while other citrus are grown in small quantities. Regarding regions, Valencia is the largest producer of citrus in Spain, followed by Andalusia and Murcia.

Of the total production, about 50% is exported, 25% is sold on the home market as fresh fruit and the rest is processed by the food industry, primarily as juice. Spain is the leader in world trade of fresh citrus for different reasons. On the one hand, Spanish-grown citrus fruit is of high commercial quality, due not only to the good climatic conditions but also to the productive structure and good level of technology. On the other hand, Spain has such a wide varietal composition it is able to supply the market for 10 months a year, and even the remaining two months can be covered by oranges held in storage. Moreover, Spain is well located given its proximity to major import markets to be found in the European Union. More than 80% of Spanish exports are destined for EU countries. This proximity enables fast and divisible supply according to the needs of each retailer. And finally, the citrus industry in Spain enjoys a modern infrastructure in terms of processing, storage, cold chambers and means of transport.

Cultivation

Not all citrus are grown commercially. Agriculture uses only a select few high-yielding varieties of high quality. The cultivated citrus trees are small and the



On the left, percentages of citrus production in Spain. On the right, a stall selling citrus fruits at Ruzafa market (Valencia).

lower part belongs to a rootstock while the aerial portion corresponds to the grafted variety chosen, which is responsible for producing fruit with commercial value. Rootstocks are an essential part of citrus fruit growing, as they affect the vigour and size of the variety (fruit number and quality) and tolerance or resistance to biotic and abiotic stress.

Irrigation is a key issue in citrus growing. Both vegetative growth and the production of abundant yield and quality depend on the frequency and volume of water supplied to the crop, and on the characteristics of soil and climatic conditions. Irrigation is absolutely essential between spring and fall. Typically, the volume of water to be applied is between 5,000 and 8,000 cubic meters per hectare per year. In Spain, the traditional system was flood irrigation, but localized irrigation started to be implemented by 1980.

Pruning is a common practice in citrus growing. Mechanized pruning is rarely implemented in Spain and so pruning by hand, with saw and clippers is still commonplace.

Fertilization is administered based on an analysis of nutrient availability in the soil and the plant. This allows fertilizer composition to be adapted to the absorption capacity and needs of the tree. Usually fertilizers are kept in tanks in concentrated solutions and then pumped into irrigation water, where they are dissolved and distributed. This system is called fertigation. Furthermore, Plant Physiology research has shown the effect of hormones on the development of



On the left, a graft. On the right, plant protection treatment by spraying.

citrus, extending the use of these substances, which is currently standardized and greatly contributes to increasing the profitability of orchards.

Sanitation, Quarantine and Certification

As we indicated before, the need for programmed sanitation, quarantine and certification became patent in Spain after the outbreak of the disease caused by the tristeza virus, which led to important economic losses in the sector in the 1960s. Thus, 1975 witnessed the implementation of the Citrus Sanitary Improvement Programme, which combined three coordinated programmes: Sanitation, Quarantine and Certification. The programme aimed to ensure the cultivation of healthy plants in Spain by certifying them and maintaining them in a citrus germplasm bank. This programme intended to prevent the serious threat posed by the frequent incidence of devastating citrus diseases. Different public institutions are responsible for each programme, but they all coordinate and work together closely. The Sanitation Programme is run by the Valencian Institute for Agricultural Research (Instituto Valenciano de Investigaciones Agrarias, IVIA); the Quarantine Programme by the Plant Protection Unit of the Spanish Ministry for Agriculture and Marine Affairs (Ministerio de Agricultura y Recursos Marinos,



Fruit harvesting.

MARM); while the Certification Programme is run jointly by the Spanish Office for Plant Varieties (Oficina Española de Variedades Vegetales, OEVV) at MARM and the corresponding departments of the Autonomous Regions.

Sanitation is performed by the technique known as shoot-tip grafting *in vitro*, which involves grafting an apex comprising an apical meristem and three leaf primordia onto the rootstock (in this case Troyer citrange). This micrograft measures some 0.1 or 0.2 mm, so it is done in test tubes under a microscope. Micrografted plants grow in culture chambers for 4-6 weeks and are then transplanted to the greenhouse.

Sanitation is carried out not only on native citrus but also on varieties that are imported from abroad, which have to go through the Quarantine Station. Here official sanitary checks are performed and micrografting is done following the same process as for the autochthonous plants.

The Citrus Germplasm Bank is headquartered at the IVIA, and plants resulting from the Sanitation Programme are also housed there. Trees are protected under insect-proof screen-houses to prevent recontamination, since many diseases are transmitted by insects, and they are monitored periodically to ensure their sanitary status. These plants represent the Certification Programme's *mother trees*, known as the initial block. This is the source of the material supplied



Aerial view of the Valencian Institute for Agricultural Research (IVIA).

to authorized nurseries for them to establish blocks of base trees. Normally these base blocks belong to numerous nurseries that form partnerships. From these blocks, each nursery receives the plant material with which to establish budwood multiplication blocks, and hence they obtain certified nursery trees and subsequently provide them to citrus growers. The certification programme ensures optimum sanitary status and varietal identity of the acquired plants.

Today, citrus is the only crop in Spain where all plants produced by commercial nurseries are certified and have originated in a germplasm bank, ensuring their sanitary pathogen-free status.

The Citrus Germoplasm Bank

Current agriculture is based on a few select high-yielding first-rate varieties, with the consequent abandonment of traditional varieties. This fact, coupled with



Above, different identification labels used throughout history to sell authorized nursery trees (courtesy J.A. Pina).
On the right, authorized nursery trees ready for sale.

the loss of many wild species as a result of deforestation, lead to strong genetic erosion and loss of genetic resources, which are the result of thousands of years of evolution. These genetic resources contain genes or gene combinations related to traits of interest, such as pathogenic resistance or ability to withstand adverse environmental conditions, yield, quality, nutritional compounds in fruits, and so on. Plant genetic resources are the basis for crop improvement programmes and are essential for adaptation to unpredictable environmental changes and future human needs. Therefore, these genetic resources must be conserved to ensure stable agricultural development in the future.

The Citrus Germplasm Bank at the IVIA (BGCI) was set up in 1975 with a dual purpose. On the one hand, to preserve the maximum genetic variability of the *Citrus* genus and of other genera within the *Aurantioideae* subfamily, as this could provide the basis for crop improvement, research and gain of knowledge. On the other hand, as previously mentioned, it aimed to maintain pathogen-free varieties that could serve as source material for commercial propagation in authorized citrus nurseries. This feature, together with the fact that the BGCI does not hold duplicates in the collection, makes it unique in the world.

Currently, the BGCI houses 694 genotypes. These include 51 species of the *Citrus* genus, 44 species of 20 citrus-related genera and 142 intra- and



On the left, plot belonging to the IVIA Citrus Germplasm Bank. On the right, screenhouse holding the collection at the IVIA Citrus Germplasm Bank.

inter-specific hybrids. It contains three collections: a) The field collection, in which the evaluation and characterization of genotypes is performed; b) The screenhouse collection, which is used to maintain healthy material and prevent recontamination and losses due to abiotic stresses; c) The collection of cryopreserved embryogenic calli, with 60 genotypes.

The most numerous varieties are the most commercially important ones, which are sweet oranges (142 varieties), clementines (77 varieties), mandarins and their hybrids (136 varieties) and lemons (47 varieties).



Arrangement of protected plants in the IVIA Citrus Germplasm Bank inside the screenhouse.



Jardín Botánico Citrus Collection Genus Data Sheets

■ Genus *Citrus*

1. *C. aurantium* L.
2. *C. bergamia* Risso et Poit.
3. *C. excelsa* Wester
4. *C. karna* Raf.
5. *C. limon* (L.) Burm. f.
6. *C. macrophylla* Wester
7. *C. madurensis* Lour.
8. *C. maxima* (Burm.) Merr.
9. *C. medica* L.
10. *C. myrtifolia* Raf.
11. *C. paradisi* Macfad.
12. *C. pyriformis* Hassk.
13. *C. shunkokan* Hort. ex Yu. Tanaka
14. *C. sinensis* (L.) Osbeck
15. *C. webberii* Wester

Mandarins

16. *C. clementina* Hort. ex Yu. Tanaka
17. *C. daoixianensis* S.W. He et G.F. Liu
18. *C. depressa* Hayata
19. *C. unshiu* (Mak.) Marc.

Papedas

20. *C. hystrix* DC.
21. *C. macroptera* Montr.
22. *C. micrantha* Wester

Limes

23. *C. aurantifolia* (Christm.) Swingle
24. *C. latifolia* Yu. Tanaka
25. *C. limetta* Risso
26. *C. limettioides* Yu. Tanaka
27. *C. limonia* Osbeck

■ Genus *Fortunella* and hybrids

28. *F. crassifolia* Swingle
29. *F. hindsii* (Champ.) Swingle

- 30. *F. margarita* (Lour.) Swingle
- 31. *F. polyandra* (Ridl.) Yu. Tanaka
- 32. *C. aurantifolia* x *Fortunella japonica*

■ Genus *Poncirus* and hybrids

- 33. *P. trifoliata* (L.) Raf.
- 34. *Citrus sinensis* x *P. trifoliata*

■ Genus *Clausena*

- 35. *C. anisata* (Willd.) Hook. f.
- 36. *C. excavata* Burm. f.
- 37. *C. lansium* (Lour.) Skeels

■ Genera *Microcitrus*, *Eremocitrus* and híbridos

- 38. *M. warburgiana* (F.M. Bail.) Yu. Tanaka
- 39. *E. glauca* (Lindl.) Swingle
- 40. *M. australis* x *M. australasica*

■ Genus *Atalantia*

- 41. *A. ceylanica* (Arn.) Oliv.
- 42. *A. citroides* Pierre ex Guill.

■ Genera comprising the Bael group

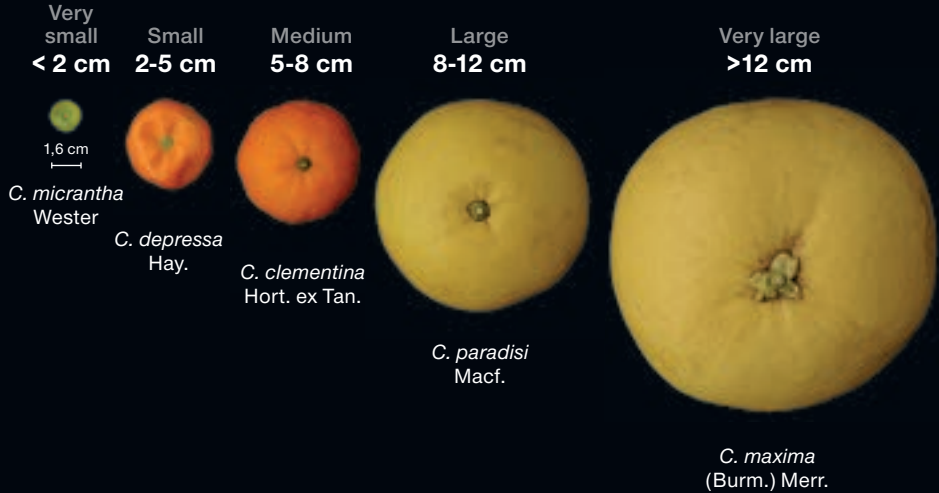
- 43. *Aegle marmelos* (L.) Corr.
- 44. *Aeglopsis chevalieri* Swingle
- 45. *Balsamocitrus dawei* Stapf.

■ Other genera

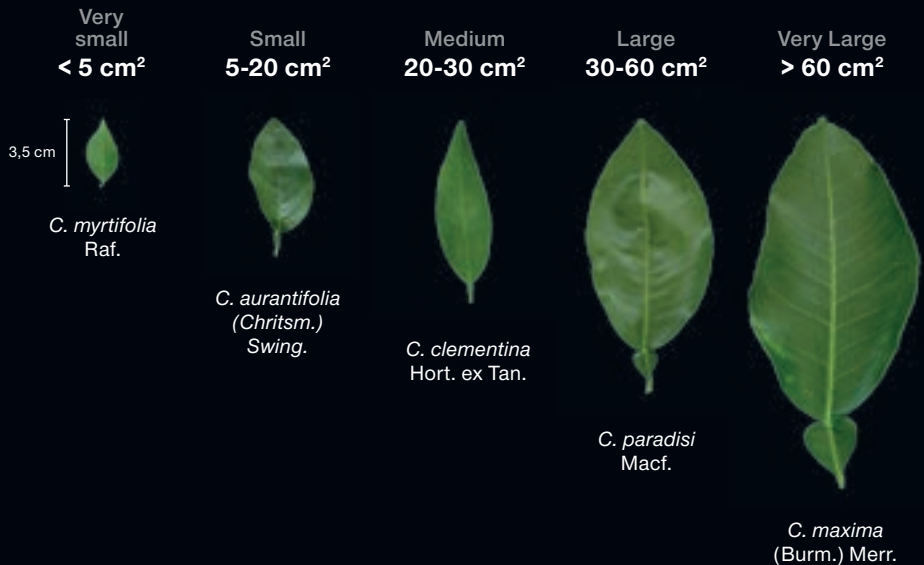
- 46. *Feroniella oblata* Swingle
- 47. *Citropsis gilletiana* Swingle et M. Kell.
- 48. *Severinia disticha* (Blanco) Swingle
- 49. *Hesperethusa crenulata* (Roxb.) M. Roem
- 50. *Murraya paniculata* (L.) Jack

Size criteria as cited in the text

Fruit size in terms of cross section:



Leaf size in terms of surface area:



* For compound leaves, the area of all the leaflets are added together.



Citrus aurantium L.

Common name: **Sour orange.**

This citrus is native to the region between northwest India and neighbouring areas of China and Burma. It is probably a hybrid between pummelo and mandarin. It was introduced into Europe by the Arabs, who used it for medicinal purposes and as an ornamental plant in gardens. It was the first citrus to reach America, taken there by the Spaniards.

Description

Medium to large-sized leafy tree, drooping growth habit and somewhat more erect than the sweet orange; more rustic and resistant, hence its use as rootstock for sweet orange grafts. It bears thorns and medium to large sized elliptical leaves with entire leaf margin. The petiole is longer than in the sweet orange and has well developed wings. Flowers are medium-sized, with white petals and yellow anthers. They exude a pleasant fragrance due to their essential oils, known as neroli oil. Generally, fruits are medium in size and spherical or globular in shape, but may be somewhat oblate. There is a slight depression in both the basal and apical zone. The rind, deep orange when ripe, is thick and rough to the touch. Juicy, pale orange-coloured acidic pulp with characteristic bitter taste. Semisolid central axis which, on ripening, becomes hollow. Holds numerous seeds, which are polyembryonic, with purple chalaza.

Use and exploitation

Sour orange is not consumed fresh. Its commercial importance lies in the essential oils extracted from flowers, leaves and rind, which are of higher quality than those from sweet orange. The fruit is highly valued by the Anglo-Saxon market for the manufacture of sour orange marmalade. However, the most important use of the sour orange in the citrus industry is as a quality rootstock. In the Pacific Islands, shredded fruit and macerated leaves are used as soap for washing clothes and as hair shampoo. In Cuba, the wood is prized for making baseball bats.



Citrus bergamia Risso et Poit.

Common name: **Bergamot orange.**

Its origin is unknown. This is probably a hybrid of sour orange and lemon, or more likely a limetta of Mediterranean origin, since the special fragrance of its essential oil is closer to the latter. It is mainly cultivated in the Italian region of Calabria. Bergamot has been known in Italy for centuries, and probably originated there.

Description

Medium-sized tree, drooping growth habit, and of average vigour. The new shoots are green. It bears very few thorns or is thornless, and has large dentate leaves, similar to the lemon tree in shape and colour, differing in that they bear not very well developed wings on the petiole. Flowers are medium in size with white petals and yellow anthers and they give off a very appreciated fragrance. The fruit is medium-sized, spherical or slightly ellipsoidal, yellow when ripe, and often retains the style. It may have a relatively pronounced nipple-like projection and a small navel. The rind is smooth or slightly rough, and tightly adhered. Yellow and firm pulp, with a high citric-acid content and slightly bitter taste, and a solid or semi-solid central axis. It presents monoembryonic seeds, which often fail to develop completely, with white or slightly greenish cotyledons.

Use and exploitation

The bergamot is grown mainly for the essential oil extracted from the rind, one of the most widely used in the perfume industry. It is the main ingredient in cologne (eau de Cologne) developed in Germany in the seventeenth century. It is also used to flavour Earl Grey tea and some tobacco varieties. The oil obtained from the leaves (petitgrain bergamot) and flowers (neroli bergamot) is primarily used in toiletries for men, for example, shaving lotions.



Citrus excelsa Wester

Common name: **Royal lemon.**

It is of unknown origin but is grown in the Philippines. Its name shows it is held in high esteem in that country.

Description

Citrus excelsa is a medium-sized vigorous tree, drooping growth habit, somewhat untidy due to its intertwining branches. It has fine straight thorns. The new shoots are purple in colour. Leaves are medium-sized and elliptical with dentate margins and winged petiole. Flowers are also medium in size and the petals have traces of purple; anthers are yellow and stamens usually free. The fruit is medium sized and spherical-oblate in shape, it is yellow when ripe. Its base is truncated and has a strongly marked nipple-like projection on the tip of the fruit. The rind is smooth, thin and tight. Its pulp is yellow, with a firm texture and with irregular and semi-solid central axis. It holds numerous, polyembryonic seeds, with light green cotyledons and red chalaza. Its juice is not very plentiful and is very acidic like the lemon's.

Use and exploitation

The royal lemon is used similarly to the lemon or lime.



Citrus karna Raf.

Common name: **Karna, Khatta.**

This is an ancient citrus to be found in India but it is of unknown origin. It is probably a natural hybrid between sour orange and lemon. The fruits are typical of the orange, whereas the purple flowers and emerging vegetative shoots are typical of the lemon.

Description

This tree is medium to large in size, moderately vigorous and drooping growth habit. It bears short, straight thorns. Both new shoots and flowers are purple, though not as intense in colour as those of the lemon. The leaves are large, similar to the lemon, but darker green in colour, medium firm to hard, with serrated margin and wingless petiole. The flowers are also large with purplish petals and yellow anthers. The fruits are ovoid in shape with a pronounced nipple-like projection. They are large, orange and rough skinned, and sometimes retain the style. The pulp is orange and the central axis is semi-solid or solid. They have a very thick rind, and consequently a fairly low proportion of juice, which is pale orange in colour and highly acidic. There are large numbers of seeds, which are polyembryonic, have white cotyledons and purple chalaza.

Use and exploitation

The commercial importance of *Citrus karna* lies in its use as a rootstock in India. Cooked pulp has been used as an antipyretic. It is also used in jam making.



Citrus limon (L.) Burm. f.

Common name: **Lemon.**

The latest research indicates that this species could be a direct cross between sour orange and citron. The origin of the lemon is a mystery, but it may have arisen in the northwest of India, northern Burma and China.

Description

The lemon tree is medium to large, vigorous, and drooping growth habit. Its branches bear abundant small thorns. Although more cold-hardy than the Mexican lime and citron, it is more sensitive to cold than other commercial citrus. Young shoots are deep purple. Large pale green leaves give off a pleasant lemon scent when crushed. Elliptical leaf blade with a serrated margin, and petiole either wingless or with the presence of very small wings. Flowers are large with purple petals, yellow anthers and mainly staminate due to the abortion of pistils. If conditions are favourable, it can blossom several times during the year. The light yellow fruit is ellipsoidal with a nipple-like projection more or less pronounced in the apical area and smooth or slightly rough rind. The fruit may taper at the base, forming a neck. Very acidic, juicy yellow pulp. Solid or semi-solid central axis. Harbours seeds with a low degree of polyembryony.

Use and exploitation

The lemon is mainly used for its juice and essential oils. The former is used as an ingredient for lemonade and other soft drinks as well as in baking; the latter, both from the leaf and fruit, in perfumery. In the past it was very important in maritime navigation to prevent scurvy, a disease caused by the lack of vitamin C. Lemon juice is widely known for its diuretic, astringent and febrifuge properties. The wood is compact and easy to work and in Mexico it is used to carve chessmen, toys, small spoons and other items.



Citrus macrophylla Wester

Common name: **Alemow, Macrophylla.**

Native to Cebu Island in the Philippines, it is probably a hybrid of *Citrus celebica*, or another species of papeda, and pummelo.

Description

The trees are large, vigorous, drooping growth habit and have numerous short, straight thorns. Usually they are not particularly productive trees. The new shoots are purple. Leaves are medium-sized, pale green, and have a pointed apex and dentate margin. The petiole is winged, similar to those of the pummelo, while leaf aroma is reminiscent of lemon. The flowers are medium-sized with purple petals and yellow anthers. The fruit is large, yellow when ripe, spherical-ellipsoidal in shape, with a nipple-like projection and distinct areola. The rind is rough and bumpy. The pulp is yellow, with a large solid central axis and scanty juice. It bears many polyembryonic seeds. Its high acidity and bitterness make it practically inedible.

Use and exploitation

It is mainly used as rootstock for lemon grafts. Currently this use is extending to other commercial citrus due to its excellent properties as a rootstock, despite its sensitivity to the tristeza virus.



Citrus madurensis Lour.

Common name: **Calamondin orange, Chinese orange, Panama orange, Limonsito.**

Citrus madurensis is the result of a natural hybridization event between sour mandarin and kumquat. It originated in China, where it soon spread to Indonesia and the Philippines.

Description

The tree is of medium size and vigour, densely branched and erect growth habit. It bears few thorns. It is very hardy to low temperatures and highly productive. The new shoots are green. There is a variegated variety of great ornamental value. The aromatic leaves are small, oval-shaped with a slightly dentate margin and short narrowly winged petiole. Flowers are small and fragrant, with white petals and yellow anthers. The fruit is small and oblate, concave in the basal area. Bright orange when ripe. The rind is thin, with numerous essential oil glands, easy to peel and sweet to taste. Orange coloured pulp, tender and juicy, with an irregular central semi-solid axis. Very acidic. Few, small, polyembryonic seeds with green cotyledons. The fruits can remain on the tree for a long time without spoiling.

Use and exploitation

The calamondin is prized as an ornamental tree, and can bear flowers, green and orange fruit at the same time. It also has value as a bonsai. The juice can be used similarly to the lemon or lime to manufacture soft drinks, season fish, make cakes, jams, preserves, sauces or for use in soups and teas. It has many medicinal uses. The juice, when rubbed onto insect bites, relieves itching and reduces irritation. It is also a natural medicine for acne. It is still used orally as a cough medicine and is a natural anti-inflammatory. It is an excellent hair conditioner and good body deodorant. In the Philippines it is used to clean ink stains from fabrics.



Citrus maxima (Burm.) Merr.

Common name: **Pummelo, Pampelmus, Shaddock.**

The large fruit size, in fact it is the largest citrus fruit, is reflected by its botanical name (*C. maxima*, previously *C. grandis*). It originated in Indonesia and Malaysia, where it can be found in the wild. Its fruit is held in high esteem in Southeast Asian countries.

Description

Large tree, drooping growth habit, vigorous and thorn bearing. Young shoots, green in colour, are pubescent unlike grapefruit. Very large, elliptical, dark green leaves with slightly dentate or entire margins. Well-developed wings on the petiole. The flowers are usually borne in terminal clusters and are the largest of the genus. They are aromatic, with yellow anthers, pilose calyx and thick white petals, which turn outwards when in full bloom. The fruit is very large. Its shape can range from spherical to oblate or even piriformis, depending on the variety. The rind is thick and pale yellow, sometimes showing a greenish hue. The pulp, firm in texture, can be yellow-green, yellow or reddish. Large, hollow or semi-solid, central axis. The membranes covering the segments are very tough and can be removed easily. The juice vesicles are the largest in citrus. Seed content varies from few to very many and these are large and monoembryonic. There are varieties ranging from almost dry to very juicy, and from very acidic to tasteless.

Use and exploitation

Peeled segments are consumed fresh and used to prepare salads and desserts. They are also used for their juice while the flowers are used to make perfume. The hardwood is suitable for making tools. In the Philippines and Southeast Asia they have various applications in traditional medicine; brewed concoctions of leaves, flowers and rind are administered as a sedative for epilepsy and whooping cough. The rind is sometimes used to make marmalade and preserves. In China it is sauteed with pork.



Citrus medica L.

Common name: **Citron.**

This citron dates from the earliest times. Seeds have been found in excavations in Mesopotamia dating back to 4000 BC. The term "*medica*" refers to the Medes, a Persian tribe that lived in present-day Iran. It may have originated in the area between northern India, Pakistan and Burma, where it can be found growing wild in the valleys at the foot of the Himalayas.

Description

Small, slow-growing tree with irregular growth habit. It is very sensitive to the cold and bears numerous thorns, some of them stout. Deep purple shoots (except the Corsica citron variety). Large elliptical leaves, dentate margin and rounded apex. Short and wingless petiole. The flowers are large, and many have aborted ovaries; purplish petals and large yellow anthers. The style is particularly thick, similar to the ovary. Fruit is large or very large in size, ovoid or ellipsoidal, with a pronounced nipple-like projection. Fruit may be highly variable even on the same tree at once. The highly aromatic rind is usually smooth, but may be wrinkled or even pitted. The pulp is scarce (Buddha's hand variety is pulpless), firm with scant juice, which may be sour or sweet depending on the variety. It produces a large number of monoembryonic seeds with white cotyledons and generally purple coloured chalaza.

Use and exploitation

Almost all parts of the citron are used in medicine: leaves, flowers, rind, fruit, juice and essential oils. In ancient times it was prized as a remedy against fever, intestinal disorders and lung diseases. The most important part of the fruit is the peel, particularly the albedo, which being highly aromatic is used for cooking, especially in baking. The wood is white and hard, and serves for manufacturing poles in India. In China and Japan it is highly valued to scent closets or rooms, and the Buddha's hand variety is made as an offering in Buddhist temples. It also has religious uses for Jewish people in the rite of the Feast of Tabernacles. According to the Bible, the citron was one of the four fruits that the God of the Jewish people allowed them to use in religious rites (Leviticus 24-40).



Citrus myrtifolia Raf.

Common name: **Chinotto orange, Myrtle-leaved orange tree.**

It owes its scientific name to the resemblance of its leaves with myrtle (*Myrtus communis* L.). It is native to south-eastern China. Sometimes it has been considered a variety of sour orange (*C. aurantium* var. *myrtifolia*) but, due to the large number of morphological differences, it is now considered a separate species.

Description

This thorn-free tree is small, compact, slow-growing and barely vigorous. The crown is dense due to the short distance between the branch nodes, which makes the leaves very close together. These are dark green, small and leathery. Elliptical leaf blade, usually with entire margins, and wingless petiole. It usually bears single flowers with white petals and yellow anthers. The fruit is small, spherical or slightly oblate. The rind, bright orange, has a rough texture. The orange-coloured pulp is juicy, and the central axis is hollow. It harbours a variable number of polyembryonic seeds. Acidic and sour to the taste, this fruit can last several months on the tree without spoiling.

Use and exploitation

Chinotto, as it is known in Italy, is very popular in this country, where the juice is an essential flavouring in most *amari*, like the well-known Campari, as well as various soft drinks. The fruits are too sour to be eaten fresh, but preserved make a prized dessert. The tree is also an attractive ornamental plant, planted either in pots or in the ground.



Citrus paradisi Macfad.

Common name: **Grapefruit.**

It is one of the latterly known commercial citrus fruits. It was first described in 1750 by Griffith Hughes who called it the forbidden fruit of Barbados. It is a hybrid that seems to be from an accidental crossing event between pummelo and sweet orange on these islands. In his *Flora of Jamaica* (1837), James Macfayden gave it the botanical name *Citrus x paradisi*, indicating its hybrid origin.

Description

The grapefruit tree is vigorous, leafy, drooping growth habit and large in size. It is usually thornless but may bear some short straight thorns on its branches. While cold tolerance is average, it requires high temperatures to produce good quality fruits. They are productive trees, tending to bear fruit in clusters; hence its English name, grapefruit. Foliage is dense, deep green, with large elliptical leaves. The leaf margin is entire or slightly dentate. The petiole bears well-developed wings that normally overlap the lead blade. The petiole is glabrous, which differentiates it from the pummelo. The flowers are large, with white petals and large yellow anthers. The fruit, with smooth rind, is large, uniform yellow or reddish in pigmented varieties, and can be globular, oblate or pyriform to a lesser extent. The yellow or red pulp is tender, with abundant juice and semi-solid or solid central axis. The albedo is white and thick. It is seedless, or harbours very few seeds in commercial varieties. The juice, yellow or red in colour, has an excellent and highly characteristic sour flavour due to the flavonoid naringin. The seeds are large, polyembryonic, with white cotyledons and brown chalaza.

Use and exploitation

Grapefruit is considered a typical breakfast fruit, both fresh and as juice. In the nineteen-seventies it became very popular due to the fashionable weight loss programme known as the Grapefruit Diet. It is part of a healthy diet because it contains vitamin C and fibre (pectin), besides the antioxidant lycopene in the pigmented varieties. However, it may interact harmfully with some drugs due to the presence of furanocoumarins in the juice. The rind is an important source of pectin, used for preserving other fruits. The extracted naringin is used to give a bitter flavour to tonic beverages or chocolate. The essence extracted from the flowers is used to treat insomnia and stomach ailments.



Citrus pyriformis Hassk.

Common name: **Ponderosa lemon.**

This variety originated around 1887 in a nursery belonging to George Bowman in Hagerstown, Maryland, and was named and launched commercially in 1900. It is believed to be a hybrid of lemon and citron. Both the tree and the fruit resemble citron, although the taste is typical of a lemon.

Description

The tree is small, not very vigorous and slow-growing, with sparse short thorns. Less cold-hardy than the true lemon. Leaves are large, elliptical, resembling those of citron but less bright green in colour and with crenate margins. The apex is slightly rounded. The petiole is short and may have small wings. The new shoots are green, although they may sometimes have a faint purple tinge. Flowers are large with white petals and yellow anthers. The fruit is medium to large, yellow when ripe, with thick rind and rough skin. Fruit is spherical-ellipsoidal in shape, with a nipple-like projection in the apical area. It has yellow pulp with numerous seeds. The juice is highly acidic, similar to real lemons.

Use and exploitation

The fruit is not marketed as such, but can be used as a substitute for lemon because it has a similar flavour. Its main use is as an ornamental plant.



Citrus shunkokan Hort. ex Yu. Tanaka

Common name: **unknown**.

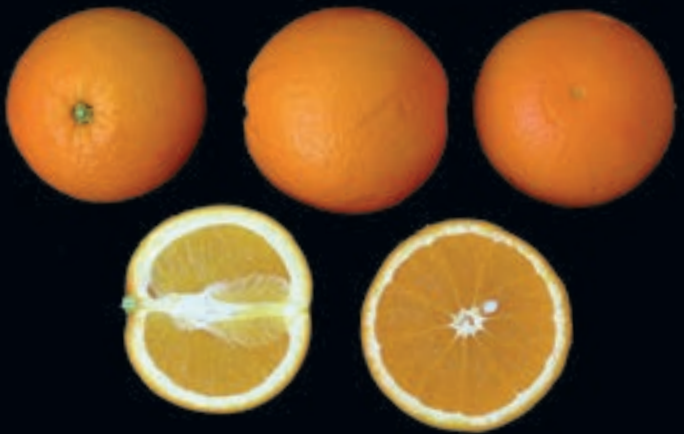
There is no information on the origin of this species but probably, like most citrus, it comes from Southeast Asia. It bears some resemblance to the orange.

Description

Medium-sized tree, leafy and drooping growth habit. The long, flexible branches tend to droop with the weight of the fruits, giving it a weeping appearance. It has few thorns. New shoots are green while leaves are large, elliptical and deep green in colour. Entire or slightly dentate leaf margin, and short wingless or very slightly winged petiole. Flowers are medium-sized and showy, with white petals and yellow anthers. The fruit, medium in size, is oblate, with a concave stylar end. Rind is rough and bright yellow when ripe, strongly attached to the pulp and thicker than in oranges. Firm textured, pale yellow pulp with a low proportion of juice divided into several segments and with semisolid central axis. It has plenty of monoembryonic seeds with light green cotyledons and reddish chalaza. Juice is of low organoleptic quality.

Use and exploitation

No known use, except perhaps as an ornamental tree.



Valencia

Citrus sinensis (L.) Osbeck

Common name: **Sweet orange.**

It is one of the most cultivated fruit trees in the world. Its origin lies between southern China and northeastern India. It is an interspecific hybrid between pummelo and mandarin. The Spanish word for orange is *naranja* and comes from the word *narang*, its local name in ancient Persia. The numerous existing varieties are classified into four groups: Common, Navel, Blood and Acidless.

Description

Sweet orange trees have drooping in growth habit, medium to large in size and vigorous. They are thorny, to varying degrees depending on the variety. Elliptical large or medium-sized leaves, with short petioles and rudimentary wings. Leaf blade with entire margin. No scent is exuded on being crushed. The flower is medium in size, with white petals and yellow anthers, except in the Navel group, which has white or pale yellow anthers. Usually, the fruits are globose, medium-sized and orange in colour. The rind is of average thickness, smooth and moderately tight. Solid or semi-solid central axis. Pulp is juicy, tender, yellow, orange or with reddish veining in the case of Blood oranges. They have a varying number of seeds, which are polyembryonic, with white cotyledons. The juice, which is abundant, has excellent qualities thanks to the balance between sweetness and acidity; its colour spans many shades, ranging from pale orange to blood red.

Use and exploitation

It is grown mainly for consumption, either fresh or as juice. Some products obtained during juice extraction, such as pulp and rind, are used to manufacture animal feed. Essential oil is also recovered from glands in the peel. The flowers are used in the perfume industry. In China it is an ingredient of traditional medicine. In the flowering season, honey of excellent quality is obtained from nearby hives, known as *miel de azahar* (orange-blossom honey).

Classification

Sweet oranges are classified in the following four groups:

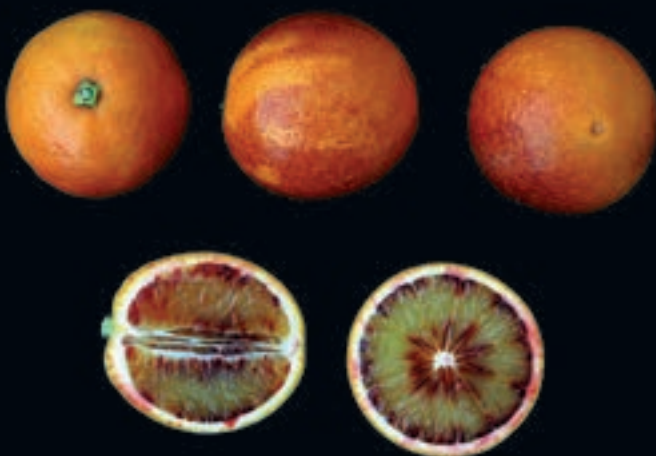
Common group: This group includes all those without a navel, without red pigmentation and that are not acidless. The vigorous trees are medium to large in size, bearing small, not very abundant, thorns on the branches. Flowers bear



Navelina



Sanguinelli



Sucreña



yellow anthers with abundant pollen. The cultivation of this group has decreased with the arrival of Navel oranges, which are of higher organoleptic quality. They are valued, however, for industrial juice processing where productivity and sugar content are important. Additionally, their limonin content is clearly lower than the navel, and virtually undetectable by the human palate.

The most outstanding varieties are: **Valencia**, **Pera** and **Salustiana**.

Navel group: This group comprises medium to large-sized trees. These bear small thorns on the branches, which usually disappear as the tree ages. Flowers are characterized by the white or pale yellow anthers, indicating the absence of pollen grains. Navel oranges can be distinguished by a small rudimentary fruit in the styler area, which resembles a “belly button” or navel, and they are seedless. Its excellent quality means it has replaced other oranges for fresh consumption. However, they are not suitable for juice production due to the limonene content, which confers a bitter taste.

The most outstanding varieties are: **Navelina**, **Washington Navel** and **Lanelate**.

Blood orange group: This group is similar to the Common orange group, but distinguished by red pigments (anthocyanins) present in the rind, pulp and juice. This colouration needs low night temperatures to develop. Trees are medium to small, less vigorous than the Common group, with smaller leaves. Flowers also have yellow anthers. The red juice has an aroma and flavour prized in Italy.

The most outstanding varieties are: **Tarocco** and **Sanguinelli**.

Acidless group: The only difference between these and the Common group is that they have an extremely low acid content. It is of scarce commercial value.

The most outstanding varieties are: **Sucreña** or **Imperial**.



Citrus webberii Wester

Common name: **Kalpi**.

Its common name comes from the Bicolano dialect of the Philippines. It grows on the islands of Mindanao and Luzon. Wester named it in honour of his director and mentor H.J. Webber, then director of the citrus experiment station in Riverside, California. This species appears to be a hybrid of *C. macroptera*, also from the Philippines, and the Philippine common Mandarin.

Description

The tree is medium-sized, lush, with deep green foliage. It may bear some small short thorns. Drooping growth habit, which has a weeping appearance when the branches are heavy with fruit. New shoots, both vegetative and flower buds, are tinged with purple. Large leaves with entire or slightly crenate margin, and winged petiole. The flowers are large with white petals and yellow anthers. The medium-sized fruits are spherical or slightly oblate, have a marked areola and nipple-like projection in the apical area. Thin, smooth yellow rind when ripe. The pulp is yellow and has a firm texture. It bears many polyembryonic seeds with light green cotyledons. Large hollow central axis. The juice is aromatic and has a high acid content similar to lemon.

Use and exploitation

In the Philippines and Hawaii it is used as a substitute for lemon to flavour food.



Citrus clementina Hort. ex Yu. Tanaka

Common name: **Clementine.**

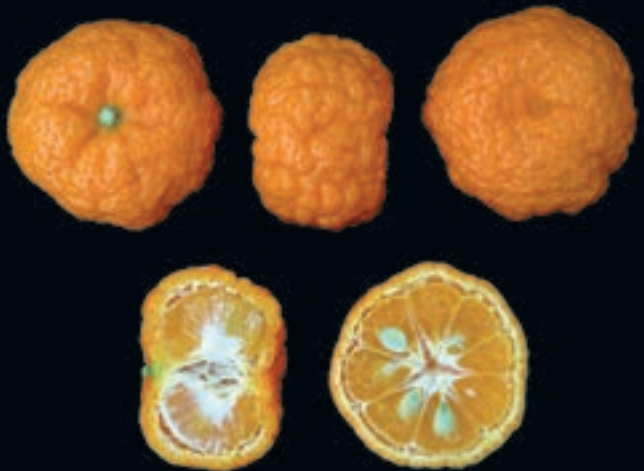
It is of uncertain origin, and there are two contradictory theories. According to some sources, the Clementine originated as an accidental hybridization event in a mandarin plantation, presumably of the Common or Mediterranean mandarin, by Father Clement Rodier in the garden of the Pères du Saint-Esprit orphanage, in Misserghin, a small village near Oran, Algeria. Other sources claim that it is of Eastern origin, probably Chinese, and is indistinguishable from the Canton mandarin, widely grown in the Chinese provinces of Guangxi and Guangdong.

Description

Vigorous tree of medium size, drooping growth habit although some varieties tend to verticality. It is usually thornless and cold hardy. Leaves are lanceolate, medium in size, with an entire or slightly dentate margin and wingless petiole. Flowers are medium-sized to small, with white petals and yellow anthers. Fruit size varies depending on the variety, ranging from medium to small. Its shape is spherical or slightly oblate. Orange or deep orange coloured rind that peels off easily. Sometimes it has highly prominent oil glands. The pulp is orange in colour, tender, with high juice content. Semi-solid central axis. It is seedless but if it is pollinated with other varieties of citrus it may bear seeds, which are monoembryonic with green cotyledons. High quality juice, given the good balance between sugar and acidity. Clementines are very similar to other mandarins, so they are not always easy to distinguish.

Use and exploitation

Clementines are mainly grown for fresh consumption, being highly valued for their excellent organoleptic quality. They are used in the juice processing industry to a lesser extent. Clementines are typical of the Mediterranean area, where the climatic conditions are suitable for good quality fruit.



Citrus daoxianensis S.W. He et G.F. Liu

Common name: **Daoxian wild mandarin.**

Citrus daoxianensis is included in the group of small mandarines, such as Cleopatra mandarin, *Citrus sunki* and others. They are primitive forms of mandarin, closely related to *Citrus reticulata*. It has been found growing wild in the mountainous southern and western regions of the Hu-nan province, China, where it probably originated.

Description

The tree is medium in size, compact and drooping growth habit. It is thornless or has very few thorns. It is highly productive. New shoots are green. The leaves are medium to small with a lanceolate leaf blade and entire margin. Wingless petiole. Flowers are small with white petals, yellow anthers and commonly fused stamens. The fruit is small, orange and oblate, with a depression in the styler area and areola. Rough rind that peels off easily. The pulp is orange and tender and the central axis is hollow. It has a low percentage of juice, which is acidic and lacks organoleptic value. The seeds are polyembryonic, globose with light green cotyledons and a light brown chalaza.

Use and exploitation

No known use. It may be used as an ornamental tree given its compact appearance and large amount of fruit, which is an attractive orange in colour.



Citrus depressa Hayata

Common name: **Shekwasha, Taiwan mandarin, Flat lemon, Hiram lemon.**

This citrus is native to Taiwan and the Japanese island of Okinawa, where it grows wild. It might be a hybrid between *C. tachibana* and a mandarin.

Description

Medium-sized tree, vigorous, bushy and drooping growth habit with few thorns. Shoots are green and glabrous. The leaves are medium, elliptical with an entire margin, and almost wingless petiole. When crushed they exude an aroma typical of mandarin. Flowers are small, with white petals and yellow anthers. The fruit is small, oblate, presenting a depression in both the basal and, especially, the apical region, where it is very distinct. The fine aromatic rind is deep orange; easy to peel. The pulp, whose central axis is hollow and large, is tender, pale orange and contains polyembryonic seeds with green cotyledons. The percentage of juice is low and has a high acid content.

Use and exploitation

The juice, which is sweet and acidic, is used as a substitute for lemon or lime to garnish meals. Bottled juice is also sold, especially in Japan. The tree has great ornamental value.



Citrus unshiu (Mak.) Marc.

Common name: **Satsuma**.

Satsuma is the name of an old Japanese province, now the Kagoshima Prefecture, on the southern tip of the island of Kyushu, where this species is believed to have originated. In Japan, where it is well known and prized, it is called *unshû mikan*, thus its name *unshiu*.

Description

The tree is small to medium-sized, slow-growing. It has a drooping growth habit, somewhat rambling with spreading branches that sometimes grow towards the ground, giving it a weeping appearance. Thornless. It is the most cold-hardy of all the commercially grown citrus and can stand unfavourable conditions. Leaves are lanceolate, medium in size and leathery. Slightly winged petiole and entire margin. The flowers are medium-sized, with white petals and white or pale yellow anthers, without pollen. Medium-sized orange fruit, oblate in shape, but it is harvested with green hues as the rind is very prone to puffing. Moreover, internal ripening of the fruit precedes that of the rind. The rind is slightly rough and peels off very easily. Deep orange pulp, with a central hollow axis and plenty of juice, although the latter is not very good quality due to low acidity and sugar indexes. Seedless, although if some seeds are found, they are polyembryonic.

Use and exploitation

Satsumas are easy to peel and seedless, making them a highly popular citrus for fresh consumption. They are harvested very early, and are the only commercially available citrus at that time. The UK is the main destination for satsumas, both fresh and for the segment canning industry.



Citrus hystrix DC.

Common name: **Kaffir lime, Mauritius papeda.**

It is the best known species of the subgenus *papeda*. Its origin lies in Southeast Asia and it is very popular in countries like Thailand, Indonesia and Malaysia.

Description

The Kaffir lime tree is medium-sized, with a thick crown, drooping growth habit and an irregular distribution of the branches, which gives it a distinctive appearance. It bears short hard thorns, which are green with brown tips. The new shoots are deep purple. Leaves are medium in size and oval in shape with a crenate margin; petioles are long with large deltoid-shaped wings, slightly smaller than the leaf blade. The upper side of the leaf (adaxial) is bright dark green, with a lighter underside. The flowers are small, purple tinged, with a short peduncle, free stamens and yellow anthers. Medium-small fruits are pyriform, with a clearly defined basal neck and a depression in the apical area. The surface of the rind is highly distinctive, being rough and bumpy, with many oil glands. It turns yellow when ripe. The pulp, yellow-green, is acidic and slightly bitter. It bears seeds in very low numbers.

Use and exploitation

Kaffir lime leaf is a staple ingredient in Thai cooking, essential to many dishes ranging from soups and salads to curries and stir-fries. Both the leaves and the fruit provide a powerful citrus flavour and pungent aroma. While the juice is seldom used in cooking, the rind, with its high concentration of aromatic oils, is indispensable in many curry pastes. It is the flavour of this zest that gives Thai curries their unique refreshing taste. Because of its strong flavour, the rind should be used sparingly. The juice serves as an invigorating shampoo and scalp tonic. It is also used as an insecticide against lice in Ceylon and has historically served as a natural bleach to remove stains. In folk medicine it is recommended for brushing teeth and keeping gums healthy.



Citrus macroptera Montr.

Common name: **Melanesian papeda, Don-gan.**

This citrus species was discovered by Father Montrouzier on the Island of Art, in New Caledonia, in the nineteenth century. It grows in Thailand, Indochina, the Philippines, New Guinea, New Caledonia and Polynesia, and is considered to be native to Southeast Asia. Its botanical name refers to the large winged petiole, from the Greek word *ptera*.

Description

Medium-sized tree with dense foliage and drooping growth habit. Hardly thorny. The new shoots are deep purple. Large, dark green leaves with entire margins. The great length of the petiole (longipeciolate) is striking, as well as the large wings, which are similar in size to the leaf blade and deltoid in shape. Flowers are medium to small in size, with purple tinged petals and yellow anthers. Fruit size is similar to the orange, but yellow and spherical, tapering to a neck in the basal area. Smooth and very tight rind. The pulp is pale yellow with a firm texture. It has a high acid content and an extremely bitter taste, typical of papedas, and is thus not suitable for fresh consumption. Semi-solid or hollow central axis. The seeds are present in large numbers, which are polyembryonic with light green cotyledons. Its juice content is low.

Use and exploitation

In Polynesia, the pulp is used as a substitute for shampoo and laundry soap. Both the juice and the macerated leaves are used to bleach hair. In Bangladesh it is used as a seasoning for stewed meat and fish. The Annamensis variety is grown for the perfume industry due to the high quality essential oils in the rind.



Citrus micrantha Wester

Common name: **Small-fruited papeda, Samuyao papeda.**

This papeda is endemic to Bohol and Cebu in the southern Philippines. It has the smallest flower and fruit of those considered true citrus.

Description

Small tree with slender branches and numerous thorns. Like the rest of the papedas, the leaf is longipeciolate, with large wings on the petiole. Medium to small oval blade with a slightly crenate margin. Small axillary flowers or terminal clusters, with free stamens, yellow anthers and white petals with traces of purple. The fruits are spherical although some may be pyriform with a depression in the stylar area. Rough but thin greenish yellow rind. The oil glands form pits and contain a lot of highly fragrant oil. Quite juicy greenish yellow pulp, with a solid central axis. Sour and bitter to taste, with a characteristic aroma. It contains seeds.

Use and exploitation

The crushed fruits are used in Cebu for cleaning hair, added to coconut oil to make it fragrant. Goldsmiths used it for cleaning gold. It is also used as a home remedy in traditional medicine.



Citrus aurantifolia (Christm.) Swingle

Common name: **Mexican lime.**

Known mostly as Mexican lime, it has different names depending on the region where it is grown: Key lime in the U.S.A., Galician lime in Brazil, common lemon in Latin America. It originated in the Indo-Malayan region, and can be found growing wild in the temperate valleys of the Himalayas.

Description

Very vigorous medium-sized tree, with drooping growth habit. It presents many short straight thorns. It is more sensitive to the cold than citron or lemon. Both new vegetative and flowering shoots are slightly tinged with purple. Small, elliptical leaves, similar to the orange (hence the Latin name *aurantium-folia*), with entire or slightly crenate leaf margin. They give off a pleasant aroma when crushed. Small winged petiole. The flower is small and initially tinged with purple, which fades quickly giving way to white petals. Purple style and yellow anthers. Small fruit, yellow when ripe, although it is harvested green because it falls off the tree very easily. The fruit is ellipsoidal or spherical, with a small nipple-like projection at the end. The pulp is yellow-green, tender and juicy, with polyembryonic seeds with light green cotyledons. Small solid central axis. The juice is acidic and with a very distinctive and highly valued flavour.

Use and exploitation

The Mexican lime, with its unique aroma and taste, is a highly valued culinary ingredient. It is also widely used in the manufacture of soft drinks and some alcoholic beverages. The essential oil of the rind is used in the perfume industry. When infected with tristeza virus, this plant suffers very specific symptoms, so it is used as a plant-disease indicator in biological tests.



Citrus latifolia Yu. Tanaka

Common name: **Persian lime, Tahitian lime, Bearss lime.**

The Persian lime appears to be a hybrid of Mexican lime and citron or lemon, and genetically it is a natural triploid. Its origin is unknown, but it is likely to have originated in Asia, as most citrus. It is not cultivated in either Persia or Tahiti, so these common names are probably due to the fact it was introduced into the Mediterranean basin from Persia, and in more recent times it arrived in California via French Polynesia.

Description

The tree is medium to large, of average vigour, and does not usually bear thorns. It is more cold-hardy than the Mexican lime tree, but less than the lemon. The new shoots are very pale purple. Leaves are deep green, medium-sized with an oval shaped blade. They bear small wings. Flowers are medium in size, petals have a slightly purple hue, anthers are white and pollen is unviable. Fruit is medium to small, ellipsoidal, convex at the base and with a nipple-like apical projection. Thin, smooth, tight rind, yellow when ripe (generally sold when green in colour). The greenish-yellow pulp is juicy, and has a solid central axis. The juice is quite acidic, similar to the lemon, with a very distinctive aroma. As all triploids, it is seedless.

Use and exploitation

Mainly the juice is used for making lemonade and as an ingredient in cocktails or as a substitute for vinegar. The essential oil from the cortical glands is considered to be of lower quality than the Mexican lime, which it often replaces due to its larger size, better yield and ease of transport. The juice is also used to rinse hair after washing, to dissolve calcium deposits in appliances or as an effective antidote for oral irritation produced by plants like *Dieffenbachia* spp.



Citrus limetta Risso

Common name: **Marrakech limetta, Tunisian limetta, Mediterranean sweet lemon.**

It is an old and well-known fruit in the Mediterranean area, which is important in countries such as Morocco, Tunisia and Italy. Of the known varieties, the most important is the Marrakech limetta.

Description

The tree is medium-sized, vigorous, drooping growth habit and scarcely thorny. New shoots are purple, although not as deep purple as in the lemon. Large oval shaped leaves with a slightly dentate margin. Short wingless petiole. When crushed they give off an aroma similar to the lemon. The flower bud is slightly purple; with yellow anthers and free stamens. Fruit is medium-sized and oblate spherical in shape, with a convex basal area and a well defined areola and prominent nipple. The rind is somewhat rough and yellowish. It has a semi-hollow central axis, and the pulp is tender in texture and pale yellow in colour. It is very juicy and aromatic, with high acidity, although other varieties of limetta may have low acidity levels. It bears polyembryonic seeds, with pale green cotyledons and purple chalaza.

Use and exploitation

It is of scarce economic interest and is mainly used as an ornamental tree or as a substitute for lemon.



Citrus limettioides Yu. Tanaka

Common name: **Indian lime, Indian sweet lime, Palestine (sweet) lime.**

Its origin is unknown, but it probably comes from India, where it has been cultivated for the longest time, as indicated by one of its common names. It could be a hybrid between a Mexican lime and sweet lemon or sweet citron.

Description

Medium to large-sized tree with non-dense foliage and somewhat irregular growth habit, which makes it easily recognizable. It has drooping growth habit and is thorny. Green and glabrous shoots. Leaves are medium-sized, oval in shape and paler green in colour than the lemon or orange, wingless and with a slightly dentate margin. Medium-sized flower with white petals and large yellow anthers. The fruit is spherical and medium in size, although large for a lime. The rind is thin, with a distinctive aroma. The fruit has a well defined nipple-like projection in the apical part. The rind is smooth, yellow when ripe and tight. The pulp, tender and juicy, is pale yellow. It bears a few monoembryonic seeds, with cream-coloured chalaza. Despite its name, the sugar content of the juice is no higher than in other citrus. However, the amount of citric acid is extremely low, giving it a sweet taste, and it has even been qualified as tasteless.

Use and exploitation

It is mainly produced for fresh consumption. The lime is highly prized in India, the Middle East, Egypt and Latin America, where medicinal properties are attributed such as the prevention and treatment of fevers. It is also used as a rootstock in India.



Citrus limonia Osbeck

Common name: **Rangpur lime.**

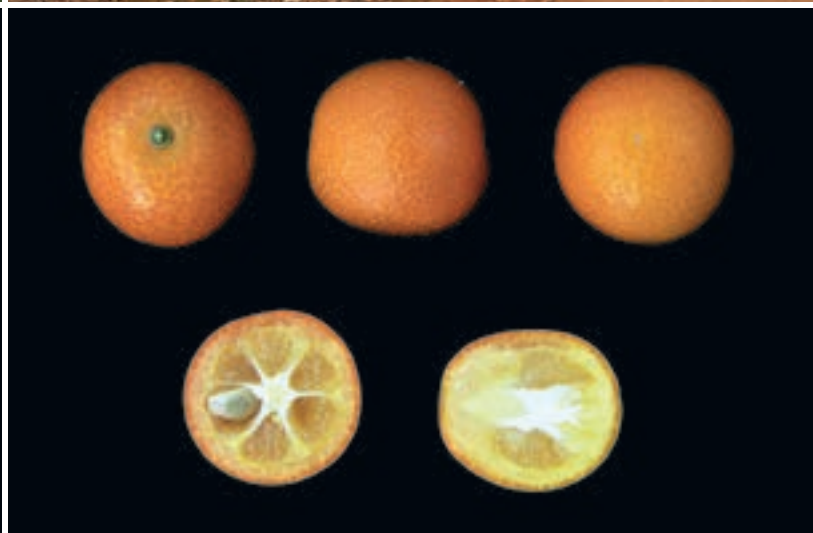
Named after the town of Rangpur, in Bangladesh, it is also known as the Canton lemon (China), Hime lemon (Japan) or Cravo lemon (Brazil). This is probably a hybrid of lemon and mandarin that originated in India.

Description

The tree is medium in size, fast growing, vigorous and productive, with drooping growth habit. It has few thorns or is thornless. New shoots are light purple unlike the flowers. Leaves are medium-sized, elliptical in shape with a slightly dentate margin. They are wingless. On being squeezed they give off a pleasant aroma, reminiscent of lemon. Flowers are medium-sized, with purple petals and yellow anthers. Fruit is medium to small, like a mandarin, and spherical or slightly oblate. Usually there is a small nipple-like projection. The rind is not tightly attached to the segments, and is reddish orange, and smooth or slightly rough in texture. The pulp is tender and juicy, with a hollow axis. Abundant seeds are small, polyembryonic with light green cotyledons. The juice is orange in colour and high in acidity. The fruits can remain on the tree for a long time without spoiling.

Use and exploitation

It is mainly used as a rootstock, especially in the Brazilian citrus industry. To a lesser extent it is used as an ornamental tree in gardens due to its hardiness, and to the fact that fruits remain on the tree without spoiling. In India its juice is added to mandarin juice to improve its organoleptic quality. Jam made from this lime is highly valued in India, where it is considered even better than sour orange marmalade.



Fortunella crassifolia Swingle

Common name: **Meiwa kumquat.**

This Kumquat is believed to be a natural hybrid between *F. japonica* and *F. margarita* and to have originated in China. It was taken from China to Japan during the Meiwa period (1764-1772), hence its name.

Description

The tree is very similar to the Nagami kumquat. Small to medium in size, it exhibits similar slow growth to the former, but bears foliage that is not as dense. It may bear thorns. Like other kumquats, it has a long semi-latent period in the winter, allowing it to withstand low temperatures. Leaves are medium to small with an entire or very slightly dentate margin. It is wingless. Its leaves are differentiated from other kumquats in that they are thicker and stiffer. The small flowers, bearing white petals, are mostly solitary, although some do form small clusters. The fruit is small, orange in colour and ellipsoidal in shape, though more rounded than the Nagami kumquat and with a thicker rind, which makes it sweeter if the fruit is eaten whole. It also differs in that it has a greater number of segments per fruit. The flesh is light orange, acidulous, with a solid central axis. It contains few seeds or is quite often seedless.

Use and exploitation

Although it is less well known than the Nagami kumquat, the Meiwa is becoming increasingly popular due to its excellent fruit flavour, considered the best kumquat for fresh consumption. It is also used in syrup for a typical dessert in Hong Kong. In Guangdong (China), kumquats are preserved in salt, resulting in a small wrinkled fruit, used as medicine for sore throat, cough or as a stimulant once rehydrated.



Fortunella hindsii (Champ.) Swingle

Common name: **Hong Kong kumquat.**

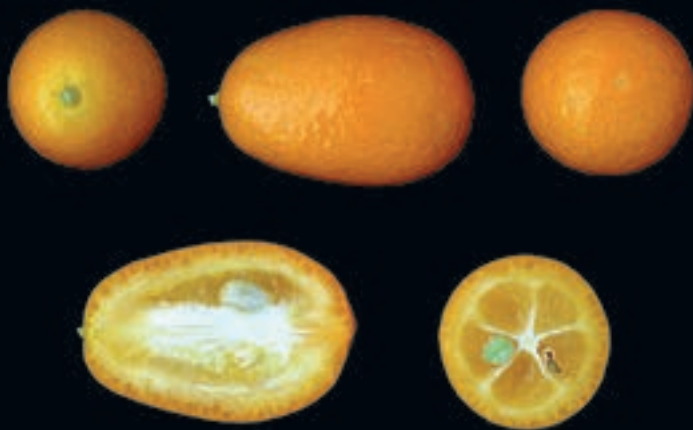
It is the most primitive of kumquats and is only found in the wild in southern China, in Hong Kong and in the provinces of Chekiang and Kwantung. The wild form of the species is a natural tetraploid.

Description

It is a small, compact, slow-growing tree. The trunk is greatly branched, and it may have thorns. Like other kumquats, it is resistant to the cold due to its long semi-latent period. Small leaf, with a lanceolate blade and entire margin; dark green adaxial and somewhat lighter green abaxial blade. Veins are only apparent on the upper side. Wingless petiole. Flowers are small and fragrant, with white petals and commonly fused stamens. Flowers are usually solitary. The fruit is very small, orange and ellipsoidal. The rind is smooth and tight; the pulp is yellowish orange, acidic with low juice content, and a solid and round central axis. It is virtually inedible due to the small fruit size and the abundance of seeds. The seeds have pistachio-green cotyledons.

Use and exploitation

The Hong Kong kumquat is of great ornamental value. It is the best suited kumquat for bonsai cultivation.



Fortunella margarita (Lour.) Swingle

Common name: **Nagami kumquat, Oval kumquat.**

Its name refers to the shape of its fruit. It is the most commonly cultivated kumquat worldwide. It probably originated in Southeast China, where records of its cultivation date back to the twelfth century. The first word of the scientific name honours Robert Fortune, of the Royal Horticultural Society, who collected specimens in China; the second comes from Latin and means *pearl*, alluding to its beady fruits. The name *kumquat* comes from Cantonese and means *golden orange*.

Description

The tree is small to medium-sized, compact, densely branched and slow growing. It is virtually thornless. This kumquat is cold resistant as it tends to remain semi-latent from late autumn to spring, blooming in summer. Its medium to small leaves are lanceolate, with a finely dentate margin and leathery texture. Wingless petiole or hardly noticeable wings. The leaf is dark green on the adaxial surface with a lighter underside. Small highly fragrant flowers with white petals, are solitary or grow in small clusters. The fruit is small, orange in colour and ellipsoidal in shape with large essential oil glands. The rind is tightly attached to the pulp and is quite thick proportionally. The pulp does not contain a lot of juice and is acidic. It has a solid but small central axis and contains a few small seeds. Green cotyledons and light brown chalaza. The fruit is eaten whole, combining the sweetness of the peel with the acidity of the pulp.

Use and exploitation

The Nagami kumquat is of great ornamental value due to its dark green foliage, which sets a dark backdrop for the multitude of orange fruits, which remain on the tree for a long time without spoiling. In addition, its small compact size makes it suitable to cultivate in pots. The fruit is eaten fresh or made into jams or syrup, for which they are allowed to dry slightly and are then soaked in baking soda and baked at a low temperature. They are also used to make pickles, either acidic in a mixture of vinegar and brine, or sweet with vinegar, syrup, cloves and cinnamon.



Fortunella polyandra (Ridl.) Yu. Tanaka

Common name: **Malayan kumquat, Long-leaved kumquat.**

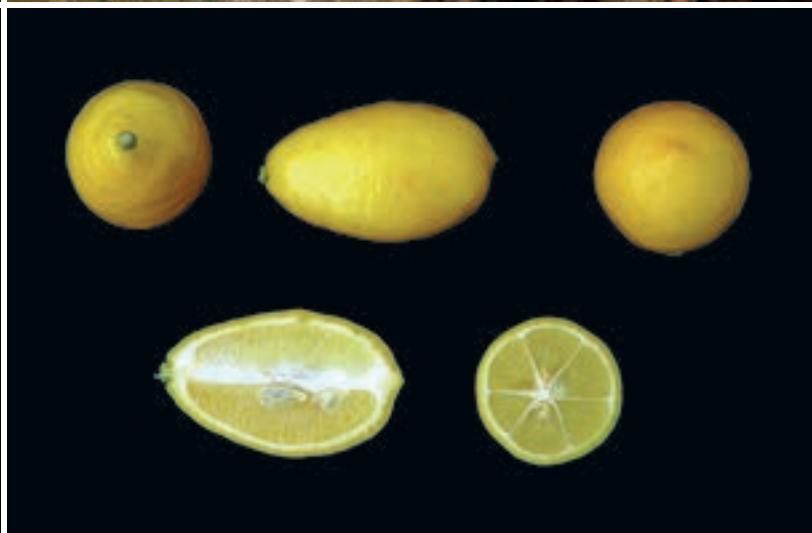
It is native to the Malaysian peninsular. It grows in this region and on the island of Hainan. It is the only kumquat from a tropical area.

Description

This slow growing tree bears hardly any thorns and is medium to small in size. It is sensitive to cold, unlike other kumquats. The leaf is medium to small, entire margin, lanceolate blade and narrow winged petiole. It differs from other kumquats in that its leaves are larger and have longer petioles. The flowers are small, growing in isolation or occasionally forming clusters of a few flowers. Blossoms have white petals, which are usually folded back. The fruit is orange, spherical or slightly pear-shaped, exceeding the Meiwa and Nagami kumquat in size. Fine and smooth rind, with the clearly visible, but not prominent, oil glands. Orange coloured pulp, tender and acidic, with a solid central axis and seeds.

Use and exploitation

The fruits are edible and consumed whole, including the rind. They are also dried and sold as a delicacy on the local markets of Malaysia, besides being processed for canning or the manufacture of beverages.



Citrus aurantifolia x *Fortunella japonica*

Common name: **Limequat.**

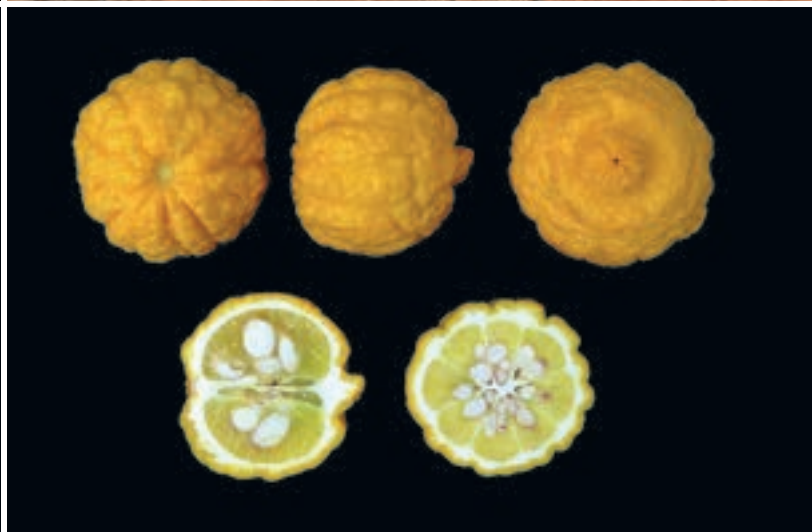
The Limequat is the result of a hybridization made in 1909 by W.T. Swingle, from the U.S. Department of Agriculture, Florida, between the Mexican lime and kumquat. The Nagami or oval kumquat was used to obtain the Tavares variety, while the Marumi or round kumquat was used to obtain Eustis and Lakeland, which are more frequently cultivated.

Description

The Limequat tree is small, compact, drooping growth habit and starts producing fruit when still young, which makes it very attractive as an ornamental plant. It bears a few small thorns. It is more cold-hardy than the Mexican lime but far less than the kumquat. Leaves are medium to small, dark green in colour. The blade is elliptical with an entire leaf margin and a glabrous wingless petiole. It exudes a lemon-like fragrance when handled. The flowers are small with white petals. The fruit is small, yellow, oval or round depending on the variety. Smooth rind, yellow, tender and acidic pulp harbouring seeds. The fruit is eaten whole to contrast the sweetness of the rind with the acid pulp, reminiscent of the Mexican lime.

Use and exploitation

It is used mainly, and almost exclusively, as an ornamental tree, either potted or planted in gardens. The fruits can be eaten fresh or used to substitute the Mexican lime. They have high vitamin C content, with greater concentrations in the peel than in the pulp.



Poncirus trifoliata (L.) Raf.

Common name: **Trifoliate orange.**

This is a member of the Rutaceae family, closely related to *Citrus*, and it is used as a rootstock for citrus grafts. The fundamental difference between them is that *Poncirus* is deciduous, with trifoliate leaves and hairy fruits. It is native to central and northern China, where it has been cultivated for thousands of years.

Description

Small tree, with erect growth habit, and easily recognizable by its numerous large, stout thorns. It is rustic and highly resistant to low temperatures. After winter dormancy the tree blossoms before sprouting new leaves. These have three leaflets, the central one generally being the largest. Entire leaf margin and long winged petiole. The flowers are large, with white petals, thinner than citrus and not as aromatic. Pinkish stamens, yellow anthers and hairy ovary. Small spherical fruit, yellow when ripe, with a rough rind covered in small hairs and bearing numerous essential oil glands. Well defined depressed areola. The pulp is yellow and juice is scanty. It contains many seeds, polyembryonic, with white cotyledons. The pulp is considered inedible due to its high acidity and bitterness. The fruit is easily removed when ripe.

Use and exploitation

It is mainly used as a rootstock for citrus grafts. It is also used as an ornamental plant in places where common citrus species do not grow. The fruit has no commercial value. In Asian countries such as China, the dried rind is used in traditional medicine. The Flying Dragon variety is characterized by smaller and more compact trees, with greatly twisted branches. They form an excellent hedge due to their bushiness and thorns.



Citrus sinensis x *Poncirus trifoliata*

Common name: **Carrizo citrange.**

Carrizo originated from a hybridization made by the U.S. Department of Agriculture in the early twentieth century, between the Washington navel sweet orange and *Poncirus trifoliata*. The aim was to obtain cold-hardy varieties. They did not manage to obtain an edible variety but one of the most commonly used rootstocks worldwide.

Description

Medium-sized compact tree exhibiting vigorous and drooping growth habit. It bears numerous straight fine thorns. The new shoots are green. Leaves are glossy dark green, trifoliate, with a clearly larger central leaflet. Leaves are ovoid with entire leaf margin and a long, winged petiole. Flowers are large with white petals, very similar to *P. trifoliata*, with free stamens, yellow anthers and pubescent ovary. The fruit is spherical, medium-sized, with a very smooth surface and orange when ripe. Rind is thin and firmly attached. Firm yellow pulp with a solid and rounded central axis. It holds numerous seeds, indispensable for its use as rootstock. These are plump, polyembryonic, with white cotyledons and purple chalaza. The juice is not very abundant and highly acidic.

Use and exploitation

In the late nineteen-fifties the citrus tristeza virus reached Spain, causing the death of orange and mandarin grafted onto sour orange. This led to a ban on the use of this rootstock and its replacement by other disease-tolerant ones. In the main, Citrange was adopted, Troyer in the first instance and Carrizo later. The latter is used much more than any other as a rootstock by the Spanish citrus industry.



Clausena anisata (Willd.) Hook. f.

Common name: **Horsewood, Umsanga, Mudede, Maggot killer.**

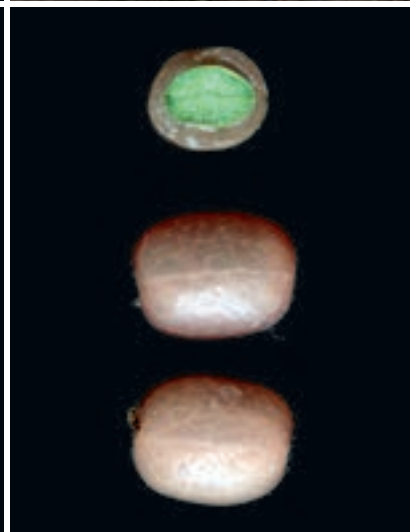
This citrus originated in West Africa. It grows in the region spanning Guinea and Sierra Leone eastward to Ethiopia, Sudan and also in the southern Cape Province. It is only absent in the driest regions.

Description

Medium-sized tree with a thick crown and flexible thornless branches. The new shoots are green and pubescent. Leaves are large, imparipinnate, with asymmetrically positioned leaflets in varying numbers, ranging from ten to twenty per leaf. The blade is elliptical with an entire margin and wingless petiole. It exudes a pungent anise-like scent when leaves are crushed. Panicle inflorescences, with small flowers bearing white or cream-coloured petals and yellow anthers. The berry-like fruit is small, spherical and red or purple. The pulp is sweet tasting and holds seeds.

Use and exploitation

Clausena anisata is commonly used in traditional medicine throughout tropical Africa. All parts of the plant are used: roots, leaves, bark and trunk. Healers prescribe them for a variety of ailments, too numerous to list here but which include treatment of fever, pneumonia, headache, sore throat, sinusitis, wounds, toothache, sores, abscesses, burns, haemorrhoids, malaria, syphilis, kidney problems and diabetes. The dried leaves are used as an insect repellent. The twigs are used as toothbrushes, and the branches as walking-sticks or to make tools. The fruit tastes sweet and is eaten locally. The bark is used as rope for barn construction. Twigs and leaves are used in religious ceremonies and magic rites to ward off evil spirits.



Clausena excavata Burm. f.

Common name: **Pink wampee.**

Clausena excavata is known as the pink wampee due to its striking pink fruit, although it receives numerous local names in different countries. A native of India, this species is widespread from Southeast Asia to New Guinea.

Description

Medium to small-sized thornless tree. It grows well in tropical or subtropical climates. It has a single trunk, but is sometimes branched from the base. The branches have small hairs. It has very large imparipinnate compound leaves, with a variable number of leaflets (up to thirty), and a wingless slender cylindrical rachis. Leaflets are lanceolate and have an entire margin, although this may be slightly dentate. They give off a characteristic curry-like smell when handled. The flowers are small, with white petals arranged in terminal clusters. Small ellipsoidal juicy fruit with a smooth surface, which turns pink when ripe. It usually has one seed per fruit.

Use and exploitation

In China, Indochina, Thailand, Malaysia peninsular and Java, the juice of the leaves is taken against intestinal worms and sometimes mixed with turmeric to treat fever, malaria and colds. A brew of the roots, flowers or leaves is ingested for digestive system disorders, such as colic, dyspepsia and stomach pain. The crushed root or leaves are used as a poultice for wounds. In Malaysia it is attributed magical properties. In Java, axe handles are made with the wood. The leaves have insecticidal properties. The tree is sometimes planted ornamentally, especially for its huge clusters of pink fruit.



Clausena lansium (Lour.) Skeels

Common name: **Wampee.**

It is native to southern China and Vietnam and is widely cultivated in tropical or subtropical regions.

Description

The tree is medium-sized, erect growth habit with flexible branches and gray-brown bark, rough to the touch. Branches are initially pubescent. Leaves are pinnate, with a total of five to nine leaflets. The leaf blade is oval, with a sinuate or slightly dentate margin. The petiole is slightly verrucose. The inflorescences are large panicles at the end of the branches, bearing whitish or greenish-yellow petals. Fruit hangs in showy dangling clusters. It is brownish-yellow in colour, spherical in shape and easy to peel. The rind is slightly hairy, thin and flexible, with numerous light brown oil glands. The pulp is yellowish-white or colourless, like grapes, sweet and juicy. Seeds are plump and bright green with brown tips; there is usually one per fruit.

Use and exploitation

The fruits are prized in parts of China for fresh consumption and for making desserts, jellies and jams. In Southeast Asia a champagne-like beverage is made with the juice. The pulp is used as a stomach remedy and as a vermifuge in traditional medicine. Unripe fruits are cut open and sun-dried to make a remedy for bronchitis in China and Vietnam. Thin slices of their roots are sold in Oriental pharmacies for the same purpose. A brew of the leaves is used as shampoo to eliminate dandruff and preserve hair colour.



Microcitrus warburgiana (F.M. Bail.) Yu. Tanaka

Common name: **New Guinea Wild Lime.**

As indicated by the name, it is native to New Guinea. It is the only one of the six known species of *Microcitrus* that does not originate in Australia.

Description

Small, slow-growing tree with a compact or bushy crown, and erect growth habit. It does not bear thorns or has very few. The leaves are lanceolate and often emarginate, medium-sized, leathery and with a dentate leaf margin. The petiole is short with very narrow wings, and is lighter in colour than the leaf blade. These leaves are not as well adapted to extended droughts or to hot dry winds as other *Microcitrus* are. Flowers are small with white petals and free stamens. The small fruits are spherical and dark green, with a slightly rough surface, and hang from the branches on thick stalks. The rind is thin, and the greenish pulp is tender and contains seeds.

Use and exploitation

No known use.



Eremocitrus glauca (Lindl.) Swingle

Common name: **Desert lime.**

Shrub inhabiting arid regions, endemic to Queensland, New South Wales and southern Australia. Its name comes from the Greek word *eremos*, meaning desert, referring to its habitat, and the Latin *glauca*, which refers to the blue-green colour of the leaves. Within the *Citrus* genus, this is the most resistant species to heat, drought and cold.

Description

It is usually a thorny shrub or small, compact tree, although larger specimens have been described. Notably xerophytic, it is able to withstand extremely severe drought and hot winds. Under these conditions it loses its leaves and photosynthesizes through its twigs at a lower rate. The seedling develops a large root system before developing the aerial part. Leaves are small, thick, wingless, lanceolate, often emarginate and with a slightly dentate or entire leaf margin. Leaves are greyish green and flowers are very small and white. Flowers are solitary or form clusters of two or three in the leaf axils, scarcely pedicellate. Small yellow fruit, which is more or less spherical in shape, though it may sometimes be ellipsoidal, with smooth-textured rind. Greenish-yellow acidic-tasting pulp, with monoembryonic seeds.

Use and exploitation

The desert lime is prized by Aboriginal peoples and constitutes part of their diet, known as *bushfood*, enabling them to survive in the Australian semi-desert. It tastes like a lime. It is also consumed in jams, beverages or as glazed fruit. It is potentially important in citrus breeding programs given its extreme resistance to drought and undemanding soil requirements.



Microcitrus australis × *M. australasica*

Common name: **Sydney hybrid.**

This hybrid is a cross between *M. australis* and *M. australasica* from seeds sent from the Botanical Garden of Sydney (Australia) to the U.S.A. It was provisionally given the scientific name *Microcitrus virgata* until its hybrid origin was discovered. It is notable for its extreme vigour, producing longer branches than any other known citrus.

Description

A highly vigorous tree with abundant thorns, compact crown and copious thin branches, which grow well even in conditions considered harsh for other citrus. The new shoots are purple. Leaf blades are elliptical generally emarginate with a finely serrated margin. Leaf size is intermediate between the parent plants, but as it has many branches and, consequently, a multitude of leaves, these are often small, more like the parent plant *M. australasica*. When crushed, leaves do not give off any fragrance. Flowers are white with spoon-shaped petals. Sepals are at a 90-degree angle, in the bisector with petals arranged in the same way. Relatively small fruits, spherical or ellipsoidal in shape, which are green or light green and rough. Thin rind with numerous essential oil glands. The greenish pulp is slightly aromatic, acidic and juicy, with a small solid central axis. It does not usually bear seeds.

Use and exploitation

It is of ornamental value given the large number of twigs and small leaves, as well as its hardiness. It might be of interest as a rootstock for other citrus for cultivation in soils with poor organic nitrogen content.



Atalantia ceylanica (Arn.) Oliv.

Common name: **Ceylon atalantia.**

Native to southern India, *Atalantia ceylanica* grows there and also on the nearby island of Sri Lanka, formerly Ceylon.

Description

Small densely branched compact tree, with drooping growth habit. Virtually thornless. Lanceolate or slightly oval, leathery leaves, often emarginate and green, though paler on the underside. Blade with entire margin and wingless petiole. The flowers are small, fragrant, white petals rounded at apex, yellow anthers and free stamens. The inflorescence forms clusters. Small dark-coloured fruits, almost black when ripe and spherical or slightly oblate in shape. Smooth rind. The fruit is almost dry, with scarcely any juice. Seeds take up most space in the pulp.

Use and exploitation

It produces very hard wood, which is recommended as a substitute for boxwood. Fruit oil can be extracted and is heated by native doctors to treat chronic rheumatism.



Atalantia citroides Pierre ex Guill.

Common name: **Cochinchina atalantia**.

It grows throughout southern Vietnam, Cochinchina and Cambodia.

Description

Medium-sized, compact tree, with fine straight thorns in the leaf axils. The colour of the bark is greyish. It is probably the most vigorous and largest of the *Atalantia* subgenus. The leaves are leathery, oval, emarginate at the apical end and with an entire margin. Wingless petiole. Inflorescences that form clusters in the axils of the leaves, with small flowers. The petals are white and stamens, often fused, have yellow anthers. The fruit resembles a small spherical or slightly oval orange. Pale orange when ripe, with a juicy orange pulp and with seeds.

Use and exploitation

No known use.



Aegle marmelos (L.) Corr.

Common name: **Bael, Golden apple, Holy fruit, Marmelos.**

Native to India, it is widely cultivated in Southeast Asia. The tree grows wild in central and southern India and Burma, Pakistan and Bangladesh. It is mentioned in writings dating back to 800 BC. It is cultivated throughout India, mainly in temple gardens as it is a sacred tree.

Description

Medium-sized slow-growing tree, irregular and drooping growth habit. It bears abundant large straight thorns. Lower branches tend to grow downwards giving it a weeping appearance. Young shoots are red-brown in colour. Trifoliolate leaves with a pair of opposite short-stalked leaflets and one larger terminal leaflet with a longer petiole (longipetiolate). Blade ovoid in shape, with a crenate margin. Flowers are greenish-white, fragrant, with fleshy petals and pubescent pedicels. The fruit is spherical or ellipsoidal-spherical in shape and medium or large in size. The reddish-brown rind is very smooth and very hard. The pulp, yellow and fibrous, is very aromatic and sweet. It may be more or less astringent. Plentiful seeds covered in woolly hairs, arranged in cells surrounded by transparent, viscous mucilage.

Use and exploitation

This fruit is held in high esteem by Hindus, who regard it as the best citrus. When ripe, it is fresh, healthy, nutritious, and very palatable. Before reaching maturity, due to its astringency it is used to stop diarrhoea and dysentery, common in India during the summer months. The pulp, eaten with sugar, is a common breakfast in Indonesia. It is also used to make jams or syrup. The pulp acts as a detergent and is used for washing clothes. Useful as homemade glue, it is even valued as an adhesive by jewellers. Young leaves and shoots are eaten as a vegetable in Thailand and are used to flavour food in Indonesia. In Hindu culture, the leaves are indispensable offerings to the god Shiva, as it is one of the sacred plants of Hinduism. The fruits, roots and leaves have antibiotic activity and the roots, leaves and bark are used to treat snakebite.



Aeglopsis chevalieri Swingle

Common name: **Chevalier's Aeglopsis.**

Native to Africa, together with *Aegle*, *Afraegle* and *Balsamocitrus* it forms the Aegle group of citrus fruits with a hard shell-like peel (woody).

Description

This small or medium-sized bushy tree bears straight, stout thorns on its branches. The leaf is simple, unlike *Aegle* and *Balsamocitrus*, leaf blade not articulated with the petiole, which is wingless. Medium in size, the leaf is elliptical, with a slightly dentate margin. The fruits are pear-shaped, similar to those of *Aegle marmelos* but smaller. Semi-woody, shell-like rind, turning yellow when ripe.

Use and exploitation

No known use.



Balsamocitrus dawei Stapf.

Common name: **Bael**.

The fruit is very similar to the *Aegle marmelos*, so it is also known by the name of Bael. This species, related to citrus, is native to the highlands of Uganda, in East Africa, where it grows at altitudes of 600 to 900 meters above sea level.

Description

The tree is vigorous, medium in size, drooping growth habit and bearing numerous long, straight thorns. The young shoots have a reddish hue. Trifoliate leaves have a pair of opposite leaflets and one clearly larger terminal leaflet. The shape of the leaf blade is oval, with a slightly crenate margin and without wings on the petiole. Flowers usually comprise four white petals and a small number of stamens with yellow anthers. They are highly aromatic. The fruit is large, the size of a grapefruit, brownish green in colour and ellipsoidal. It has a hard outer shell. The pulp is edible and gives off a pleasant aroma. It lacks juice vesicles and bears numerous seeds.

Use and exploitation

It is basically used as an ornamental tree.



Feroniella oblata Swingle

Common name: **Unknown.**

Native to the eastern part of the Indochinese peninsula, it is fairly common in the forests covering the plains and mountains in this area.

Description

Medium-sized tree, drooping growth habit and producing hardwood. It bears many axillary, short, straight thorns. Pinnate leaf usually comprising more than seven opposite leaflets, which are oval with a rounded apex. The leaf blade margin is entire or slightly dentate. Pubescent petiole. Narrow wings on the rachis. It gives off an unpleasant odour when crushed. Inflorescences bear clusters of flowers with greyish-white petals. The spherical or slightly ellipsoidal fruits are medium in size and form clusters. The rind can be black, red or pink, with a slightly rough texture and a woody firmness. The pulp is reddish and holds numerous seeds.

Use and exploitation

No known use.



Citropsis gilletiana Swingle et M. Kell

Common name: **Gillet's cherry-orange.**

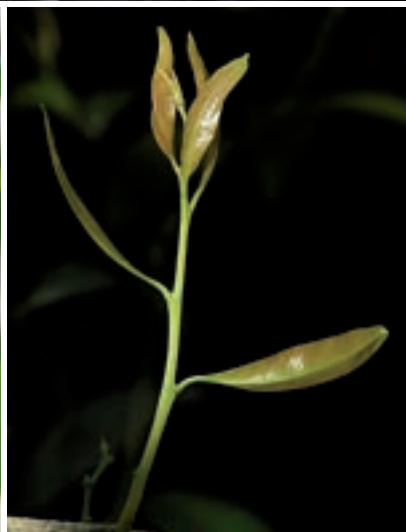
It is the largest and most vigorous of all known plants within the genus *Citropsis*. It originated in tropical forests of West Africa.

Description

Medium-sized tree bearing abundant large straight thorns. Very large leaves, usually composed of five leaflets although some may be trifoliate. Presence of large wings on the petioles, oval in shape. Oval leaf blade with dentate margin. Axillary inflorescences placed in clusters comprising numerous flowers with white petals. Small, spherical or slightly ellipsoidal fruit, yellow when ripe. Thin rind. Pulp is yellow amber and inedible as it is very sour. It has an unpleasant odour. It bears seeds, which are monoembryonic.

Use and exploitation

Given its vigour, it is being tested as a rootstock for grafting



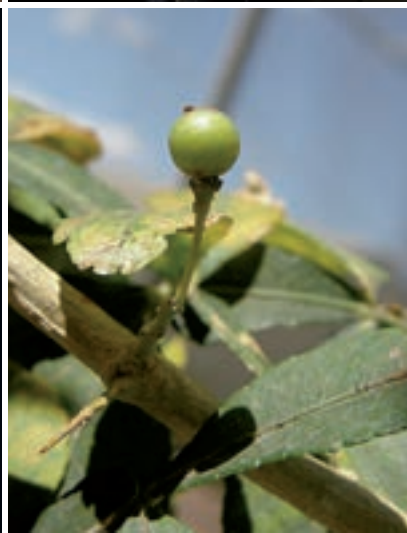
Severinia disticha (Blanco) Swingle

Common name: **Philippine box-orange.**

To be found in Luzon and Mindanao Islands in the Philippines, Sabah (North Borneo) and Banguay Island, Malaysia.

Description

Small, compact tree with drooping growth habit. Not usually thorny. Leaves with short petioles, glabrous without wings. Oval leaf blade with crenate margin, medium to small in size. Often the leaf apex is emarginate. Flowers are axillary or form terminal clusters. The fruit is small and spherical or slightly ellipsoidal, yellowish-green in colour, smooth rind with numerous oil glands. Monoembryonic seeds are present in the pulp.



Hesperethusa crenulata (Roxb.) M. Roem

Common name: **Unknown.**

Native to India and Indochina. It covers a wide area, ranging from West Pakistan to Burma and southwest China to southern Indochina (Cambodia).

Description

Small tree, drooping growth habit and thorny. It is considered semi-deciduous. The thorns are abundant, straight and thin. Leaves are pinnate with a number of leaflets, ranging between five and seven, oval and crenate margin. The glabrous petiole is long, with narrow wings. The rachis has larger wings. Axillary inflorescences, in tight bunches composed of a few flowers, which are small and fragrant with four white petals. Very small spherical fruits, black when ripe. Scarce and bitter pulp, containing a single seed.

Use and exploitation

Hesperethusa crenulata produces a hard, fine-grained pale yellow wood. Its leaves, fruits and roots are used to manufacture medicines in India. It is also used in Arabia as a condiment for fish or meat, powdered and mixed with common culinary spices. The tree is promising as an ornamental plant.



Murraya paniculata (L.) Jack

Common name: **Orange jessamine.**

Native to Southeast Asia, China and the Southwest Pacific. It is known as orange jasmine due to the fragrance of its many flowers, reminiscent of jasmine.

Description

Small to medium-sized vigorous tree, with a very compact canopy and drooping growth habit. Thornless branches. The new shoots are green and pubescent. Imparipinnate bright green ovoid leaf with entire margins. Sometimes the rachis is pubescent. Terminal corymb-shaped inflorescence, small and dense. Flowers, medium size, have backward-bending white petals; free stamens with yellow anthers. The abundant flowers have a pleasant fragrance. *Murraya paniculata* bears small, ellipsoidal red berry-like fruit; fleshy but inedible. It has one or two seeds per fruit.

Use and exploitation

It is used mainly as an ornamental tree, planted singly or to form hedges, given its spectacular bloom and aroma. Its wood, especially the roots, is highly valued by the Malays to make tools. The honey collected from hives near these trees has a distinctive and highly esteemed taste. The leaves, used in traditional medicine, have analgesic properties.



Glossary of terms

A

Abiotic (stress): Changes in cell metabolism, induced by abiotic factors, which affect plant physiology and development. Abiotic factors are not related to living organisms but to other factors such as the environment (climatic, geological or geographical).

Acidulous: Slightly acidic.

Anther: Upper stamen of the flowers, shaped like a small, single or double sack, where pollen is produced.

C

Carpel: Transformed leaf forming a pistil or part of a pistil.

Chalaza: Region of the ovule where funiculus, integuments and nucellus join.

Corymbus: Inflorescence in which the flowers cluster at the same level at the apex, their stems arising at different heights on the main axis.

Cotyledon: Embryonic leaf which absorbs and stores nutrients located in the seed until the seedling is able to produce true leaves and photosynthesize.

Cryopreservation: The process by which cells, tissues or organisms are frozen at ultra low temperatures to stop their biological activity and thus sustain them.

Cutinisation: Process whereby cutin is embedded in the outer cell wall of plant cells. Cutin is a polymer formed by saturated and unsaturated long-chain fatty acids linked by ester bonds, and is secreted by cells of the epidermis.

D

Deltoid: Usually used to describe leaves shaped like the letter delta, i.e., an isosceles triangle with a not very wide base.

Diploid: Describes a cell, tissue, organism or species that has two identical sets of chromosomes (one from each parent).

E

Emarginate: Having a shallow notch at the apex.

G

Genotype: Genetic information each organism holds in its DNA, inherited from its parents.

Glabrous: Without hair.

I

Imparipinnate: pinnate compound leaf with a single terminal leaflet, so it has an odd number of leaflets.

Inflorescence: The grouping arrangement of flowers on plant.

L

Leaf blade: Enlarged portion of a typical leaf.

Locule: Cavity in ovary or fruit in which ovules and seeds are located.

Longipetiolate: Term used when the length of the leaf petiole is similar or longer than that of the leaf blade.

M

Meristem: Describes the embryonic plant tissue formed by undifferentiated cells which, by continuous division, are able to generate specialized plant tissues and organs, and perpetuate plant growth.

Mycorrhiza: Symbiotic association between plant roots and hyphae of certain fungi.

Monophyletic: Describes the group of individuals that have evolved from a common ancestral population and includes all descendants of that ancestor.

N

Nucellus: Central tissue of rudimentary seeds, surrounded by the integument or integuments.

O

Oleiferous: Containing oil.

Organoleptic: Describes the properties perceived by the senses (colour, taste, smell).

Ovary: In flowering plants the basal gynoecium that contains ovules, which turns into the fruit when ripe.

P

Panicle: Inflorescence composed of clusters decreasing in size towards the apex.

Parent: Describes progenitors of progeny produced either sexually or asexually.

Petiole: Stalk that joins the leaf blade to its base or branch.

Pedicelled: Having a pedicel (peduncle or stalk joining each flower to the inflorescence).

Phyllotaxy: Spatial arrangement of leaves on the branches. This arrangement is characteristic of each species and its function is to maximize exposure of the leaves to sunlight.

Pinnate: describes a compound leaf with numerous leaflets (always more than three) arranged on each side of a common petiole or axis.

Piriformis: Pear-shaped.

Pistil: Female reproductive organ of flowering plants, which is bottle-shaped and located in the centre of the flower, surrounded by stamens.

Primordium: An organ in its most rudimentary form or initial stage of development.

Pubescent: Covered with fine soft hairs.

R

Rachis: Central vein of compound leaves to which the leaflets are attached.

Receptacle: End of the pedicel or peduncle, somewhat widened, to which the floral whorls (calyx, corolla, androecium or gynoecium) or flowers are attached.

RH: Relative Humidity is the percentage ratio of actual water vapour content of the air and the amount needed to reach saturation at the same temperature.

S

Stamen: Each pollen-forming organ which together form the androecium.

Stigma: Apical portion of the style where pollen grains collect.

Style: Top of the ovary, elongated and style-shaped and terminating in one or more stigmata.

Sepal: Parts of the flower that collectively form the calyx; they are usually greenish in colour and serve a protective function. Together with the petals of the corolla they form the perianth.

T

Tetraploid: Describes cells, tissues or organisms that have four sets of chromosomes.

Thermal regime: A parameter describing the distribution of monthly temperatures throughout the year.

Triploid: Describes cells, tissues or organisms that have three sets of chromosomes.

V

Variegated: Describes plants that have multicoloured leaves, fruits or trunks.

W

Wing: Prominent widening of the petiole.

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Links of interest

- <http://www.ivia.es/>
- <http://www.fao.org/statistics/es/>
- <http://www.magrama.gob.es/es/estadistica/temas/estadisticas-agrarias/>
- <http://www.fao.org/forestry/4994/es/>
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