Tropical and Subtropical Fruits

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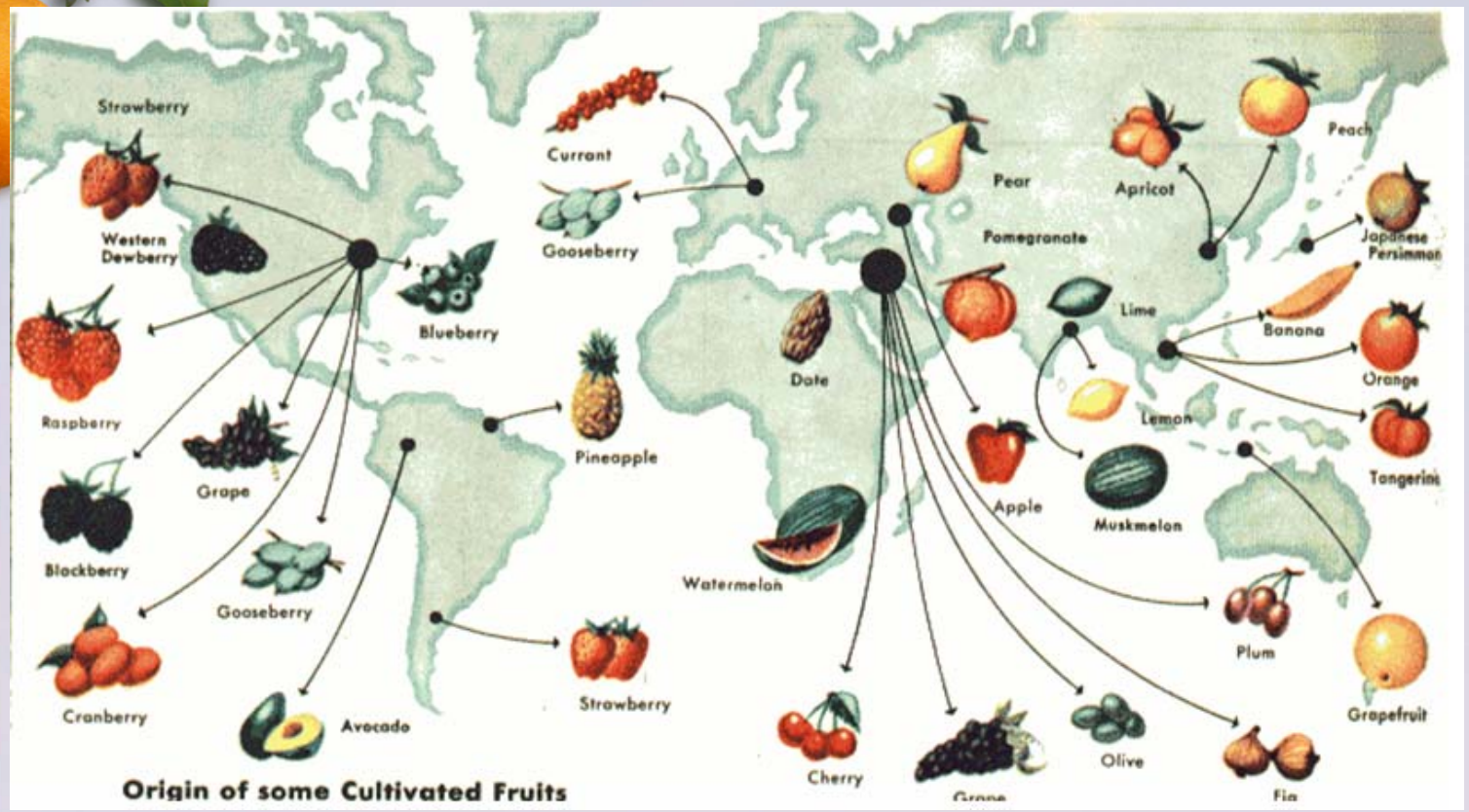
Citrus

Latitude: 35° N and S (Citrus Belt)

Origin:

Citrus plants are native to subtropical and tropical regions of Southeast Asia, from northeastern India to South China

Geographical distribution of the origin areas of the Asian *Citrus* species divided by Tanaka's line


Strawberry
Western Dewberry
Blueberry
Raspberry
Grape
Blackberry
Gooseberry
Cranberry
Avocado
Currant
Gooseberry
Pineapple
Strawberry
Watermelon
Date
Cherry
Pear
Pomegranate
Grape
Olive
Apricot
Peach
Japanese Persimmon
Lime
Banana
Orange
Lemon
Tangerine
Apple
Muskmelon
Plum
Grapefruit
Fig
Origin of some Cultivated Fruits

Centre of origin in citrus spp

Origin	Citrus spp
China	Sweet orange, Mandarin
India	Kagzi lime
South- east	Pummel, lemon

History:

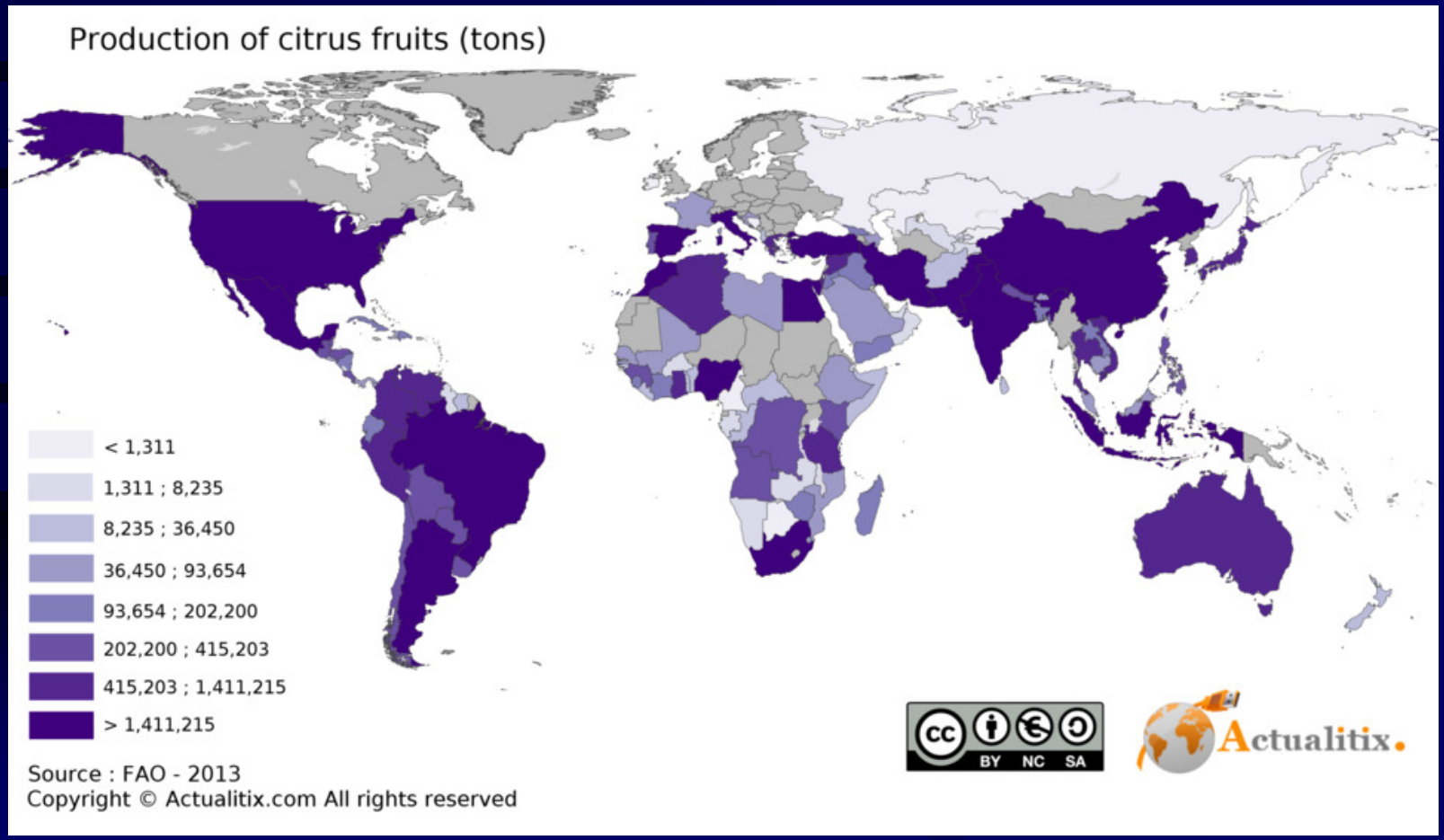
Cultivated as tree fruit for at least 2,200 B.C. (China)

The first book (1178, China)

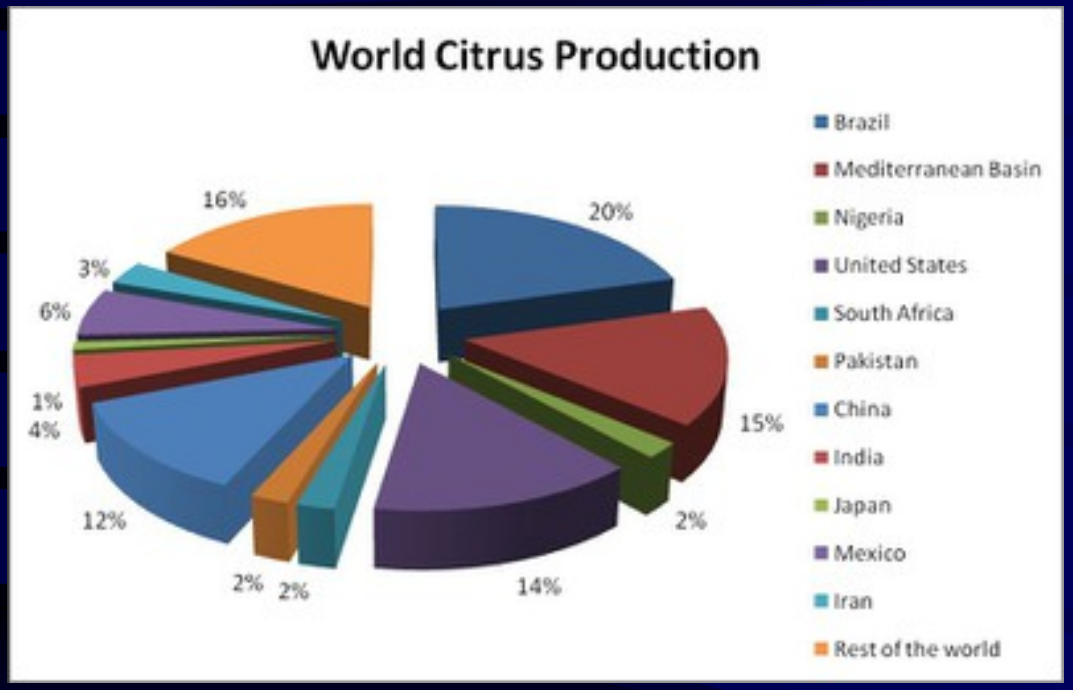
Mediterranean regions (200-250 B.C)

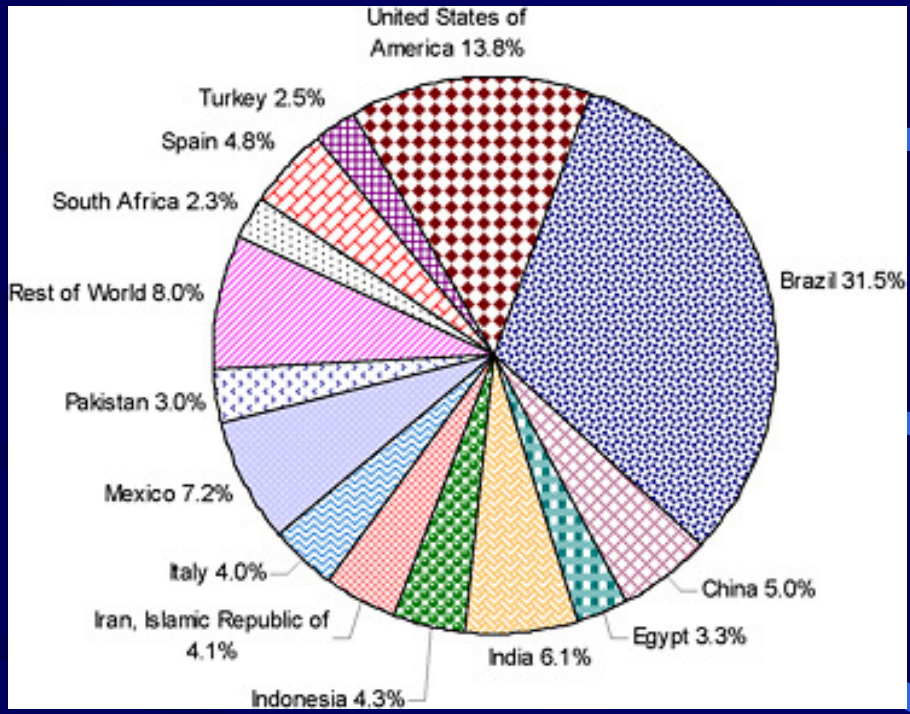
America Continental country (1493, Haiti)

Distribution and World Production



Distribution and World Production





Worldwide orange production, percent total production, Source: FAOSTAT, 2007.

پراکنش کشت مرکبات در ایران

ایران دارای سه ناحیه کشت مرکبات شامل نواحی ساحلی دریای خزر، نوار مرکزی و نوار جنوبی است.

ناحیه ساحلی شمالی شامل استانهای مازندران، گیلان و گلستان است قسمت عمده تولید مرکبات این نوار مربوط به استان مازندران است در این ناحیه پرتقال و نارنگی کیفیت بهتری نسبت به سایر مرکبات دارد.

ناحیه مرکزی شامل استانهای فارس، کرمان، جنوب کرمان، کرمانشاه، ایلام، کهگیلویه و بویراحمد و خوزستان است قسمت عمده تولید مرکبات این نوار مربوط به استانهای فارس و کرمان است. کشت و کار انواع مرکبات در این نوار مرسوم بوده و قسمت عمده لیموشیرین و کریپ فروت در این نوار تولید می‌شود

ناحیه ساحلی جنوب کشور در واقع حاشیه باریکی در ساحل خلیج فارس و دریای عمان است و شامل استانهای بوشهر هرمزگان و سیستان و بلوچستان است در این نوار لایم و لیمو نسبت به پرتقال و نارنگی کیفیت بهتری دارند و قسمت عمده تولید مرکبات این ناحیه در استان هرمزگان است.

سطح زیرکشت:

سطح زیرکشت مرکبات کشور در سال ۱۳۹۶ بالغ بر ۲۹۸ هزار هکتار بوده است. استان مازندران با حدود۳۶ درصد سطح زیرکشت مرکبات بیشترین سطح را دارا بوده و استانهای فارس، جنوب کرمان ،هرمزگان ، گیلان و کرمان به ترتیب مقام های دوم تا ششم را به خود اختصاص داده اند و شش استان مذکور در مجموع ۹۰ درصد از سطح زیرکشت مرکبات کشور را دارا هستند.

میزان تولید:

میزان تولید مرکبات کشور حدود بیش از ۵ میلیون تن در سال ۱۳۹۶ بوده است و بیشترین میزان تولید مرکبات با ۴۴ درصد مربوط به استان مازندران است . استانهای فارس ، جنوب کرمان، هرمزگان، گیلان و کرمان به ترتیب مقام های دوم تا ششم را بخود اختصاص داده اند. شش استان مذکور حدود۹۴ درصد تولید مرکبات کشور را دارا می باشند

Citrus in Iran

ردیف	کشور	تولید (تن)	سطح بارور (هکتار)	عملکرد (کیلوگرم بر هکتار)	درصد ازکل تولید نارنگی جهان
۱	چین	۱۷۱۵۵۴۹۳	۱۷۲۲۱۶۲	۹۹۶۱	۵۲/۳
۲	اسپانیا	۲۹۴۱۹۷۱	۱۶۴۰۴۰	۱۷۹۳۴	۹
۳	ترکیه	۱۳۳۷۰۳۷	۴۶۵۶۹	۲۸۷۱۰	۴/۱
۴	مراکش	۱۰۷۷۶۲۸	۶۲۱۹۳	۱۷۳۲۷	۳/۳
۵	مصر	۱۰۲۰۴۹۲	۴۴۸۲۴	۲۲۷۶۶	۳/۱
۶	برزیل	۹۹۷۹۹۳	۴۹۲۳۲	۲۰۲۷۱	۳
۷	ژاپن	۸۰۵۱۰۰	۴۱۵۰۰	۱۹۴۰۰	۲/۵
۸	آمریکا	۷۷۹۷۸۷	۲۷۰۴۶	۲۸۸۳۲	۲/۴
۹	ایران	۷۷۸۶۳۲	۳۶۱۹۵	۲۱۵۱۲	۲/۴
۱۰	کره جنوبی	۶۹۸۷۴۱	۲۱۶۶۷	۳۲۲۴۸۶	۲/۱
جهان		۳۲۷۹۲۵۳۰	۲۶۰۹۱۲۱	۱۲۵۶۸	

میزان تولید، سطح بارور و عملکرد نارنگی در کشور های برترتولید کننده در سال ۲۰۱۶

	کشور	میزان تولید(تن)	سطح بارور(هکتار)	عملکرد(کیلوگر م بر هکتار)	درصد ازکل تولید پرتقال جهان
۱	برزیل	۱۷۲۵۱۲۹۱	۶۵۸۹۴۵	۲۶۱۸۰	۲۳/۶
۲	چین	۸۴۱۹۸۸۱	۵۰۱۰۹۲	۱۶۸۰۳	۱۱/۵
۳	هند	۷۵۰۳۰۰۰	۵۷۸۰۰۰	۱۲۹۸۱	۱۰/۳
۴	امریکا	۵۱۶۰۰۰۰	۲۲۳۱۴۴	۲۳۱۲۴	۷/۱
۵	مکزیک	۴۶۰۳۲۵۳	۳۱۴۵۸۸	۱۴۶۳۳	۶/۳
۶	مصر	۳۴۳۸۰۳۰	۱۵۱۴۸۷	۲۰۷۱۱۶	۱/۸
۷	ایران	۲۸۸۷۴۴۲	۱۵۹۰۶۴	۱۸۱۵۲	۳/۹
۸	اندونزی	۲۱۳۸۴۷۴	۱۳۶۰۱۵	۲۵۲۷۷	۲/۹
۹	ترکیه	۱۸۵۰۰۰۰	۵۶۵۱۱	۳۷۸۴۲	۲/۵
۱۰	ایتالیا	۱۴۹۵۰۶۷	۳۳۳۴۶	۴۰۹۶۴	۱/۹
جهان		۷۳۱۸۷۵۷۰	۳۹۶۵۲۶۵	۱۸۴۵۷	۱۰۰

میزان تولید، سطح بارور و عملکردپرتقال در کشور های برترتولید کننده در سال ۲۰۱۶

Nutritional Value

Table 1: Chemical composition of *Citrus Fruits* (per 100g of edible portion).

Component	*C. Sinensis*	*C. paradisi*	*C. reticulate*	*C. aurantifolia*	*C. aurantium*	*C. Limon*
Moisture (g)	88.4	88.5	87.8	84.6	87.6	85
Protein (g)	0.8	1	0.9	1.5	0.7	1
Fat (g)	0.3	0.1	0.3	1	0.2	0.9
Fibre, g	0.5	-	-	1.3	0.3	1.7
Carbohydrates (g)	9.3	10	10.6	10.9	10.9	11.1
Minerals (g)	0.7	0.4	0.4	0.7	0.3	0.3
Calcium (mg)	40	30	50	90	26	70
Phosphorous	30	30	20	20	20	10
Iron (mg)	0.7	0.2	0.1	0.3	0.3	2.3
Thiamine (mg)	-	0.12	40	0.02	-	0.02 (in juice)
Riboflavin (mg)	-	0.02	-	0.03	-	0.01 (in juice)
Niacin (mg)	-	0.3	-	0.1	-	0.01(in juice)
Vitamin C (mg)	50	-	68	63	30	39 (in juice)
Carotene, µg	-	-	350	15	1104	-
Energy, K cal	43	45	-	59	48	57

Systematic Description of the Citrus

Family: Rutaceae (130 Genus)

Subfamily:Aurantioideae (33 Genus)

Tribe: Citreae (28 Genus)

Subtribe: Citrinae (6 Genus)

Genus:

Citrus
Poncirus
Furtunella
Microcitrus
Eremocitrus
Clymenia

Poncirus trifoliata (Trifoliate Orange)

Citrange: *P. trifoliata*× *C. sinensis* (Troyer, Carrizo)

Citrandarin: *P. trifoliata*× *C. reticulate*

Citradia: *P. trifoliata*× *C. aurantium*

Citrumelo: *P. trifoliata*× *C. paradisi*

Citrumquat: *P. trifoliata*× *Fortunella sp.*

Citrangor: Citrange × *C. sinensis*

Poncirus sp.

- *Poncirus trifoliate*
- Rootstock
- Deciduous tree
- Trifoliate leaves

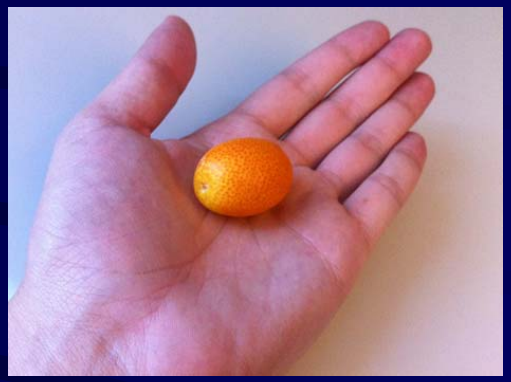
Fortunella (Kumquat)

F. margarita

F. japonica

F. hindsii

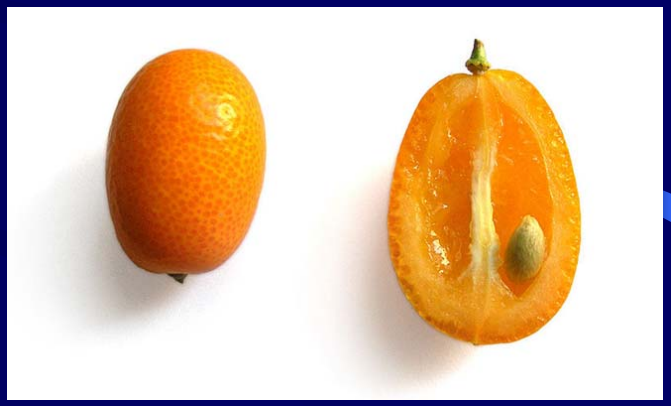
F. crassifolia



Limequat

Orangequat

Citrumquat



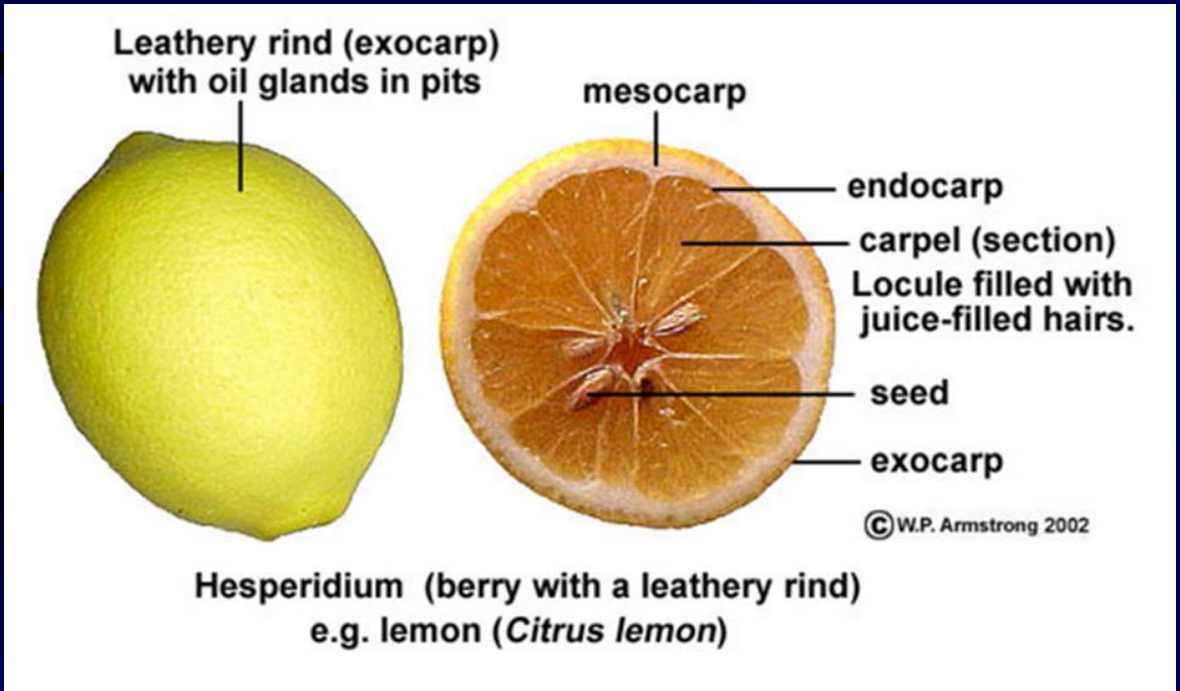
Fortunella Sp.

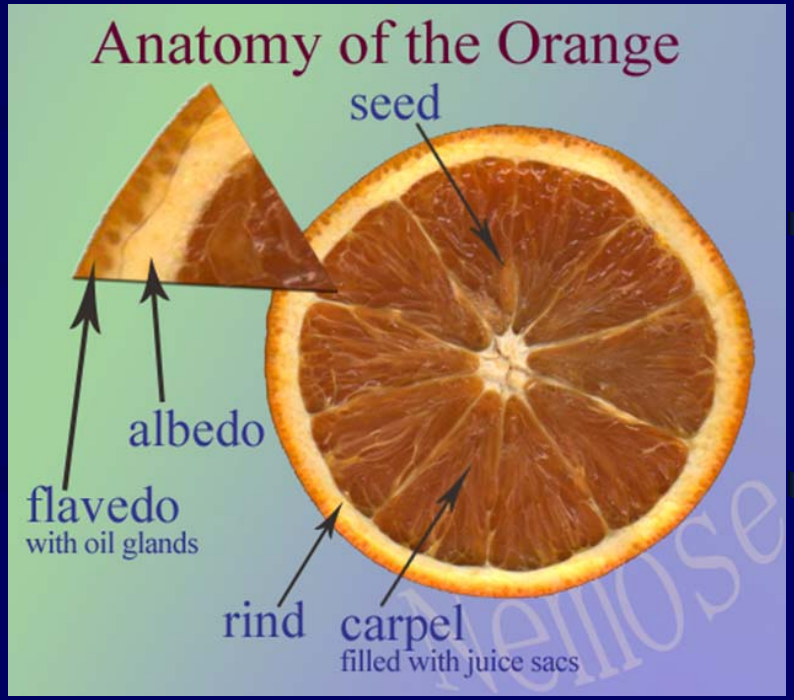
- Kumquats
  - Naghmi (Oval Kumquat)
  - Mewa (Round Kumquat)

Kumquat (*Fortunella margarita*)

Citrus

Hesperidium (Berry)





Citrus Classification

1- Swingle (16)

Eucitrus (10)

Papeda (6)

2- Tanaka (144)

Archicitrus (98)

Metacitrus (46)

3- Hodgson (36)

4- Macrowitch (20)

Aurantium (7)

Nobilis (5)

Intermedium (6)

Medica (2)

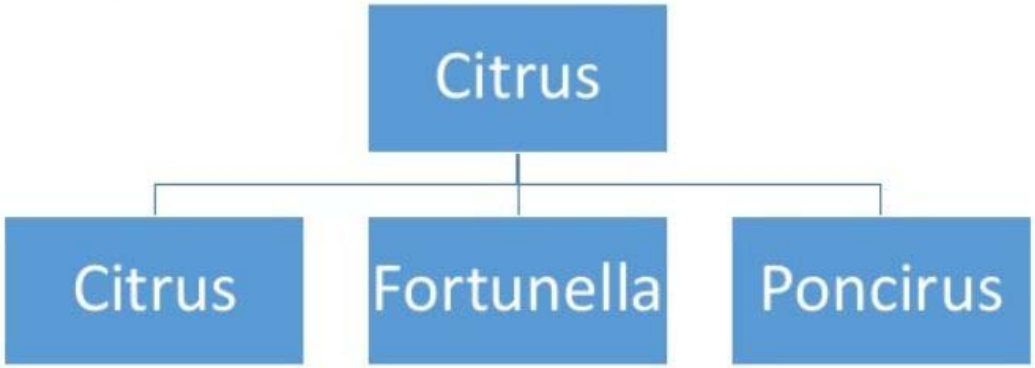
Taxonomy of Citrus (Swingle, 1943)

SECTION	BOTANICAL NAME	COMMON NAME	نام فارسی
Subgenus *Eucitrus*	*C. aurantifolia*	Lime	لیمو آب شیراز
	C. aurantium	Sour orange (Bitter orange)	نارنج
	C. indica	Indian wild orange	-
	C. limon	Lemon	لیمو خارکی
	C. maxima (*C. grandis*)	Pummelo	بطابی
	C. medica	Citron	بالنگ (ترنج)
	C. paradisi	Grapefruit	گریپ فروت
	C. reticulata	Mandarin	نارنگی
	C. sinensis	Sweet orange	پرتقال
	C. tachibana	Tachibana orange	-
Subgenus *Papeda*	*C. latipes*	Khasi papeda	-
	C. hystrix	Kaffir lime	-
	C. micrantha	Small fruited papeda	-
	C. celebica	-	-
	C. ichangensis	Ichang papeda	-
	C. macroptera	Melanesian papeda	-

C. limetta (Sweet Lime)

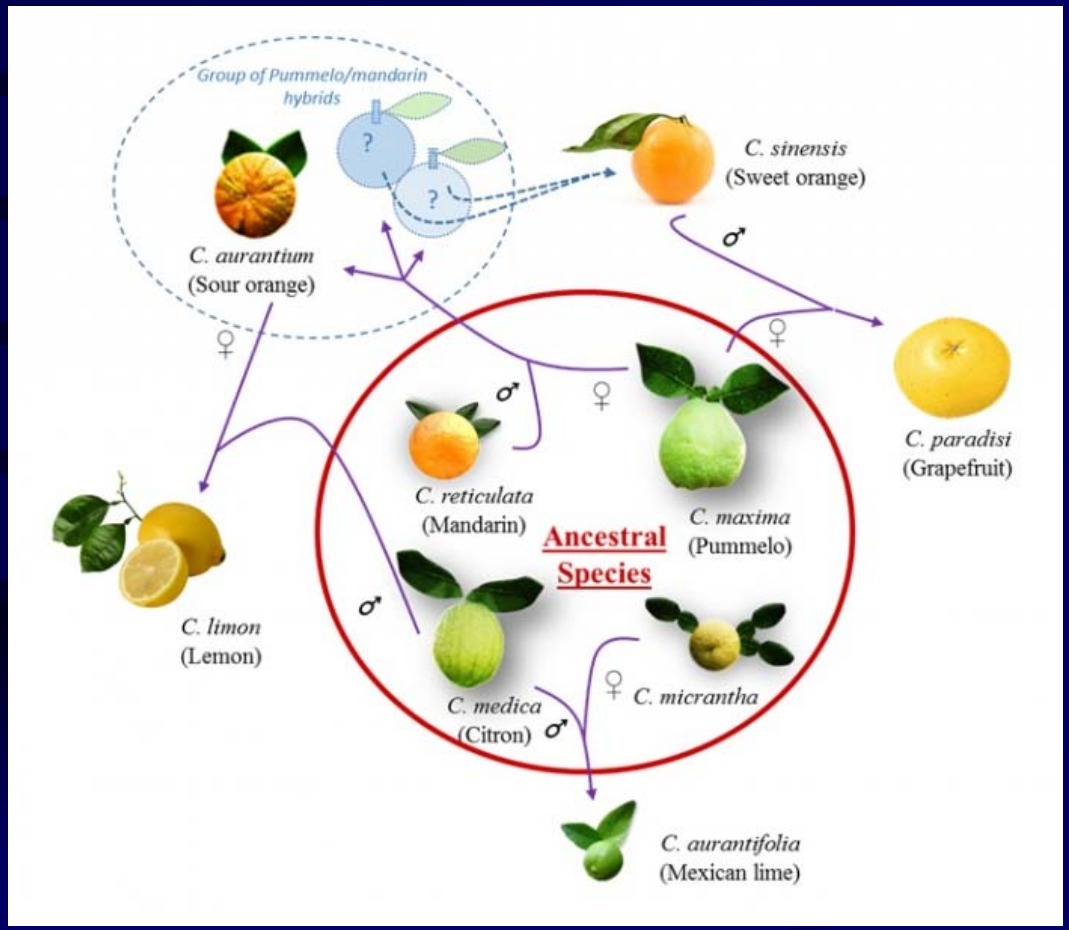
Classification of citrus

Family: *Rutaceae* Sub family: *Aurantioideae,* Tribe: *Citreae*




Sweet lime
Kumquat
Key lime
Meyer lemon
Pink pomelo
Star Ruby grapefruit
Washington navel orange
Satsuma mandarin
Cara Cara navel orange
Blood orange
Makrut lime

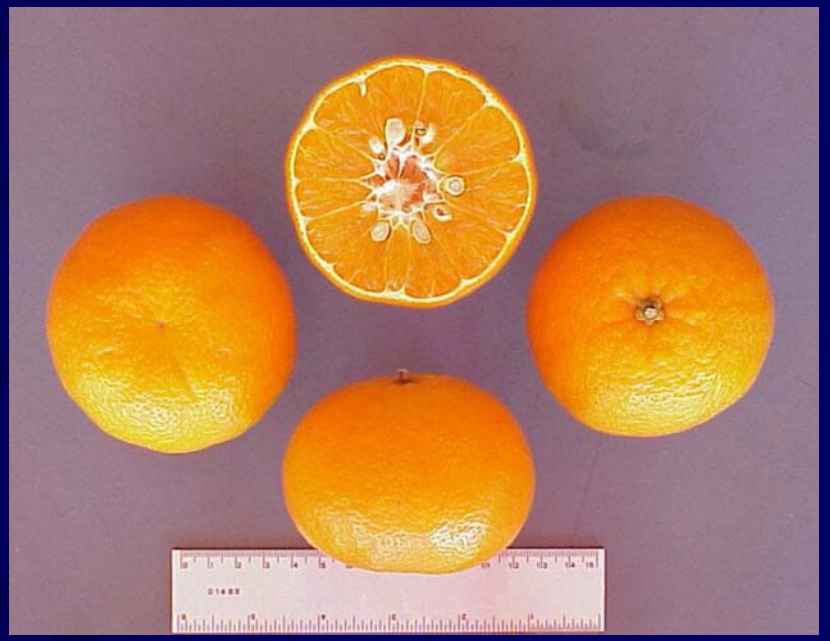
Phylogenetic origins of major secondary Citrus species



Citrus Hybrid

Tangelo: *C. reticulate* × *C. paradisi* (Orlando, Minneola, Seminole)

Minneola Tangelo



Orlando Tangelo

Hybrid: Tangerine × pomelo = Tangelo

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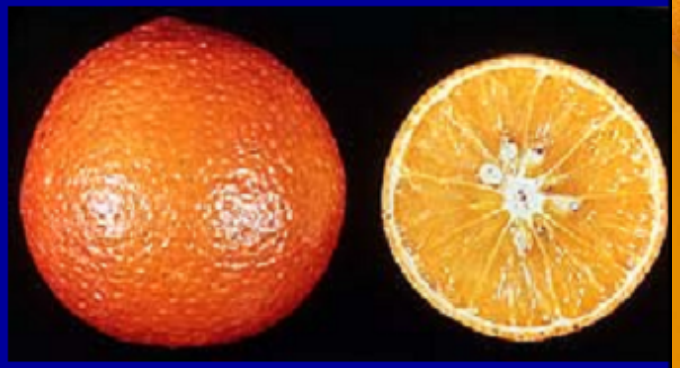
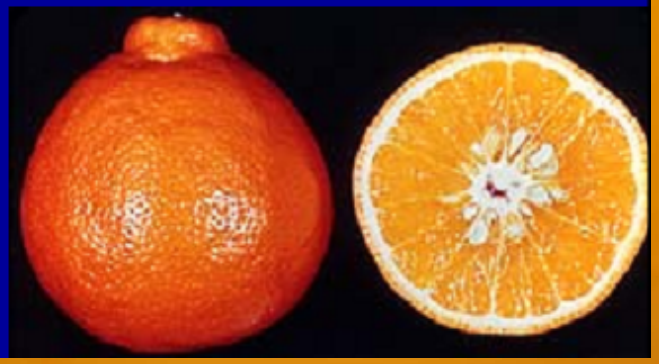
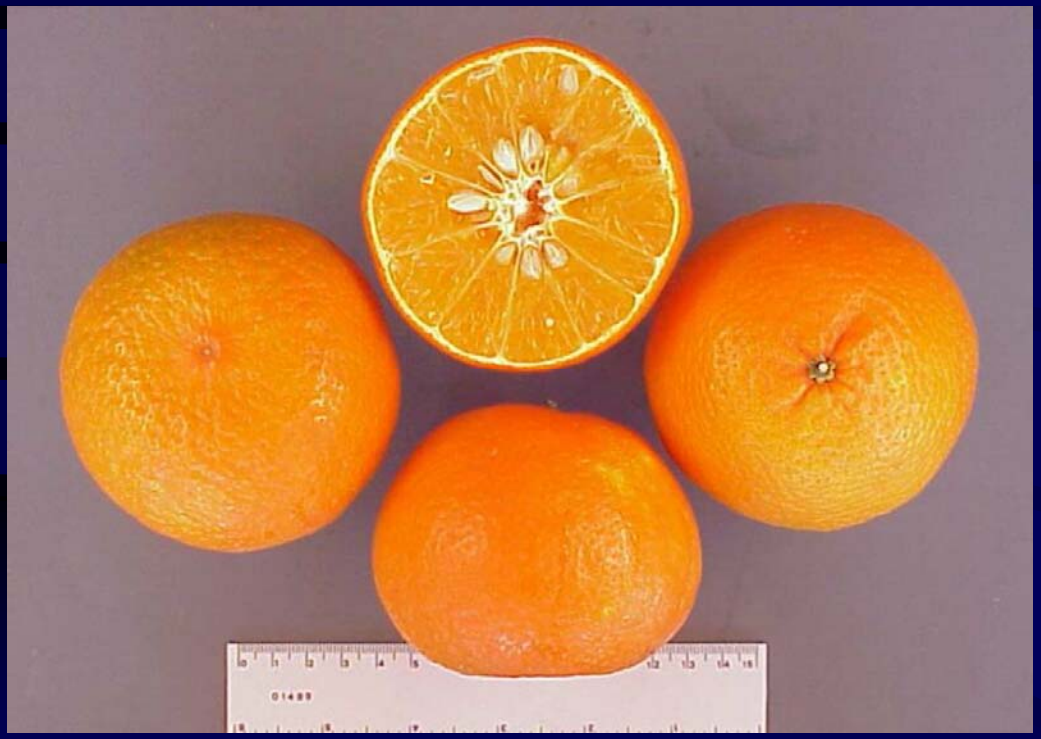


Minneola



Tangor: *C. reticulate* × *C. sinensis* (Temple, Murcat)

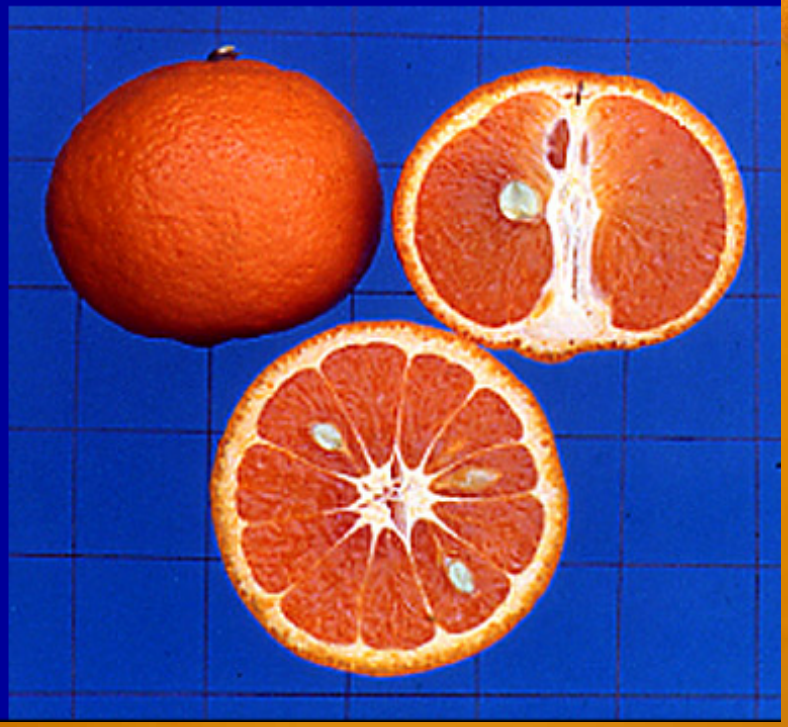


Temple

Murcat

Hybrid: Tangerine × orange = Tangor

Murcott



بکرایی

C. reticulate × *C. limetta*

Orange

Cultivars

Sweet orange (*Citrus sinensis*)

There are four classes:

- Common round orange such as a 'Valencia'
- Navels ('Washington Navel', syn.='Bahia', 'Jaffa')
- Blood oranges (red pigmentation in the flesh, found in Mediterranean areas, and require cool weather'
- Acidless

In Florida citrus, sweet orange production has three seasons:

- Early (before December) –
  - 'Navel', 'Hamlin', 'Parson Brown'
- Midseason (December to February) –
  - 'Queen', 'Pineapple'
- Late (February to Summer) –
  - 'Valencia', one of the best quality oranges for juice and fresh fruit.

Note: Citrus can be stored on the tree from February to Summer.

It does not ripen like an apple, but when fruit gets too old it loses juice and becomes dry.

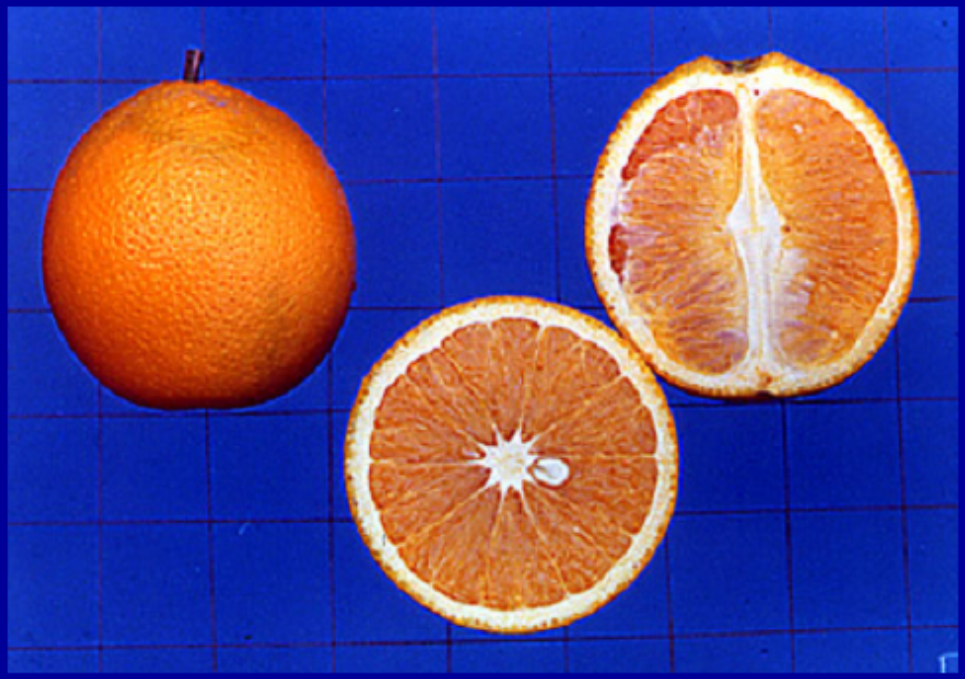
Sweet Orange Subdivision

1. Common Oranges (Blond Oranges)
   - Shamouti, Valencia Late, Pera, Hamlin, Pineapple, Musambi
2. Navel Oranges
   - Washington Navel, Lane Late, Navelate
3. Pigmented Oranges
   - Blood Red, Moro, Sanguinelli
4. Acidless or Sugar Oranges
   - Succari
5. Seedless Oranges
   - Salustiana, Tarocco

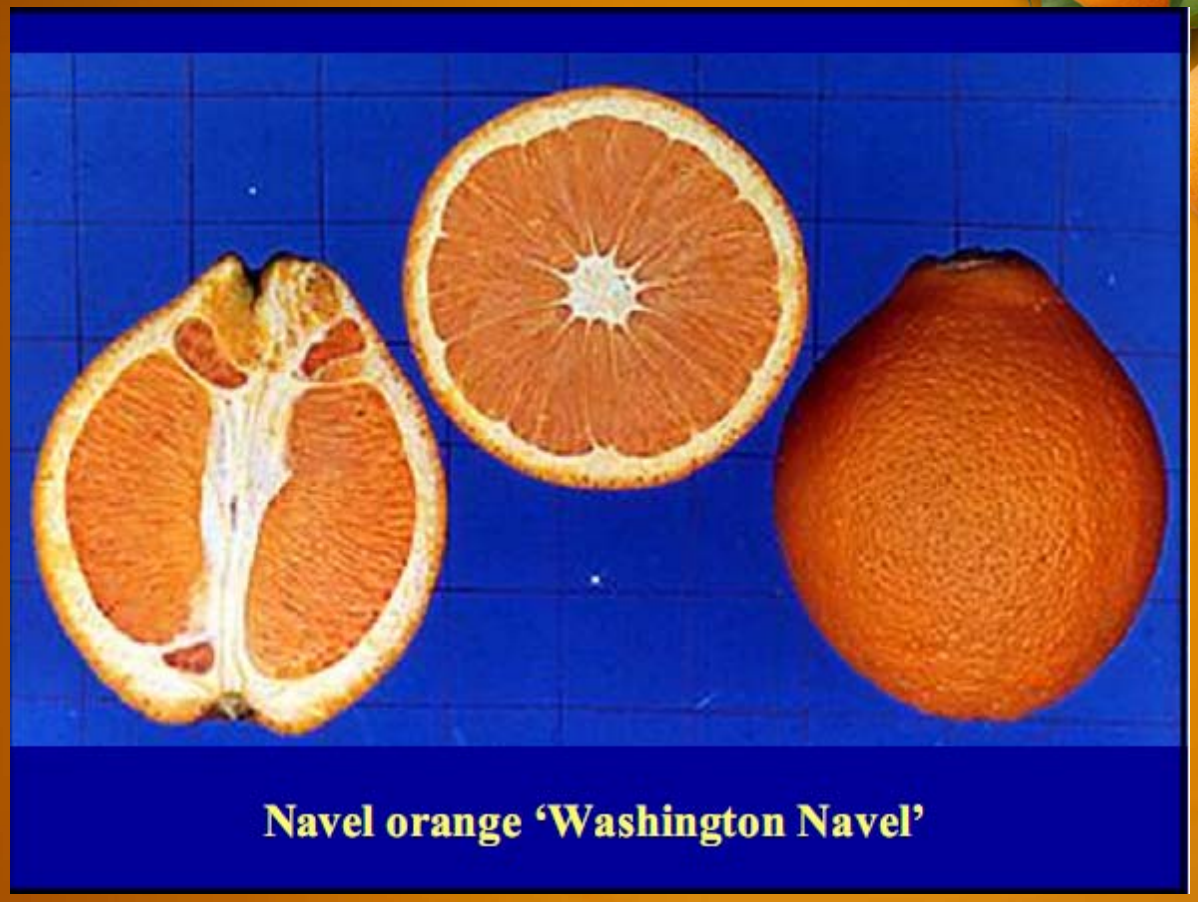
Navel Oranges

Moro

Sweet orange, *Citrus sinensis*



(Round orange) 'Valencia'



Navel orange ‘Washington Navel’

Blood orange

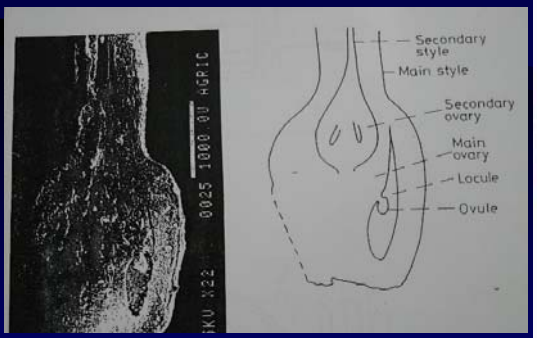
Orange Groups

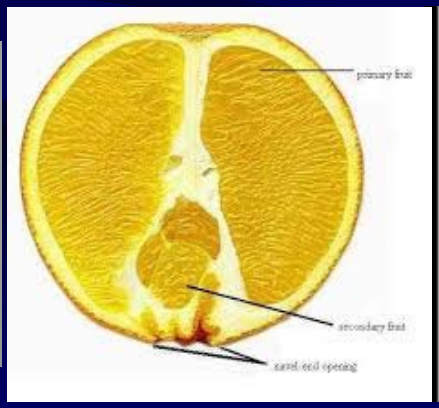
Spain cultivars: Early Oblong, Enterprise

Mediterranean cultivars: Valencia, Jafa

Blood Orange cultivars: Moro, Sunguino

Navel Orange cultivars: Thomson, Washington





Mandarin

Mandarin Groups

Satsuma (Japanese Mandarin) : Satsuma, Owari

Satsuma

Owari

King (Chinese Mandarin): king (Tangor)

Willowleaf (Mediteranean Mandarin): Willowleaf

Tangerine: Clementine, Cleopatra, Dancy

Clementine

Cleopatra

Dancy

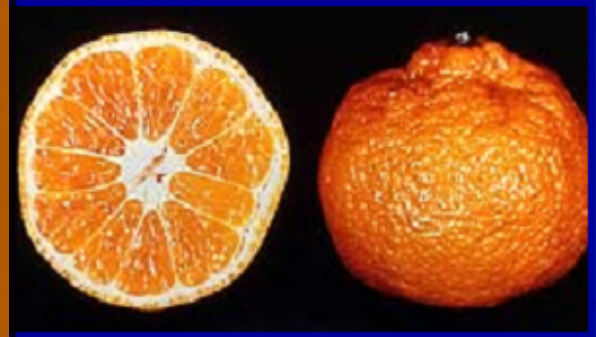
Tangerines (*Citrus reticulata*)

Highly prized for easy peeling (zipper skin).

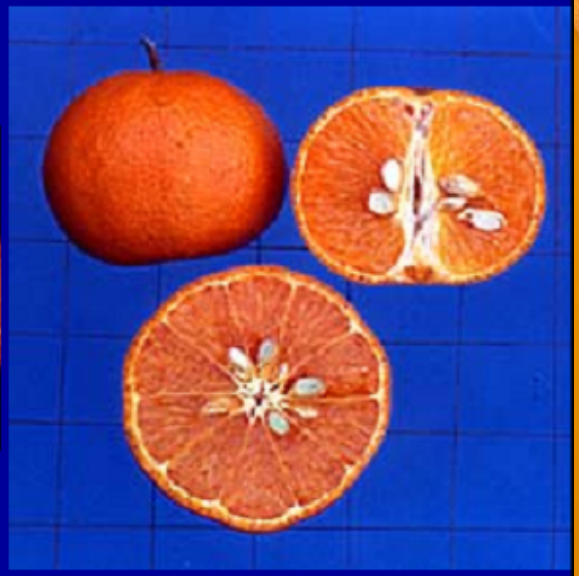
Some consider four horticultural groups.

- Satsuma Common in Japan, are seedless and sections are exported.
  These are often called mandarins.
- Hybrids such as 'King' and 'Temple' orange. Large, good quality and are easy peel.
  Many believe that these type of fruit are the future of the fresh fruit citrus industry.
- Mediterranean
- Common Mandarins (called tangerines).

Mandarin, *Citrus reticulata*

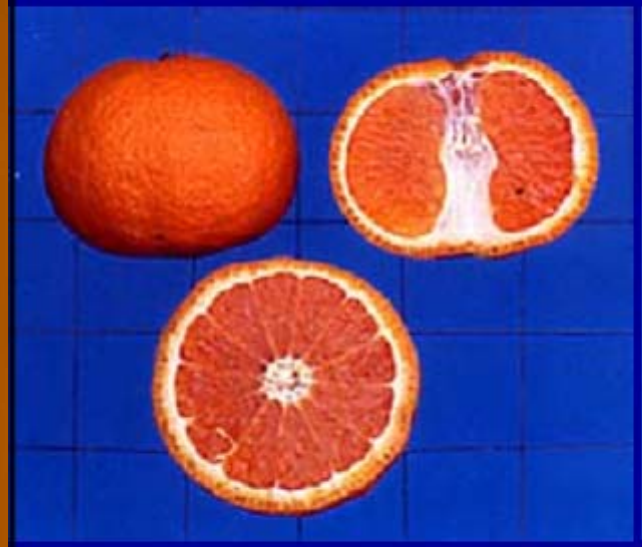


Satsuma

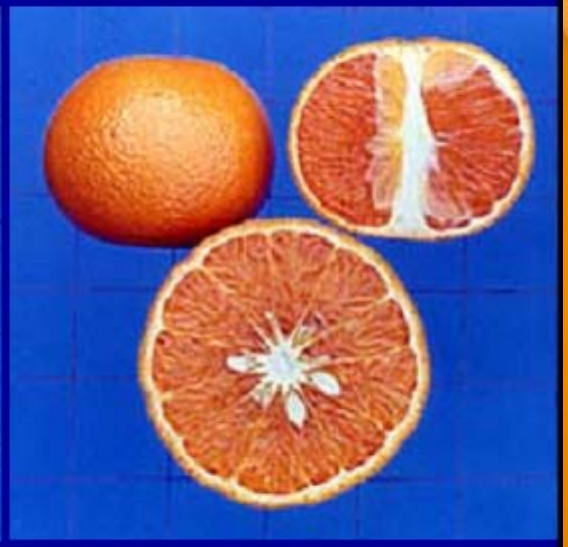


Wilking

Mandarin, *Citrus reticulata*

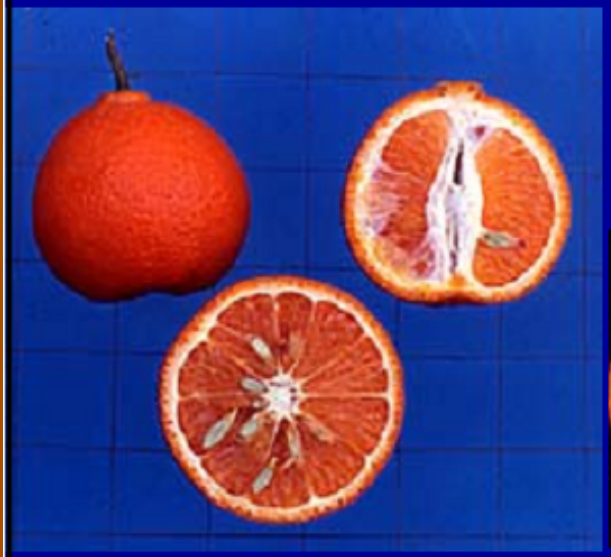


Pixie

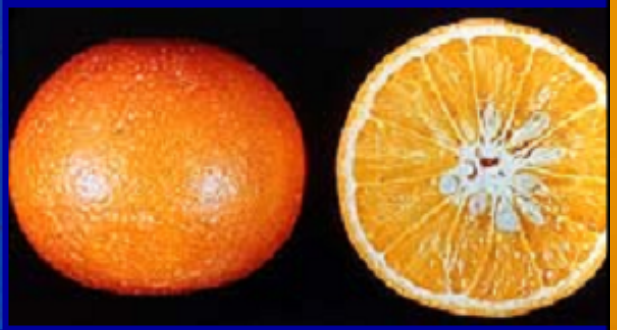


Kinnow

Mandarin, *Citrus reticulata*

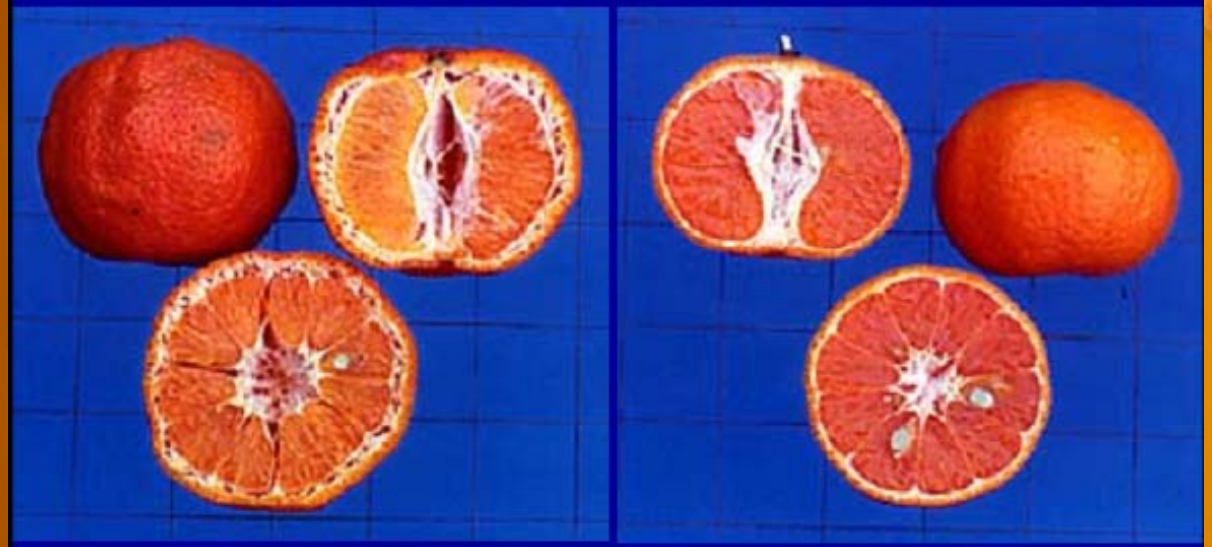


Clementine



Fairchild

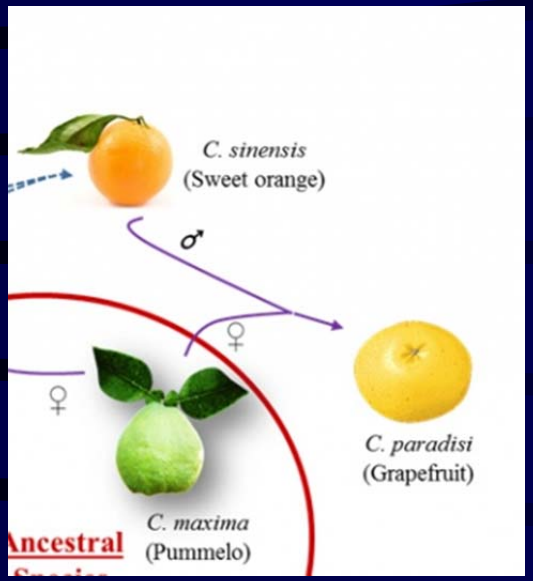
Mandarin, *Citrus reticulata*



Frua

Kara

Grapefruit



Ruby Red

Marsh

Grapefruit (*Citrus paradisi*)

Probably arose as a hybrid between sweet orange and pomelo (Shaddock) in Jamaica and long known as the forbidden fruit!

A Captain Shaddock introduced pomelo to Barbados in 1696.

There are four horticultural types, all due to mutations from a single clone:

white flesh and seedy, the original grapefruit ('Duncan')

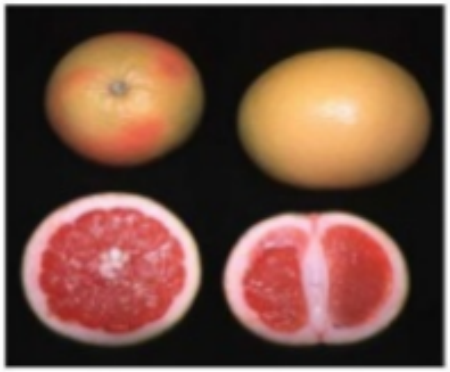
white flesh and seedless ('Marsh')

pink and seedless ('Thompson')

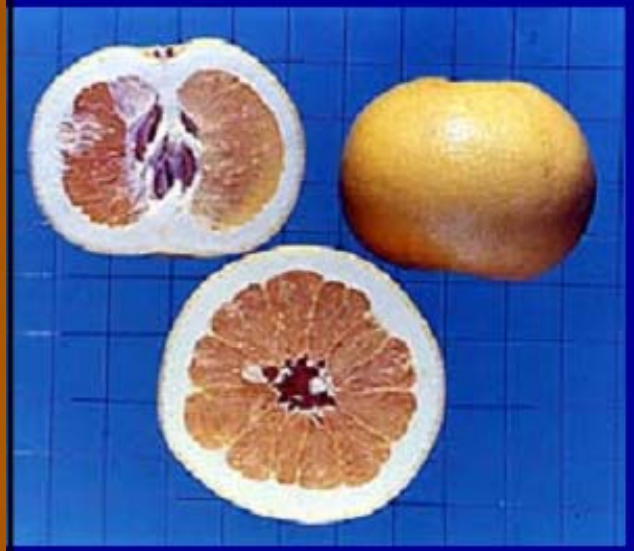
pink-red and seedless ('Redblush')

Grapefruit

1. Seedy
   - Red Blush, Shamber, Rio Red, Star Ruby, Flame
2. Seedless
   - Marsh Seedless



Grapefruit (*Citrus paradisi*)



Marsh

Redblush

Lime

Key Lime or Mexican Lime (2n)

Tahiti lime or Persian Lime (3n)

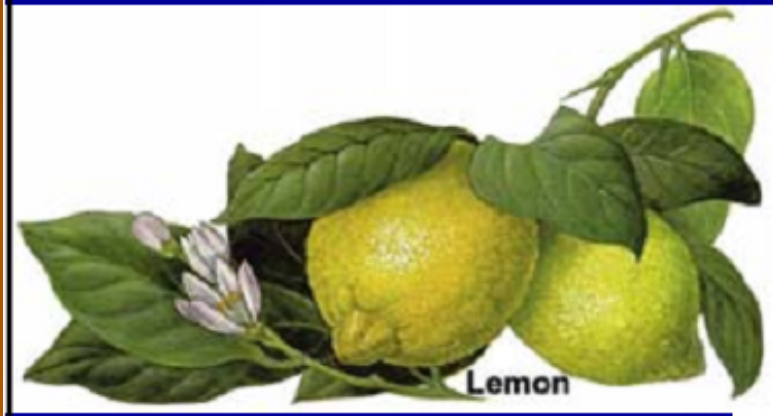
Lemon

Eurka Lemon

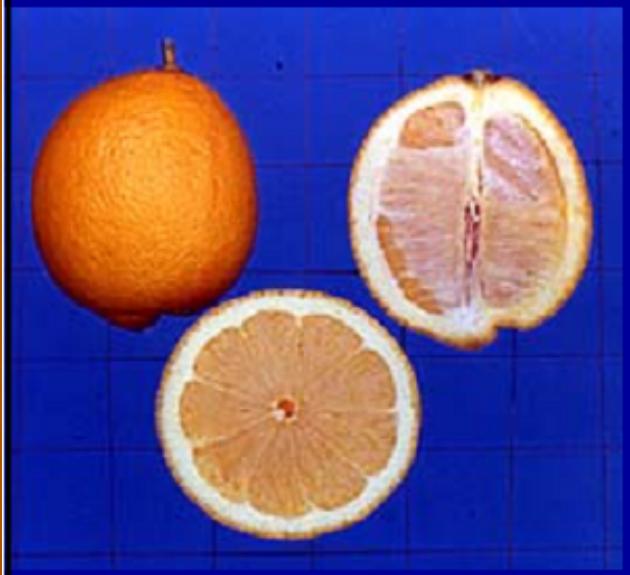
Lisbon Lemon

Rough Lemon

Lemon (*Citrus limon*)
Lime (*Citrus aurantifolia*)



Lemon (*Citrus limon*)



Eureka

Lime (*Citrus aurantifolia*)

Bearss Seedless

Lemons

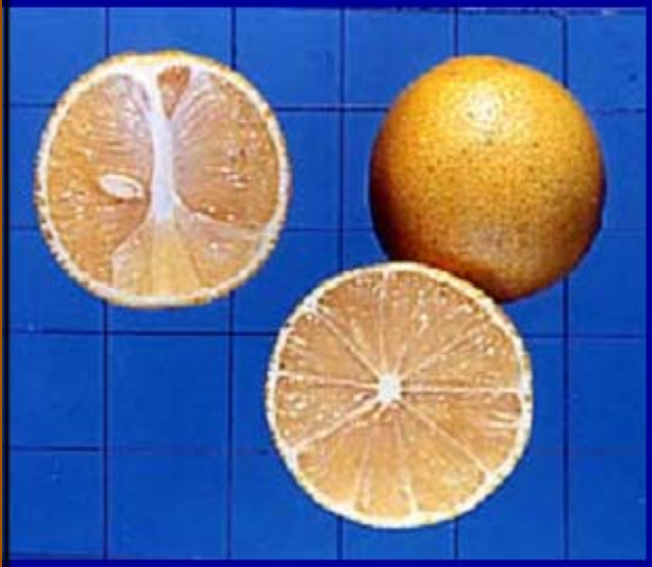
- Eureka Lemon
- Femminello
- Lisbon Lemon

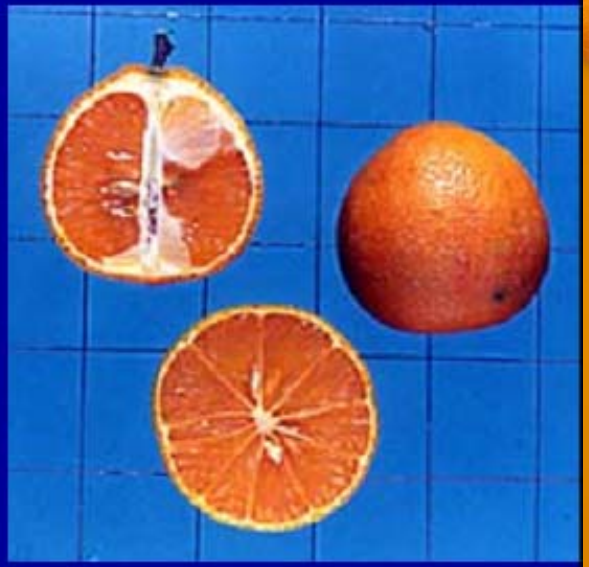
Limes

- Kaghezi Lime
- Tahiti Lime

Sweet Lime (*Citrus limettiodes*)

Lime rootstock



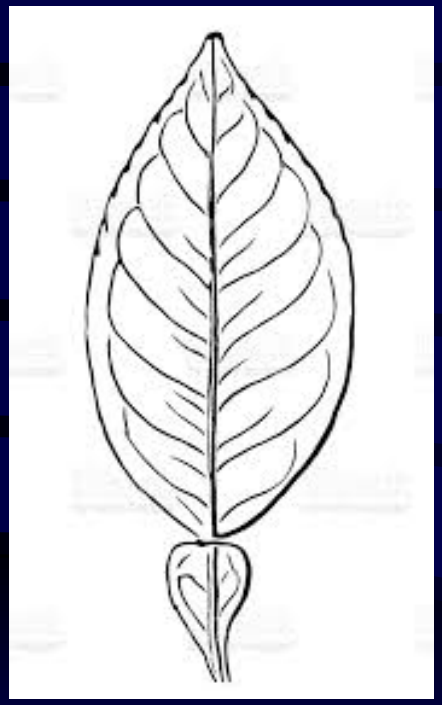


Sweet Lime

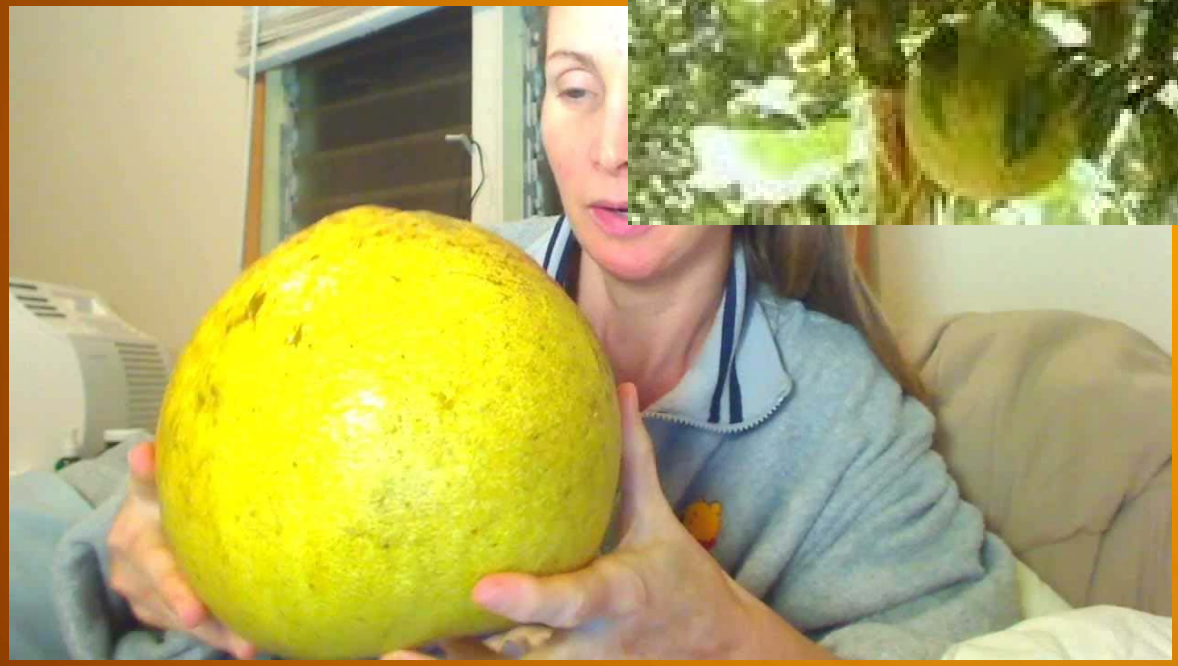
Rangpur Lime

Sweet Lime

Sour Orange



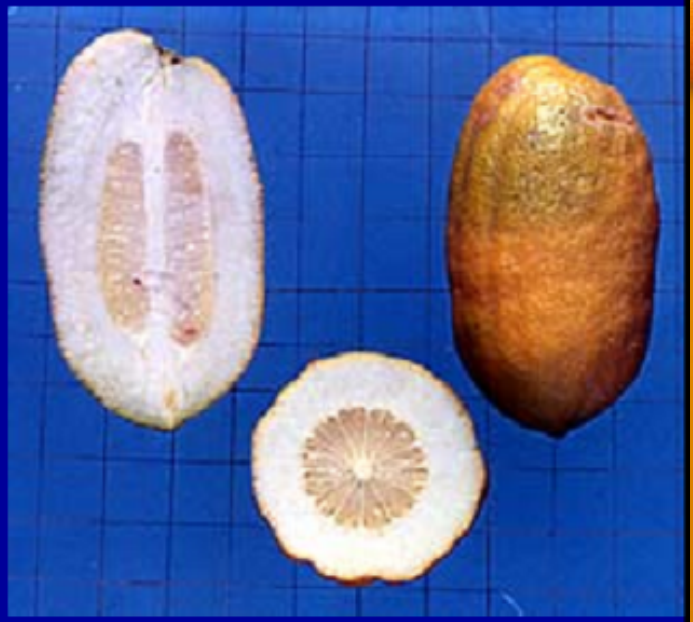
Pummelo



Citron

Citron (*Citrus medica*)

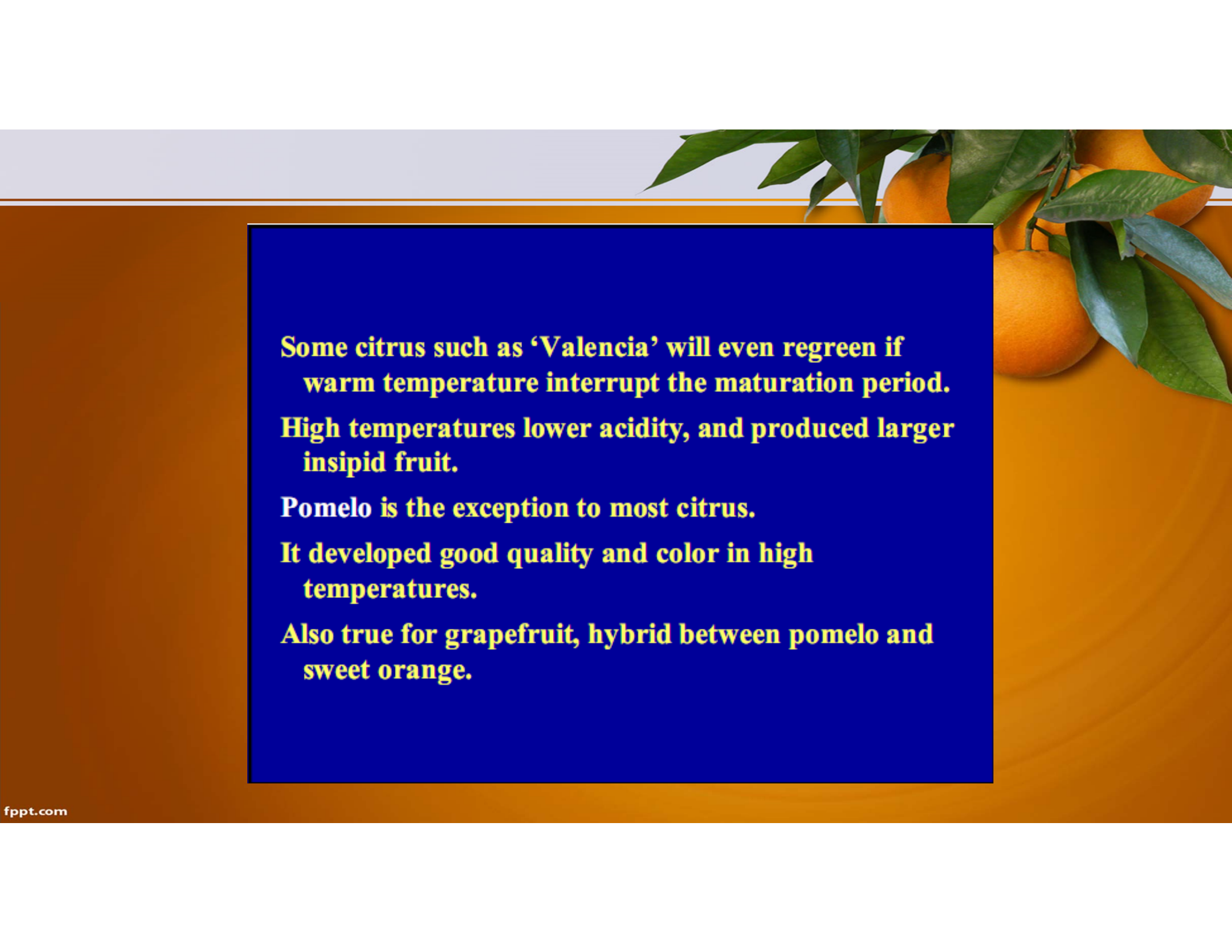
Etrog



Corsican

Ecology

- Citrus grows best in a band 30–40° latitude on either side of the equator.
- It is a true subtropical crop.
- Good growing temperatures are 75–80°F, but 40°F good for rest, development of acidity, and color.
- Quality is best where there is a certain amount of low temperature.
- Peel color is especially related to temperature.
- Low temperature brings out orange color.



- Some citrus such as ‘Valencia’ will even regreen if warm temperature interrupt the maturation period.
- High temperatures lower acidity, and produced larger insipid fruit.
- Pomelo is the exception to most citrus.
- It developed good quality and color in high temperatures.
- Also true for grapefruit, hybrid between pomelo and sweet orange.

Climate Requirement

- Growth of citrus trees can occur within a temperature range of 13 °C to 35 °C.

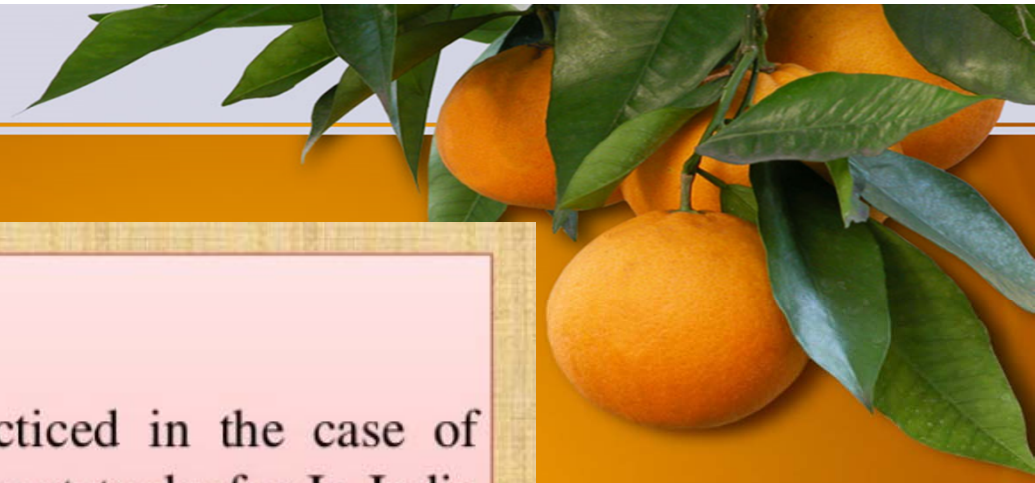
- The ideal temperature for growth is between 21°C and 32 °C
- Trifoliate orange are cold-hardy species and can withstand temperatures as low as 20°C
- Most mandarin trees can tolerate temperatures down to -5.5°C; 'Satsuma' even -8.0 °C
- Oranges tolerate temperatures down to -5°C
- lemons -3.3°C; limes -2.2°C

- Grapefruit can tolerate high temperature (49°C)

Soil

- Sandy Loam soil, Deep, Well drained and aerated
- pH 5.5-7.5
- Salt sensitive

EC (dsm^{-1})	Reduction of Yield (%)
2.3	10
3.2	25
4.8	50



Citrus propagation:

Propagation is still practiced in the case of acid limes and to produce rootstocks for In India citrus trees are propagated both by seeds and vegetative means. Seed budding purposes. It produces true to type seedlings i.e. polyembroynic seedlings. Shield or T budding is the most commonly used method of vegetative propagation. Budding is generally done either in spring or in September.

Nucellar Embryony

Apomixis
development of an embryo without the fusion of male and female gametes.

Polyembryony
occurrence of more than one embryo in a seed.

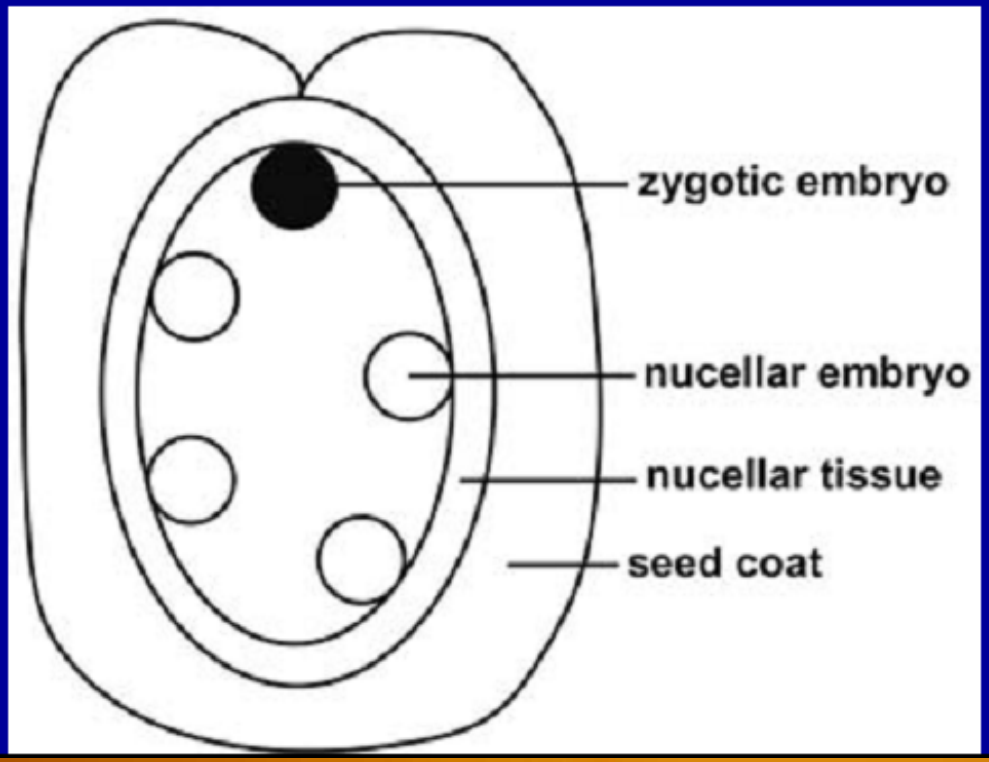
Nucellar embryony
embryos form from nucellar tissue.

Nucellar embryony in citrus means that most embryos are vegetative not zygotic.

They are produced from nucellar tissue and are therefore clones of the mother tree.

Pollination is needed to trigger nucellar development.

Nucellar Embryony



- Nucellar embryos begin development as soon as pollination occurs while zygotic embryos take four weeks to develop; thus, nucellar embryos crowd out the zygotic embryos.
- There are various degrees of nucellar embryony.
- Some cultivars produce only nucellar embryos, and some vary in the percentage of nucellar embryos.
- Three citrus types produce monoembryonic and therefore zygotic seed;
  - 'Temple' tangelo
  - 'Clementine' tangerine
  - Shaddock, *Citrus grandis* (pomelo)

There are some important implications of nucellar embryony.

Rootstocks such as 'Rough Lemon', 'Sour Orange', and *P. trifoliata* can be produced true-to-type from seed. This is important for nurseries because virus is not transmitted through either nucellar or zygotic seed. Thus, nurseries can produce virus-free, clonal rootstocks from seed.

Virus can be eliminated from infected clones.

However, because nucellar seedlings are juvenile it takes a long time to obtain productive clones.

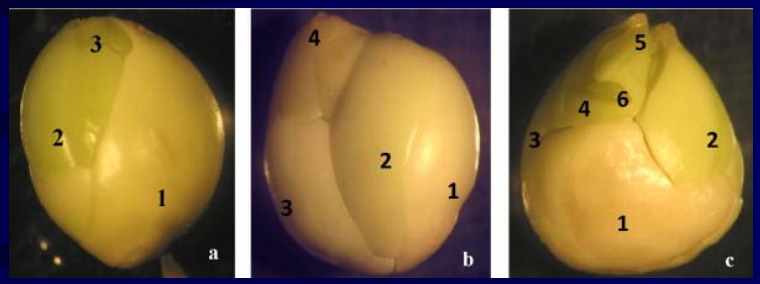
These can then be propagated by budding from the indexed nucellar mother tree.

Breeding of citrus is made difficult because of the difficulty obtaining genetically variable populations.

Propagation

Seed:

- Polyembryony



- Shows no seed dormancy

- Prevention of seed drying

Rising of seedling:

- Freshly extracted seeds are shown on well prepared nursery bed at the distance of 20 x l0 cm and 1.5 to2cm deep.
- Germination completes within 3 weeks.
- The apogamic seedlings are identical to the parent in growth and production.
- Seedlings are ready for transplanting 6 to 9 months after sowing.
- Seeds are sown in seedbed during July- August.

Rootstock characters:

•Must be compatible with the scion variety allowing good growth, long good yield and good fruit qualities.

•Seeds must be readily available, preferably high poly-embryonic to get uniform seedlings and with high percentage and germination.

•Must be adaptable to a wide range of soil depth, texture, structure, pH, salinity, moisture, and nutrient supply. Must be resistant to soil-borne diseases, such as Phytophthora gummosis.

Rootstocks

As all citrus are propagated by budding, rootstocks are an important part of citrus culture.

In citrus, unlike apple, many scion cultivars are also used as rootstocks.

Common rootstocks in Florida include 'Rough Lemon' (*C. limon*) which is adapted to light sandy soils and 'Sour Orange' (*C. aurantium*) adapted to heavier soils and is more cold hardy.

'Cleopatra' mandarin is an important rootstock because of resistance to tristeza virus.

Grafted trees bear in 2–3 years.

Poncirus trifoliata (trifoliate orange)

This is a deciduous species used as rootstocks because:
- Produces high quality fruit on scion cultivars;
- Resistant to *Phytophthora* (foot rot);
- Grows well on heavy soils;
- Produces a small tree, i.e. somewhat dwarfing;
- Cold hardiness is transferred to the scion.

Poncirus trifoliata has been hybridized with *Citrus* to impart cold hardiness but it contains an inedible glycoside which is transferred to all hybrids.

Protoplast hybrids between citrus species are being made at the University of Florida and Citrus Experiment Station to produce new rootstocks.

Budding:

- Free virus (Tristeza ⟶ West Indian lime; Exocortis ⟶ Rangpour lime)

- T budding

Cutting and Layering

Rootstocks

- Sour Orange: Tolerant to Gummosis; susceptible to Tristeza
- Sweet orange: Susceptible to Gummosis (not recommended for heavy soils)
- Rough lemon: Tends to produce fruit rough in texture and lower in juice
- Cleopatra mandarin: Tolerant to cold, Triseza
- *Poncirus trifoliate*: Tolerant to Gummosis and Tristeza
- Rangpur lime:
- Grapefruit:
- Troyer and Carrizo citranges:
- *Citrus volkameriana:*

Rootstock	Characters
Rough lemon	Suitable for light (sandy) and infertile soil, resistant to Tristeza virus. But it is most susceptible to cold and induces poor quality fruit
Sour orange	Suitable for silty, clayey and poorly aerated soils , improves the fruit quality and has high sugar and acid content, improve the fruit size
Cleopatra mandarin	Suitable for heavy soils
Trifoliate orange	Cold tolerant, improves the fruit quality and has High sugar and acid content, hasten fruit maturity and the fruit size. It also induces precocity. Resistant to Citrus nematode (Tylenchulus semipenetrans). It is ideal for high density plantations

Planting

Square system and Rectangular system: Related to plant sp. and rootstock (5- 9 m)

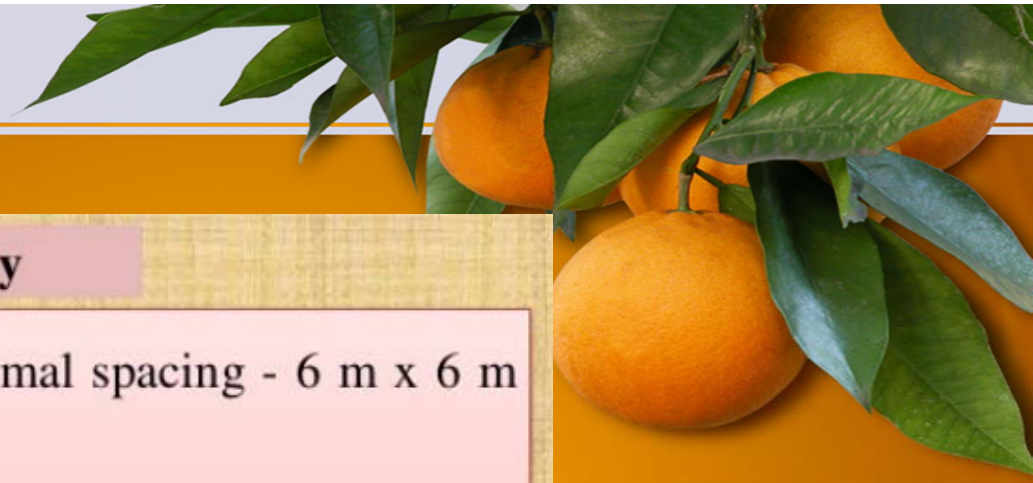
Poncirus and sour orange: Dwarf rootstocks 5× 5 m

Grapefruit, Rough lemon and Pummelo: vigorous rootstock

Generally, Orange, Mandarin and grapefruit (7 × 9 m)

Lemon (6 × 8 m)

Lime (5 × 5 m)



Plant density

a. Orange : Normal spacing - 6 m x 6 m .Plant population - 275 / ha

b. Sweet Lime : Normal spacing - 5 m x 5 m .Plant population - 400 /ha

c. Lime/Lemon: Normal spacing - 4.5 m x 4.5 m .Plant population - 494 / ha

•In very light soils, spacing may be 4 m x 4 m. In fertile soils and in high rainfall areas spacing may be 5 m x 5m.

A young orange tree recently planted showing the basin for watering and the wrapping for protection of the trunk.

Tracks between rows are left by a tank truck that fills the basin periodically.

Later an irrigation system will be installed.

Irrigation

60- 80 % root system (60-80 cm)

Very sensitive to drought

Very sensitive to flooding

Flowering and Fruiting

Seedling trees are:

- **Tall and vigorous**
- **Thorny**
- **Slow into coming into bearing taking 10–15 years.**

These are juvenile characteristics and is the reason why all citrus produced commercially is propagated by graftage (usually budding) despite the fact that many citrus comes up true-to-seed due to nucellar embryony.

Flower bloom is profuse, about 40,000 flowers are produced on a 10-year-old tree but only 1–5% of the flowers set fruit.

Flower parts are in sets of five (5 petals, 20 stamens, 5 sepals, 10 sections in a fruit, usually).

Most citrus species are self fertile and have perfect flowers but usually produce fruit from cross pollination.

- The flowers are solitary or in small corymbs, each flower 2–4 cm diameter, with five (rarely four) white petals and numerous stamens; they are often very strongly scented.

- Flowering produced on woody twigs of previous year's spring flush
- May be on younger, summer flush twigs
- Inflorescence is cymose: Terminal flower initiated first and lateral axillary flower later
- Date and duration of bloom depend upon temperature
  - Warmer weather brings opening of flower within few days resulting in concentrated wave bloom, petal fall and fruit set

Flower chracteristics

- Mostly hermaphrodite
- In grapefruit staminate flowers in addition to hermaphrodite present
- Petal colour white although pink colored flower in pummelo

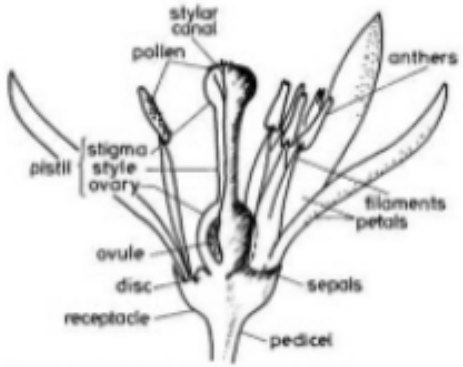
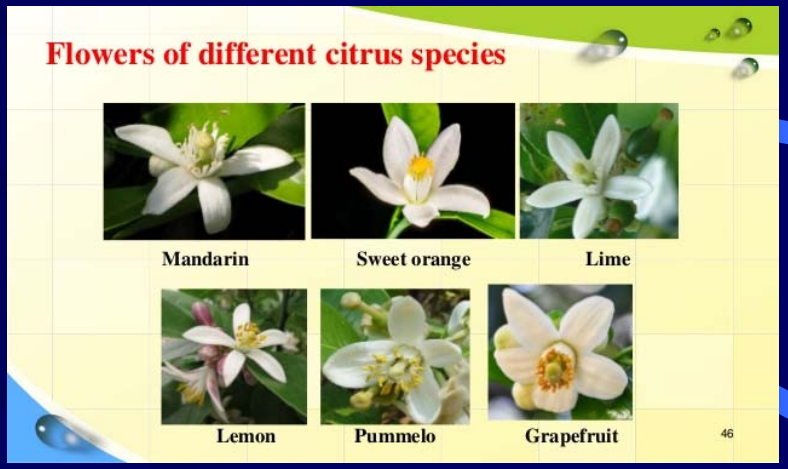


Figure 4.6 Schematic drawing of an open citrus flower

Flowering

- Juvenility (5-10 years)

- Flower Bud Production:
  Induction (Winter), *Poncirus trifoliate* (Summer)
  Initiation
  Differentiation
  Development
  Anthesis



Fortunella sp. (Late Flower), *Poncirus* (Early Flower)

Citrus sp. (4 weeks, Late Esfand- Late Farvardin)

Pollination

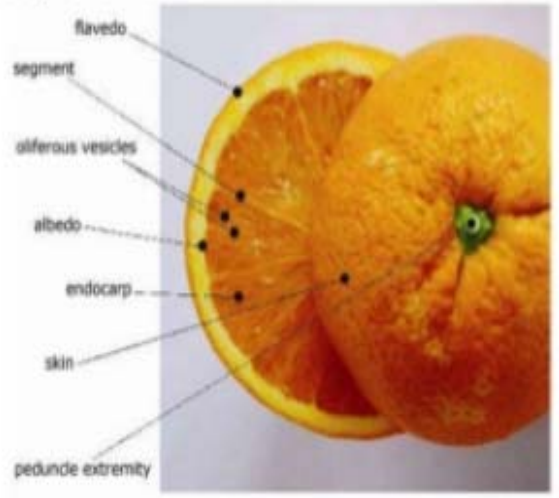
Floral Biology of Citrus

- Flowers are **hermaphrodite produced on current season** growth in cymes, both at axillary and terminal position.
- Flower opening starts from morning and extend upto evening, but **maximum anthesis is between 11.00 a.m. to 12.00 noon.**
- The **viability of pollen grains varies from 45-80%** depending upon the season.
- The **dehiscence of anthers takes place 45 minutes before anthesis or within 45 minutes after anthesis.** It varies up to 5 hours after anthesis.
- The **receptivity of stigma starts either 15 minutes to 2 hours before anthesis or within 35 minutes to 5 hours after anthesis depending upon weather.** The receptivity lasts for 4-8 days after anthesis.

Navel orange and Satsuma mandarin (Pollen sterility ⟶ Seedlessness)

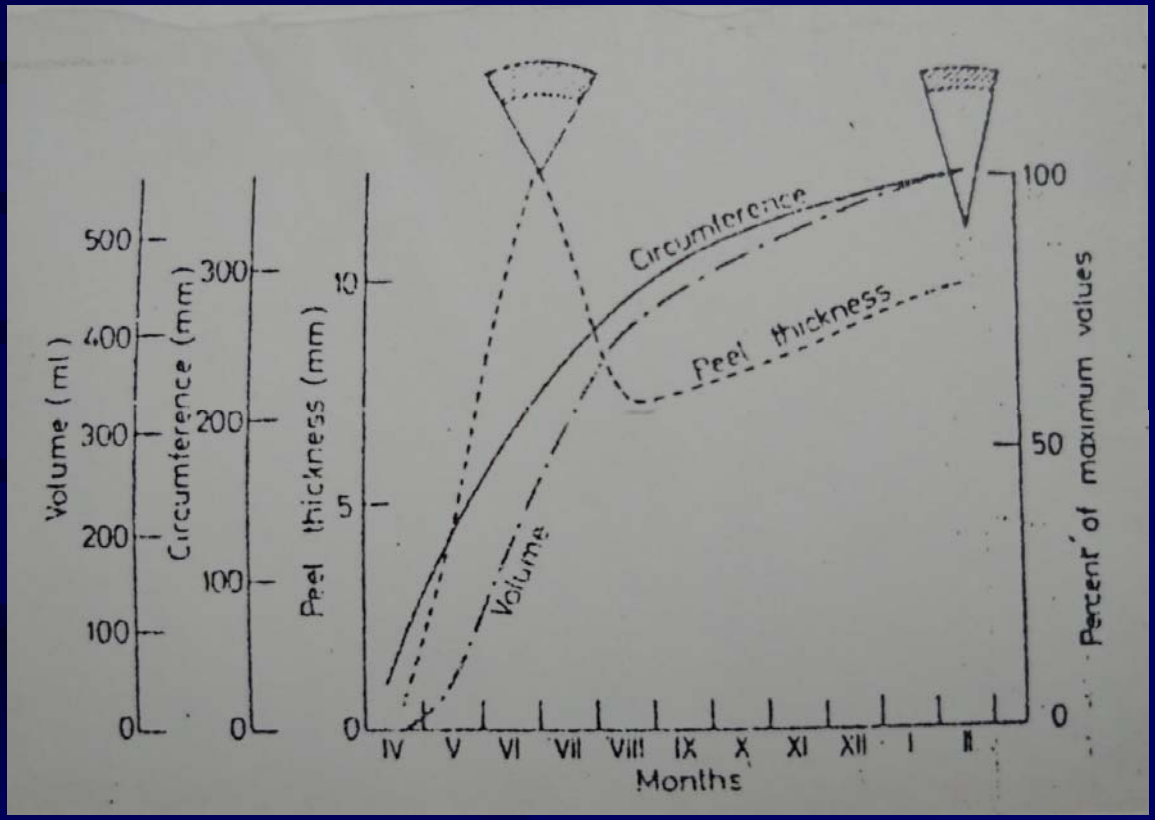
- The fruit is a *hesperidium, a specialised berry, globose to elongated,* 4–30 cm long and 4–20 cm diameter, with a leathery rind surrounding segments filled with pulp vesicles.
- Citrus fruits are notable for their fragrance, partly due to flavonoids and limonoids contained in the rind, and most are juice-laden.
- The juice contains a high quantity of citric acid giving them their characteristic sharp flavour.

- A small secondary fruit (navel) present at styler end
- Fruit composed of
  - Pericarp (Peel or Rind)
  - Endocarp: edible part of fruit (pulp)
- Peel has two distinctive layers:
  - Coloured portion is epicarp (Flavedo)
  - Internal, whiter layer is mesocarp (Albedo)



Fruit Growth and Development

Sigmoid



Seedlessness and Parthenocarpy

Seedlessness is as very desirable character in citrus.

Parthenocarpy is the ability to produce fruits without sexual fertilization.

Citrus cultivars may be classified as:

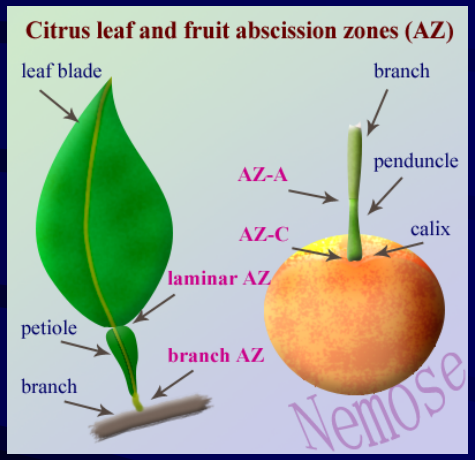
- Weakly parthenocarpic—Only a few fruit is produced without pollination (Navel oranges).
- Moderately parthenocarpic—Fair crop is produced without pollination, while pollinated sets a good crop ('Orlando' tangelo).
- Strongly parthenocarpic—Sets good crop without pollen ('Tahiti' lime).

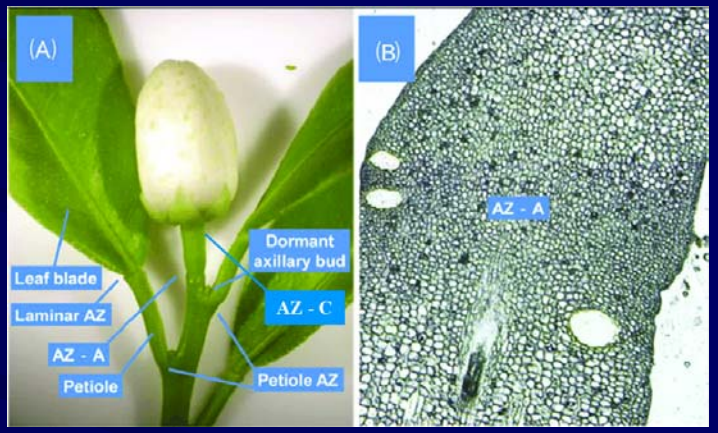
- Note: in the US, oranges are considered seedless if they have 0 to 6 seed!!
- Seedless cultivars include ‘Hamlin’, ‘Valencia’ (best quality), and ‘Washington Navel’.
- Seedy oranges such as ‘Parson Brown’, ‘Queen’, and ‘Pineapple’ are used only for juice production.
- Note: navel oranges such as ‘Washington Navel’ cannot be used for concentrate because it is bitter when processed.

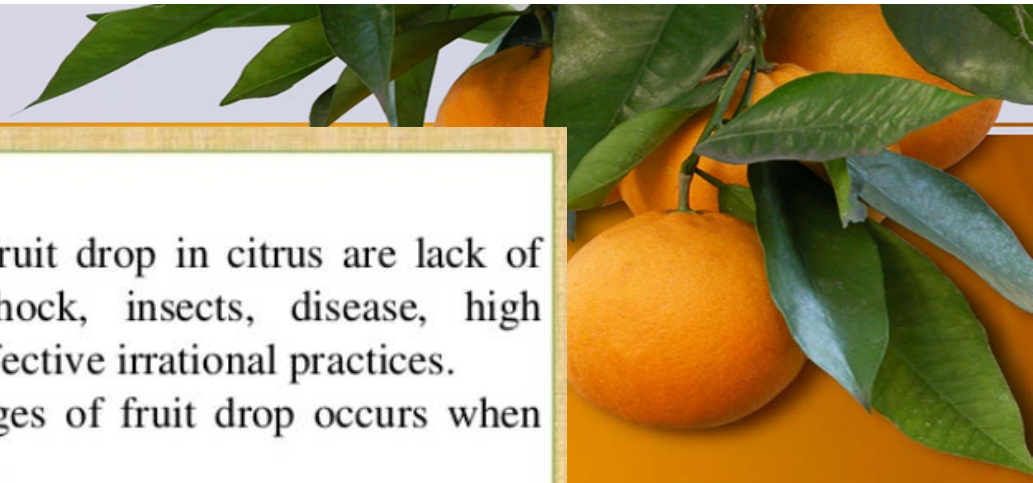
Fruit set and Fruit abscission:

Fruit set: 0.1-3.5 %

Fruit Abscission





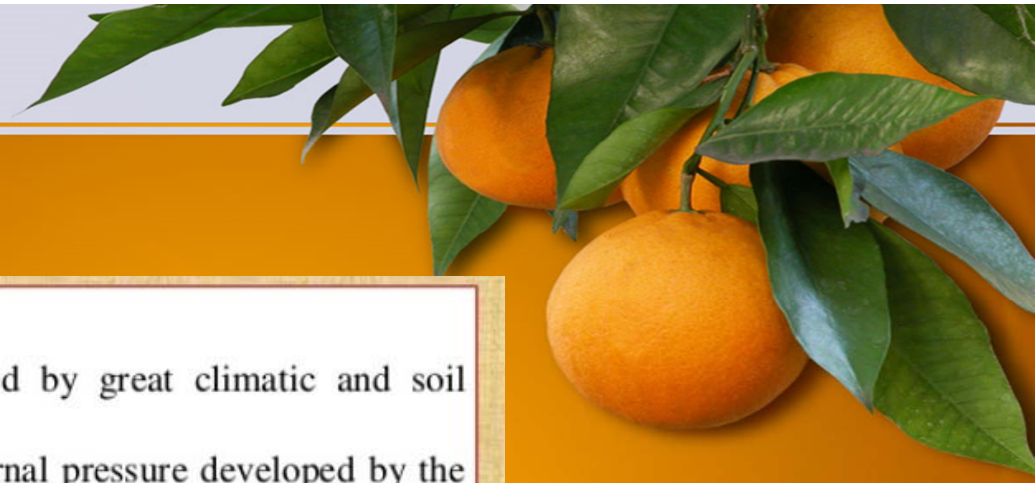


Fruit drop:

- The causes attributed to fruit drop in citrus are lack of fertilization, mechanical shock, insects, disease, high temperature, rainfall, and defective irrational practices.
- The most pronounced stages of fruit drop occurs when the fruits are at marble stage.
- On the onset of hot summer weather during May-June the second wave of intense fruit drop occurs while pre-harvest drop occurs during ripening period, which lasts from August-January.

Control:

- The method of control depends upon the causes of the drop and the variety of the fruit.
- In order to reduce the pre-harvest drop, NAA (10 ppm) is sprayed from August till October at monthly interval.



Fruit cracking:

- Fruit cracking might be caused by great climatic and soil moisture irregularities.
- It has been speculated that internal pressure developed by the pulp causes the rind to split.
- Regular application of fertilizer and water to provide Smooth uninterrupted growth might reduce the problem.

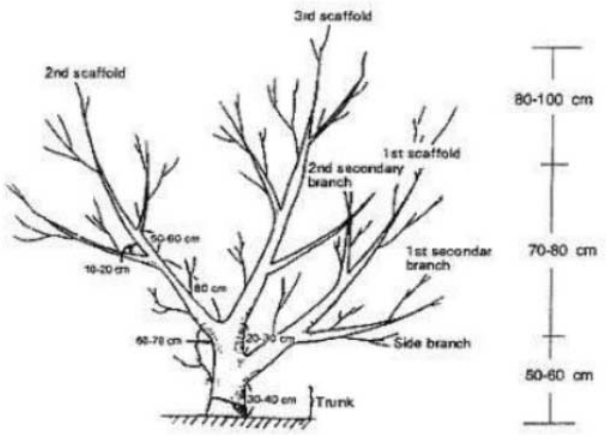
Training:

Acid lime–acid lime plants are trained to modified central leader system with a smooth trunk up to 70 to 100 cm height from ground level and with 4-5 well spaced branches.

Modified central leader

Lemon- Training system followed by open leader system method .Trees are trained to form a low headed open centered crown which can harvest maximum sunlight.

Open leader system method



MATURITY ASSESMENT

- **Fruit colour:**

  Golden orange
- **Flesh colour**

  Pale yellow or whitish
- **TSS/acid ratio**

  8 or higher with yellow-orange color at least on 25% of the fruit surface

  OR

  10 or higher and green-yellow color on 25% or greater of the fruit surface.

Harvest time

Table 5
FLORIDA MATURITY STANDARDS FOR FRESH FRUIT, ACCORDING TO SOULE ET AL.[85]

Fruit	Color break	Juice content	Minimum TA	Minimum brix	Minimum brix/TA
Oranges	25%, August—November, 50%, later	About 41.5%	0.4%	9, August—October[a] 8.5, November—July	10.5:1 to 8.5:1 as brix increases from 8—12
Grapefruits	25%	130—350 mℓ per fruit according to size[b]	None	7.5, August—December; 7, December—July	7:1 to 6:1 as brix increases from 6.5—12 and more
Tangerine	50%	None	None	9, August—November; 8.75, November—July	9:1 to 7.25:1 as brix increases from 8—12 and more
Tangelos	50%	None	0.4, August—December none later	9, August—October; 8, November—July	10.5:1 to 8.5:1 as brix increases from 8—12 and more
Lemons	None	28% Export, 30% local market	None	None	None
Limes	None	42% Large, 50% small	None	None	None

[a] TSS (brix) minimum requirement and TSS/TA minimum rates decrease, with the progress of season.
[b] Requirements decrease in three steps (August—November; November—March; March—July).

Citrus Harvesting

Citrus Packinghouse Operations

Dumping

Washing

Surface Drying

Waxing and Fungicide Application

Surface Drying

Surface Drying