


Tropical Horticulture: Lecture 32

Lecture 32
Citrus





Citrus: *Citrus* spp., Rutaceae

Citrus are subtropical, evergreen plants originating in southeast Asia and the Malay archipelago but the precise origins are obscure.

There are about 1600 species in the subfamily Aurantioideae.

The tribe Citreae has 13 genera, most of which are graft and cross compatible with the genus *Citrus*.

There are some tropical species (pomelo).

All *Citrus* combined are the most important fruit crop next to grape.

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The common features are a superior ovary on a raised disc, transparent (pellucid) dots on leaves, and the presence of aromatic oils in leaves and fruits.

Citrus has increased in importance in the United States with the development of frozen concentrate which is much superior to canned citrus juice.

Per-capita consumption in the US is extremely high.

Citrus mitis (calamondin), a miniature orange, is widely grown as an ornamental house pot plant.

History

Citrus is first mentioned in Chinese literature in 2200 BCE.

First citrus in Europe seems to have been the citron, a fruit which has religious significance in Jewish festivals.

Mentioned in 310 BCE by Theophrastus.

Lemons and limes and sour orange may have been mutations of the citron.

The Romans grew sour orange and lemons in 50–100 CE; the first mention of sweet orange in Europe was made in 1400.

Columbus brought citrus on his second voyage in 1493 and the first plantation started in Haiti.

In 1565 the first citrus was brought to the US in Saint Augustine.

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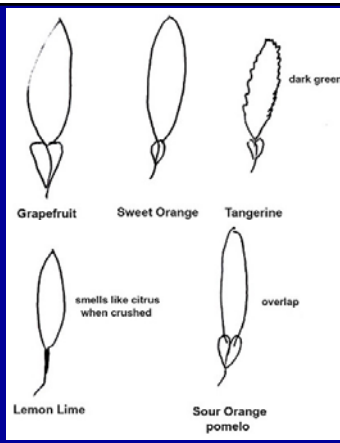
Taxonomy

Citrus classification based on morphology of mature fruit (e.g. juice sacs and vesicles) and is considered confused at present.

The citrus species originated from species with compound leaves, and although leaves are simple, all contain wings as appendages.

Leaves of pomelo, grapefruit, oranges, kumquats can develop considerable resistance to cold.

Leaf Morphology



Many do better where cold temperature or at least frost is common.

They are truly subtropical plants, but there are differences.

Pomelos never found of good quality in subtropical climates.

Taiwan, for example, has excellent pomelos in the south but quality lowers in the north.

Diploid chromosome number is $2n=18$; triploid and tetraploids are now found, and there are many sports (mutations) found in citrus.

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Tyosabura Tanaka, a Japanese taxonomist and an authority on the Old World Citrus included 145 species and is thus considered a “splitter.”

The classification of Walter T. Swingle, a USDA scientist who did much of his work in Florida, includes only 16 species and he is considered a “lumper.”

Swingle classification is relatively simple and contains 16 species.

Many hybrids exist among the species which complicates the horticultural classification.

Cultivated Familiar *Citrus* Species Include:

- C. aurantifolia* (lime, sour orange)
- C. grandis* (pomelo, shaddock; pomplousse is the French term for pomelo)
- C. limon* (lemon)
- C. medica* (citron)
- C. paradisi* (grapefruit)
- C. reticulata* (mandarin)
- C. sinensis* (sweet orange)

Fortunella margarita, *F. japonica* (cold hardy kumquat, fruits that are sweet on the outside, tart on the inside).

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



Orange

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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.

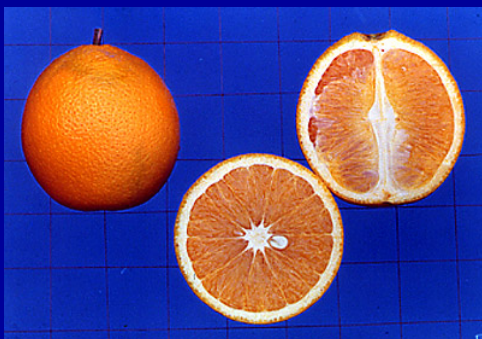
Note: Citrus can be stored on the tree from February to Summer.

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

Orange Production (2001)

Continent	1000 tonnes	Chief countries
World	61,094	
Africa	4,812	Egypt (1,714), S. Africa (1,041), Morocco (708)
North America	16,736	USA (11,240), Mexico (3,886), Costa Rica (405)
South America	19,884	Brazil (16,924), Argentina (861), Venezuela (500)
Asia	13,329	India (3,200), China (2,860), Iran (1,800)
Europe	5,855	Spain (2,734), Italy (1,935), Greece (950)
Oceania	477	Australia (470), New Zealand (4), Tonga (1)

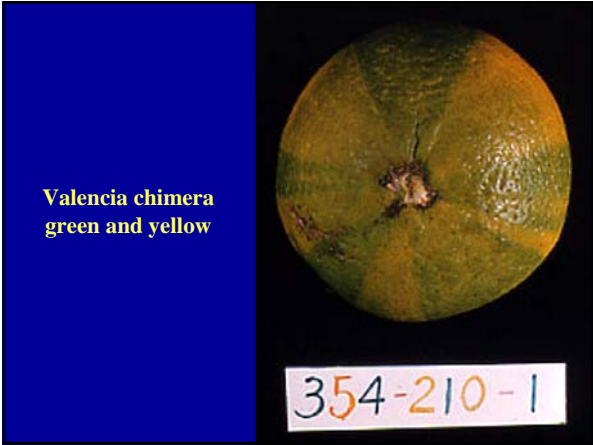
Sweet orange, *Citrus sinensis*

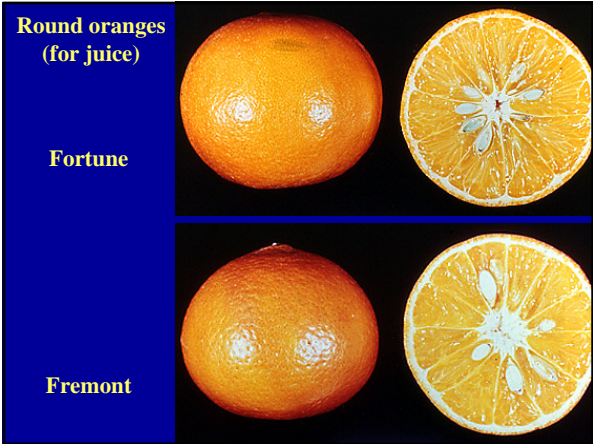


(Round orange) ‘Valencia’

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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).

Tangerines are small erect trees that fruit at the end of branches. The branches tend to be erect. The skin is loose and is hard to pick without damage but is the highest priced fruit. In Florida 10% of tangerines can be legally added to frozen orange concentrated for color. None are cold hardy.

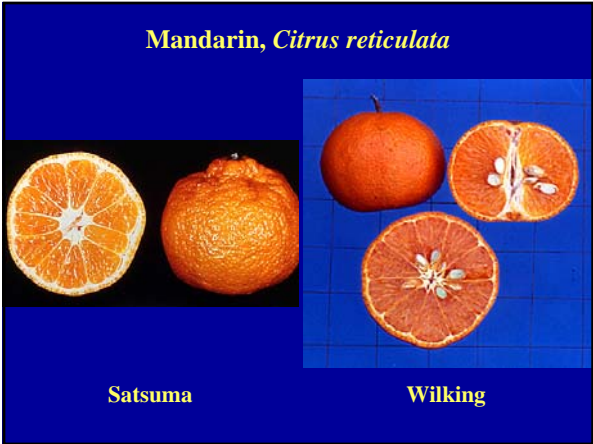


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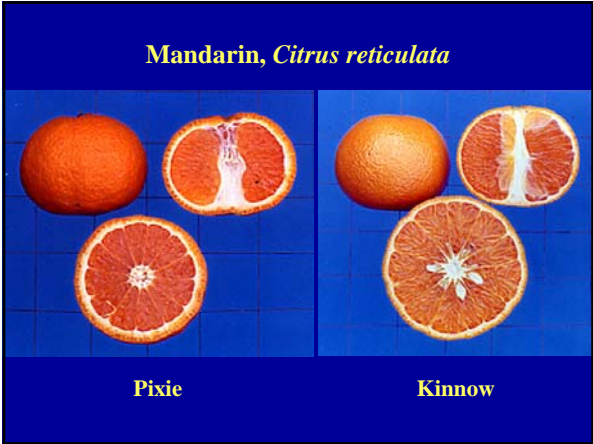
Tangerine Production (2001)		
Continent	1000 tonnes	Chief countries
World	16,613	
Africa	998	Egypt (483), Morocco (263), Algeria (110)
North America	756	USA (472), Mexico (250), Jamaica (16)
South America	1,825	Brazil (905), Argentina (474), Peru (128)
Asia	10,471	China (5,640), Japan (1,532), Iran (650)
Europe	2,470	Spain (1,653), Italy (636), Greece (90)
Oceania	93	Australia (87), New Zealand (6)

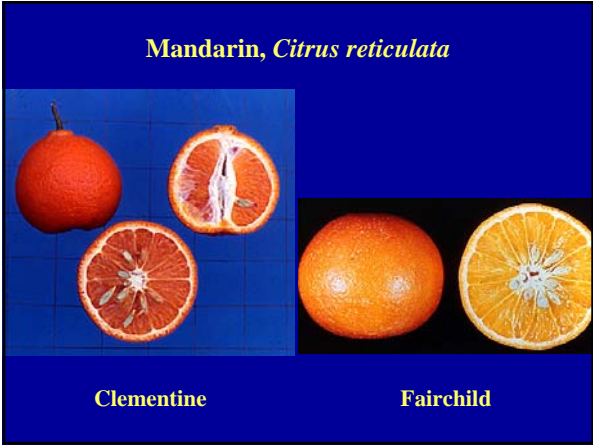


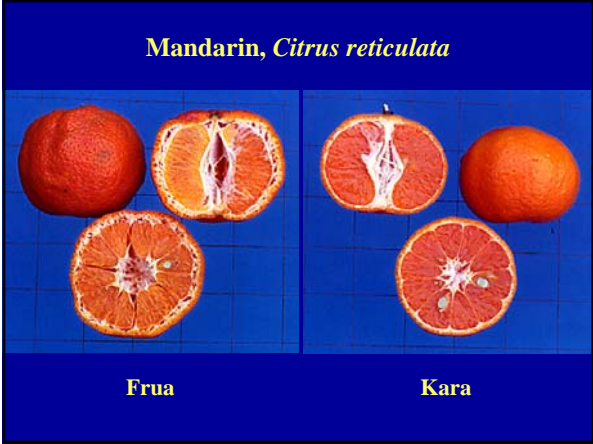
Tangerines along roadside in Japan



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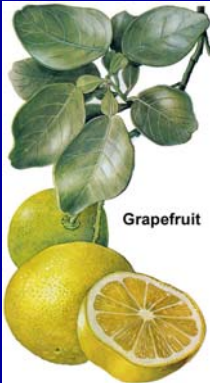


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Grapefruit (*Citrus paradisi*)

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')



The reddish seedless grapefruit now completely dominates the market.

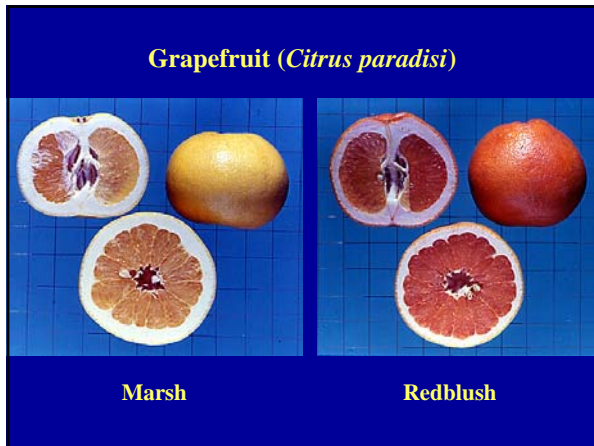
More high quality grapefruit is grown in Texas than Florida because of the higher temperatures.

In Florida, early grapefruit were induced to bear early by spraying with arsenic to induce peel injury and thus ethylene production, one of the best kept secrets of the grapefruit industry.

Grapefruit Production (2001)

Continent	1000 tonnes	Chief countries
World	4,831	
Africa	445	S. Africa (207), Sudan (67), Tunisia (50)
North America	2,813	USA (2,240), Mexico (212), Cuba (170)
South America	390	Argentina (191), Brazil (66), Paraguay (48)
Asia	1,115	Israel (318), China (275), Turkey (140)
Europe	54	Spain (29), Greece (8), Portugal (8)
Oceania	14	Australia (12), New Zealand (2)

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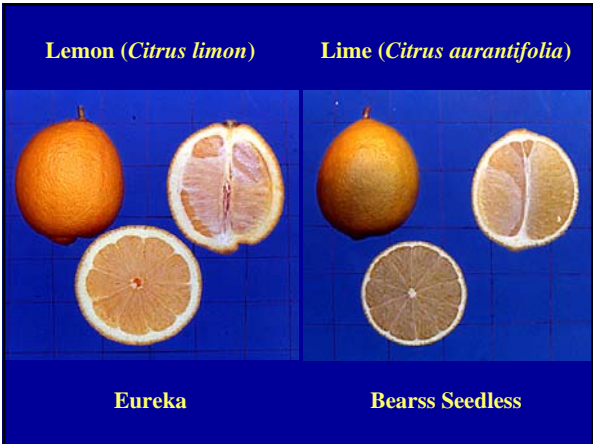


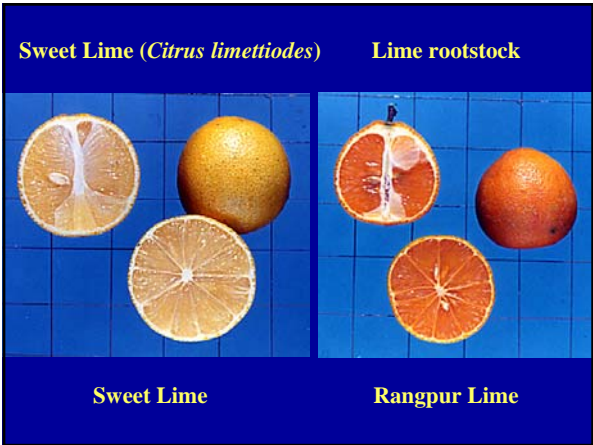


Lemon & Lime Production (2001)

Continent	1000 tonnes	Chief countries
World	10,885	
Africa	612	Egypt (301), S. Africa (106), Sudan (61)
North America	2,704	Mexico (1,547), USA (907), Guatemala (131)
South America	2,269	Argentina (1,180), Brazil (578), Peru (224)
Asia	3,605	India (1,400), Iran (850), Turkey (500)
Europe	1,654	Spain (961), Italy (537), Greece (145)
Oceania	40	Australia (34), New Zealand (4), Tonga (2)

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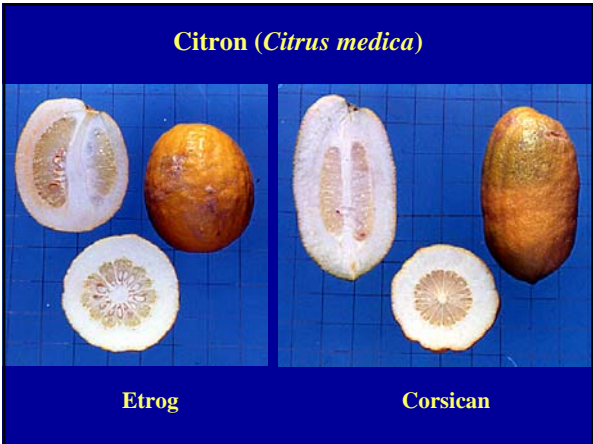


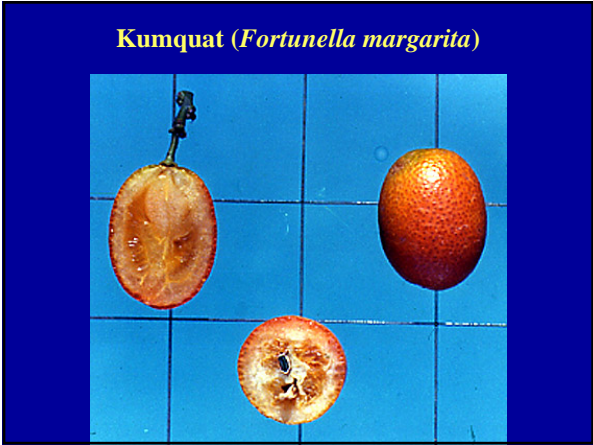


Other Citrus Production (2001)

Continent	1000 tonnes	Chief countries
World	5,309	
Africa	3,741	Nigeria (3,240), Guinea (210), Sierra Leone (80)
North America	25	Mexico (12), Guatemala (4), Trinidad (4)
South America	17	Ecuador (13), Suriname (4)
Asia	1,489	China (575), Syrian Arab Rep. (275), Japan (260)
Europe	26	Italy (15), Spain (7), Greece (3)
Oceania	11	New Zealand (8), Australia (1), Samoa (1)

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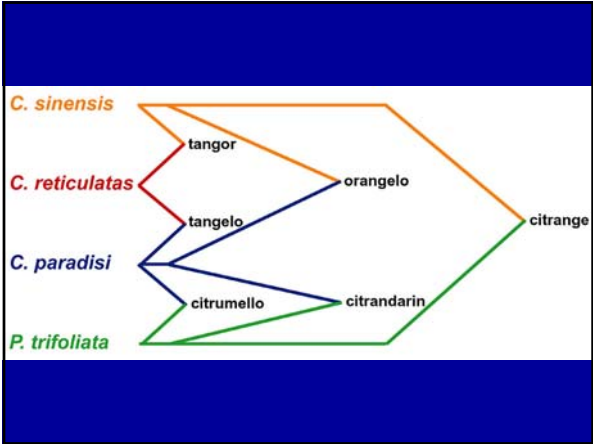


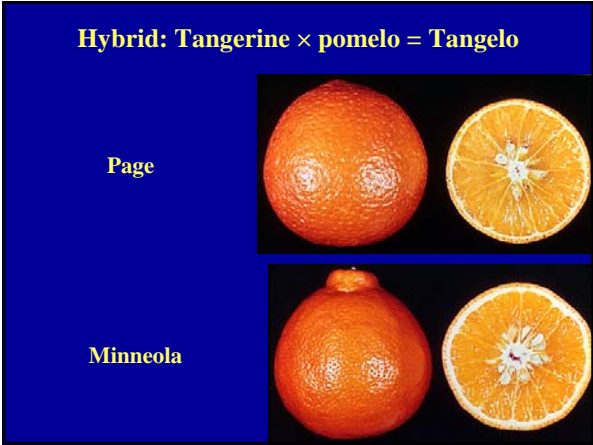
Citrus Hybrids

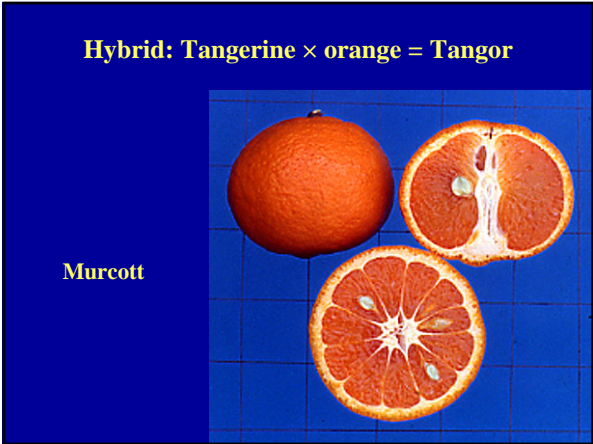
Prefixes and suffixes used in naming of citrus hybrids

- C. paradisi* (grapefruit)—suffix ummelo or ela
- C. sinensis* (sweet orange)—prefix or, suffix ange
- C. reticulata* (tangerine, mandarin)—prefix tan, suffix andarin
- C. limon* (lemon)—prefix lem
- P. trifoliata* (trifoliate orange)—prefix citr

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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.

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

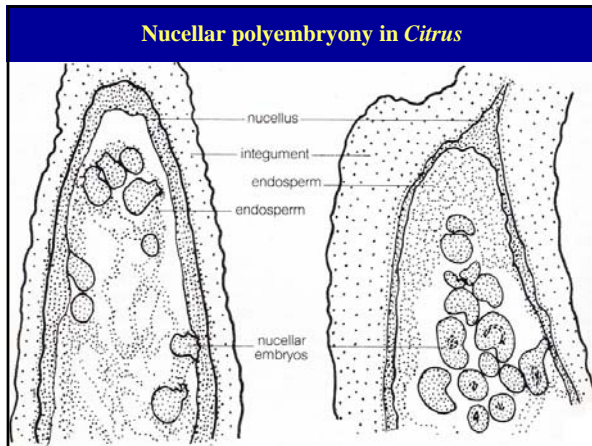
embryos form from nucellar tissue.

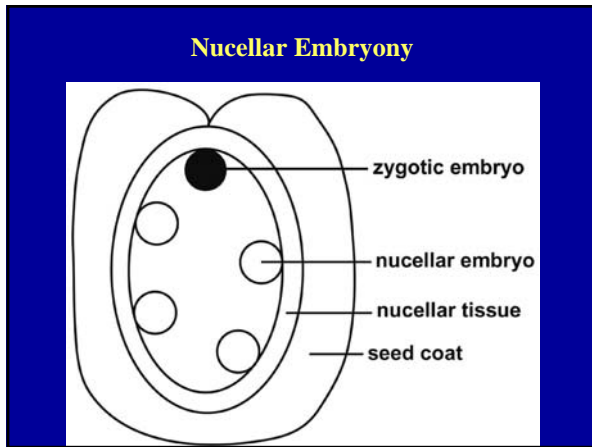
Nucellar embryony in citrus means that most embryos are vegetative not zygotic.

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

Pollination is needed to trigger nucellar development.

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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)

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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.

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 fruit is a berry, specifically a hesperidium.

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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.

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.

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Poncirus trifoliata (trifoliolate 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.

Diseases & Pests

Foot (trunk) rot is caused by fungal species of *Phytophthora*.

Rot develops on the base of the trunk.

Disease is influenced by rootstock, high humidity, high temperature, and trunk injury.

Sweet orange is very susceptible and is therefore not used as rootstock.

'Cleopatra' mandarin and 'Sour Orange' are very resistant.

Virus diseases (Tristeza, Xyloporosis, Exocortis, Psorosis) are all graft transmitted.

Tristeza is the only virus transmitted by insect vectors (aphids and leafhoppers).

Symptoms of virus diseases show up after 10 to 15 years but disease can be ruinous.

A budwood registration program is underway in most important citrus producing areas to distribute virus-free certified budwood.

These are usually produced originally from nucellar embryony or from heat treatment.

Virus is identified by ELISA (enzyme-linked immunosorbant assay).

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Bacteria—*Liberibacter asiaticus* is the pathogen responsible for Huanglongbing disease (HLB) known as citrus greening which is threatening the world citrus industry. It was found in Florida in 2005.

Nematodes—Several species cause problem. Some rootstocks are partially resistant.


Arthropods—There are many citrus pests including insects (scale, aphids, others) and mites.

Citrus Production (California)

A map of the state of California showing the major counties producing citrus.

The counties in white all produce some citrus in addition to other crops.


Primarily they are in the southern half of the state.



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.

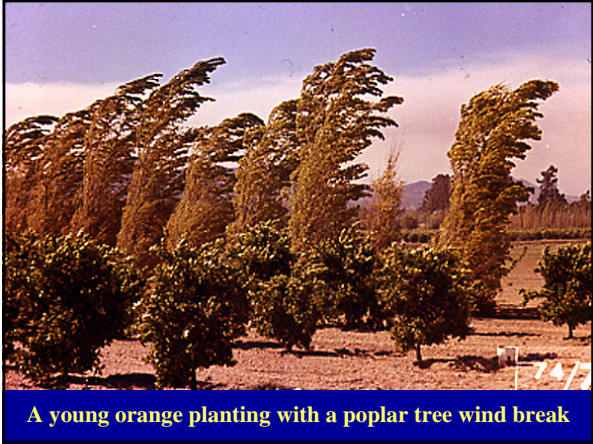
Later an irrigation system will be installed.



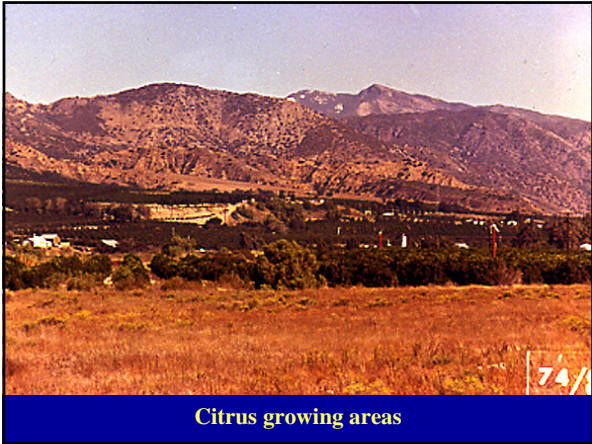
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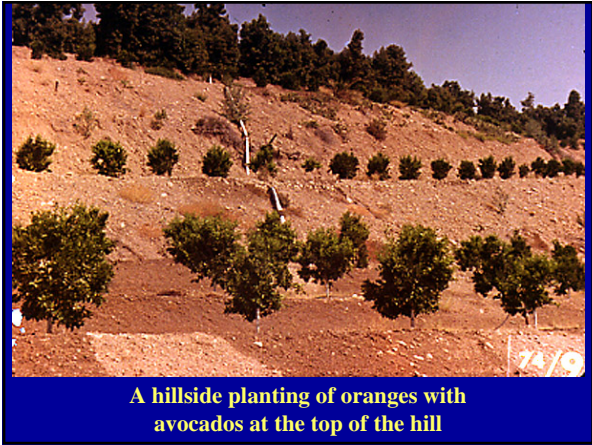




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Citrus growing areas



A hillside planting of oranges with avocados at the top of the hill



A general view showing orchard heaters and irrigation standpipes

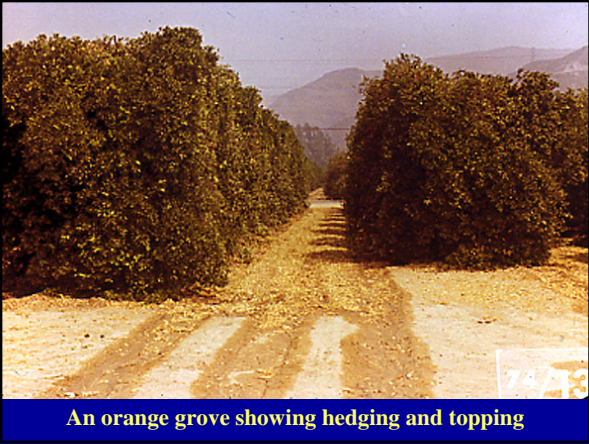
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Valencia oranges showing blossoms, green fruit, and fruit ready for picking



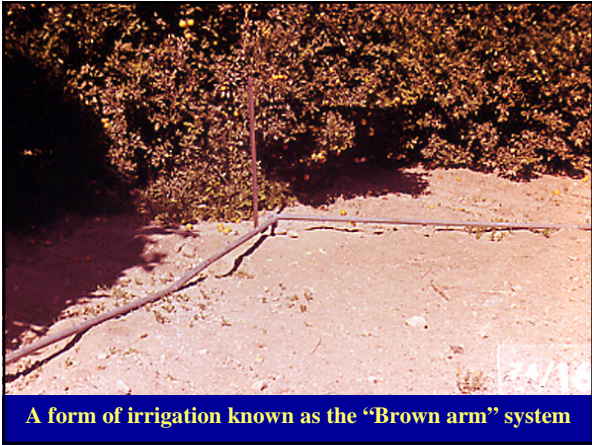
Non-cultivated orchard where the spacing of the ridges between the furrows is such that it matches the wheels of equipment



An orange grove showing hedging and topping

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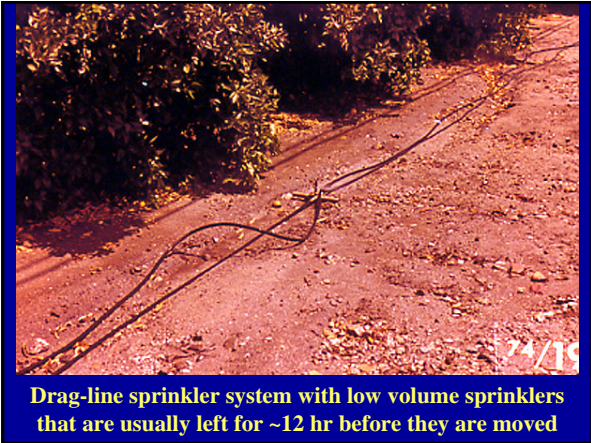


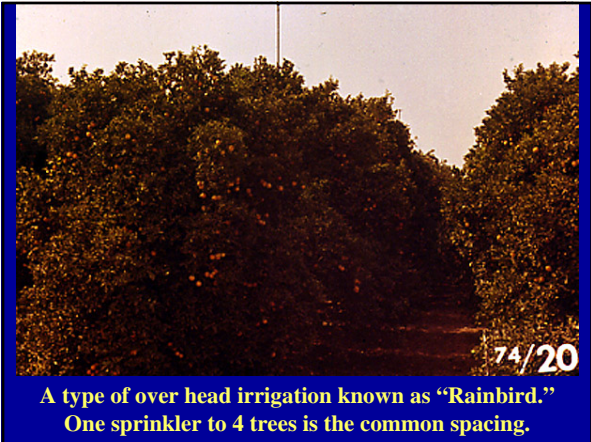




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Valencia orange grove, skirts of the tree on the right have been pruned to 2 ft above the ground in a comparison test of fruit yield and quality where a catching frame method of picking will be used



A dying tree showing the result of the Tristeza virus.



A citrus tree with Bordeaux powder sprinkled around the base to protect against brown rot gummosis

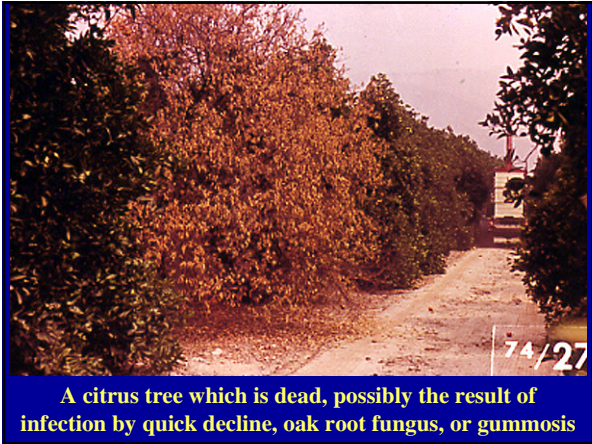
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A citrus tree which is dead, possibly the result of infection by quick decline, oak root fungus, or gummosis

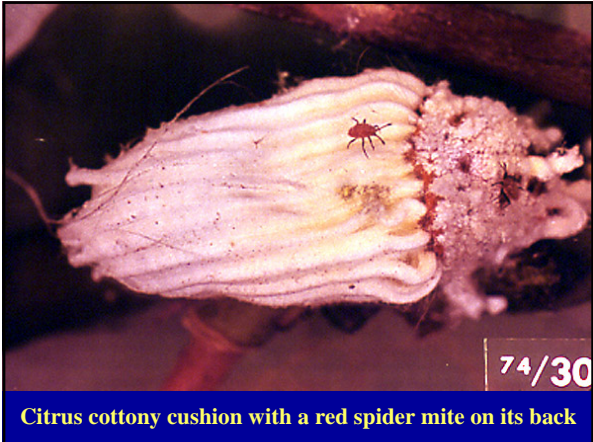


Orange Dog or Swallow-tail Butterfly



Black scale

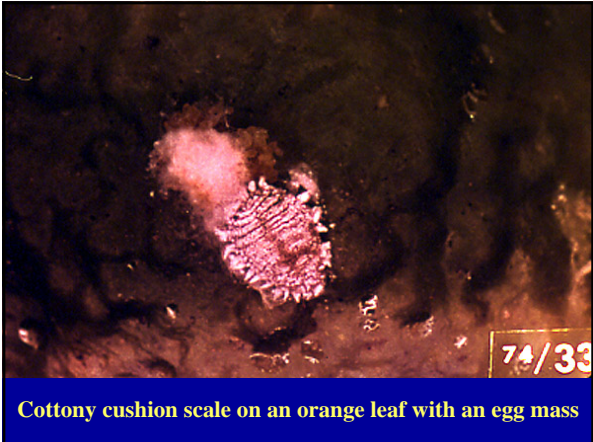
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Citrus cottony cushion with a red spider mite on its back

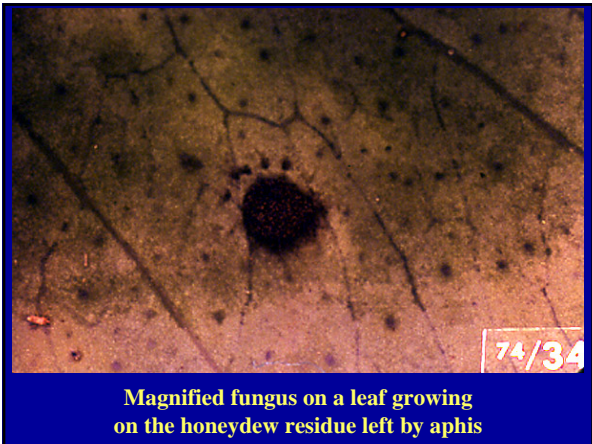


Mealy bug on a midrib of a citrus leaf



Cottony cushion scale on an orange leaf with an egg mass

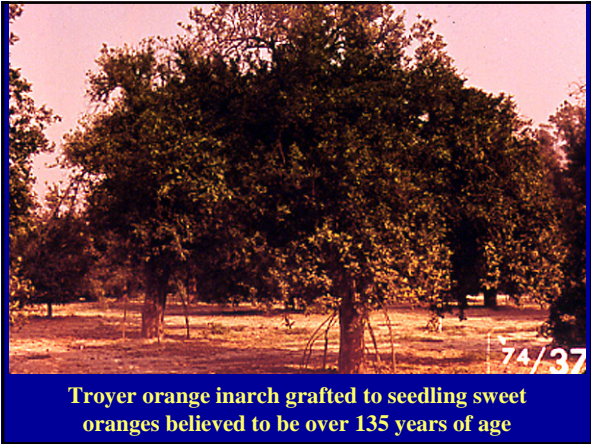
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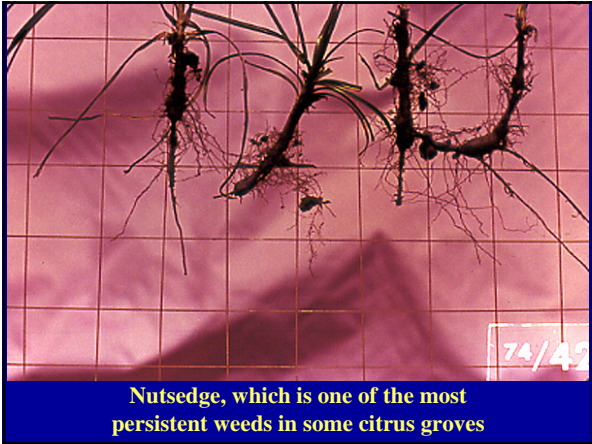
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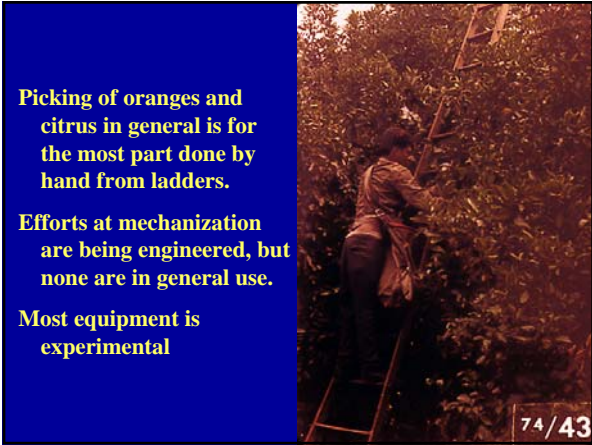






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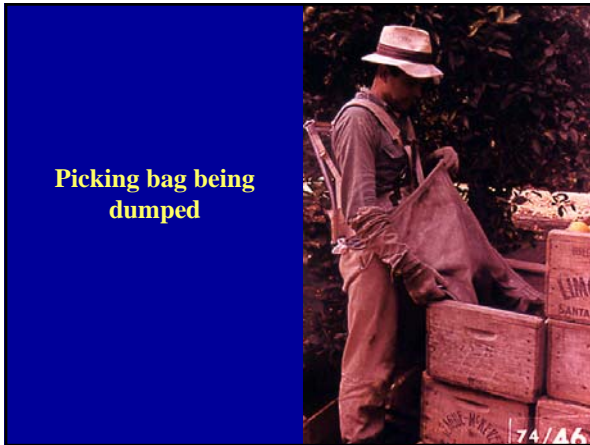




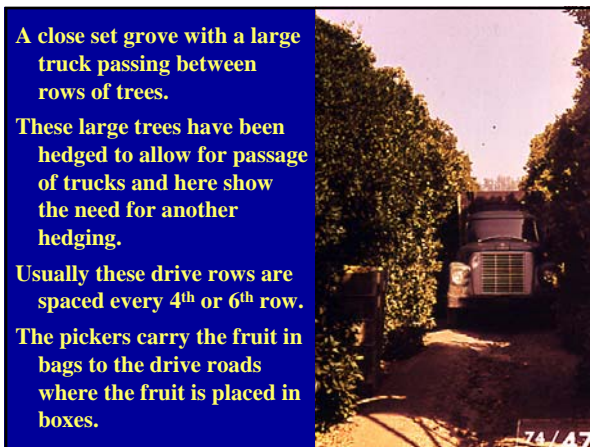
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An orange-picker using a pack frame picking-bag where the picker is high on a 15' ladder



Picking bag being dumped



A close set grove with a large truck passing between rows of trees.

These large trees have been hedged to allow for passage of trucks and here show the need for another hedging.

Usually these drive rows are spaced every 4th or 6th row.

The pickers carry the fruit in bags to the drive roads where the fruit is placed in boxes.

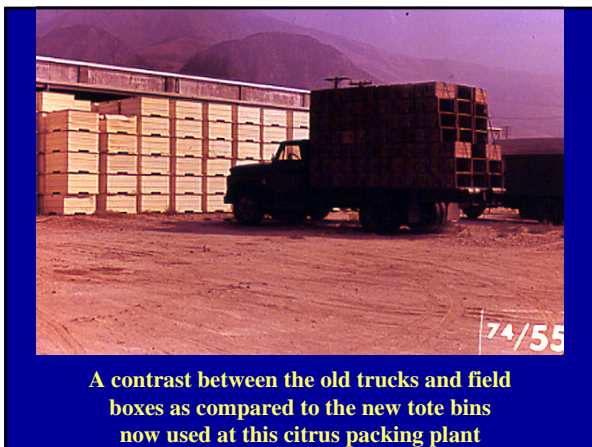
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Loading of field boxes on to the truck for hauling to the packing plant

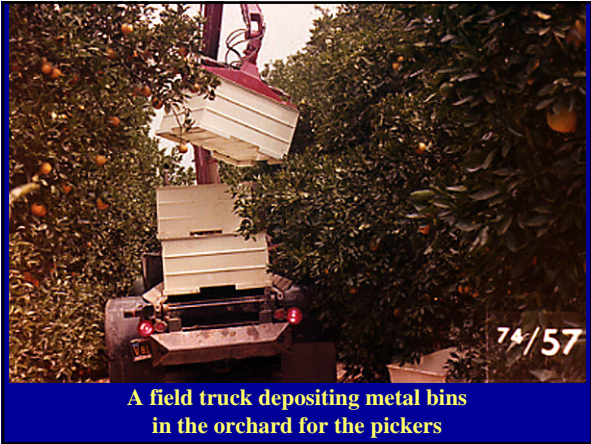


Citrus picker called an autopicker. Many attempts are being made to make the harvesting of fruit easier and less costly.

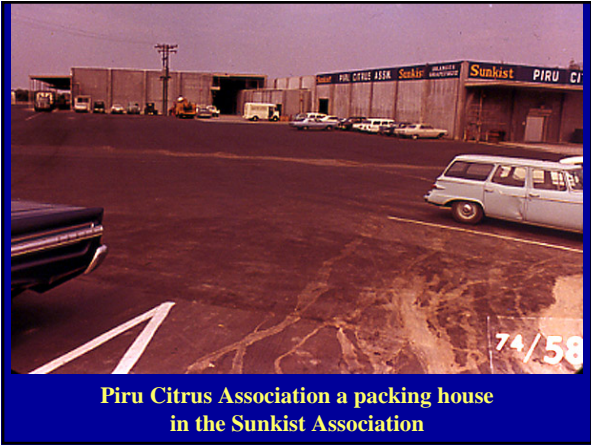


A contrast between the old trucks and field boxes as compared to the new tote bins now used at this citrus packing plant

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A field truck depositing metal bins in the orchard for the pickers



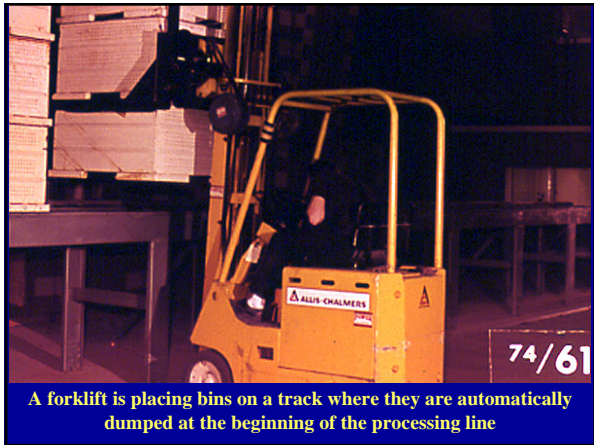
Piru Citrus Association a packing house in the Sunkist Association

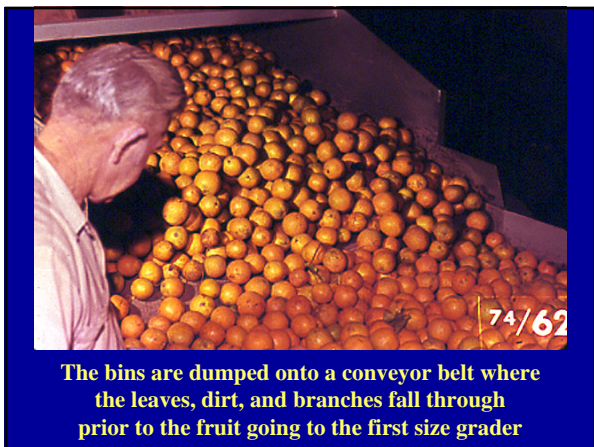


A truck unloading full bins. Rollers permit the driver to easily push the loaded bins to the platform.

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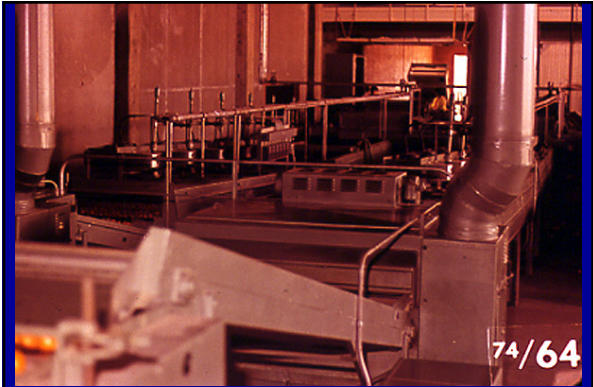




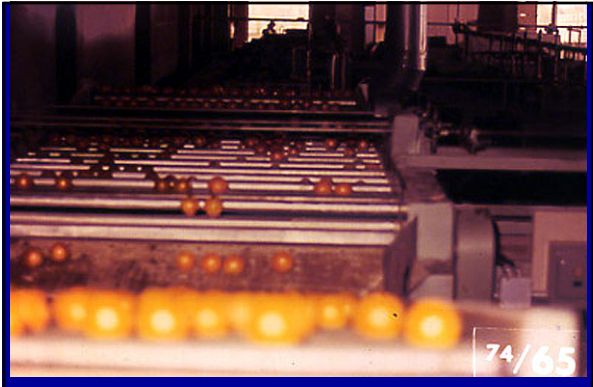
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Grading for size prior to washing



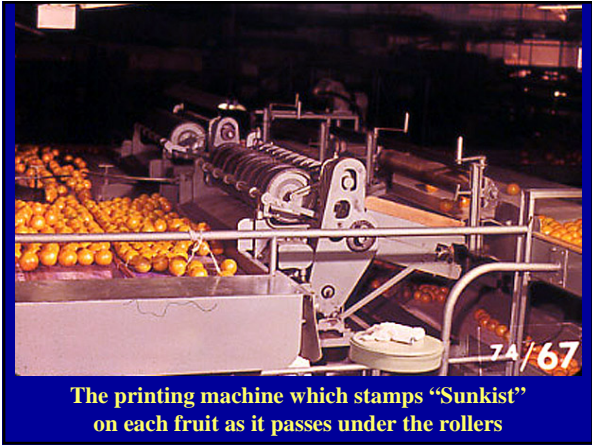
Equipment used in washing, drying, and waxing



Fruit on the conveyer as it comes out of the washer and waxer on its way to be stamped and graded for size

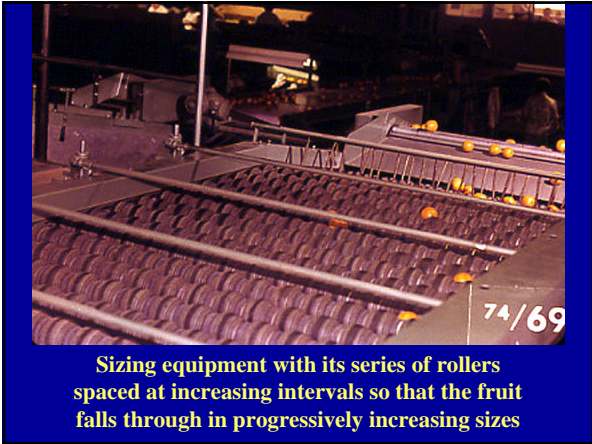
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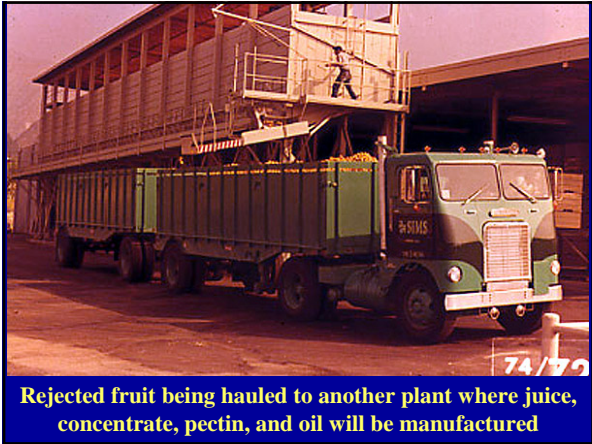
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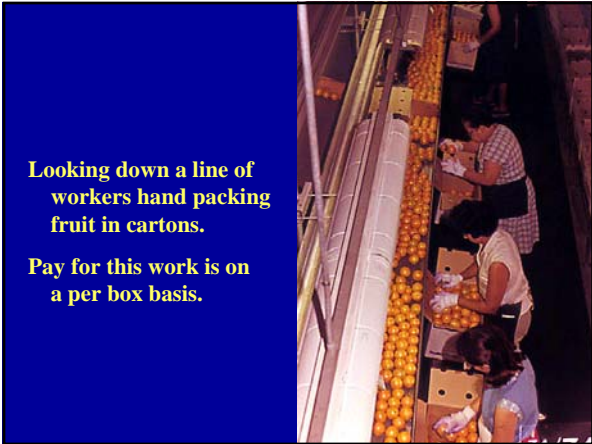




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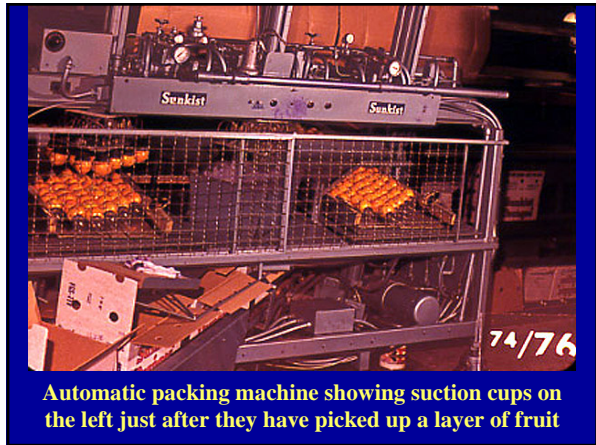


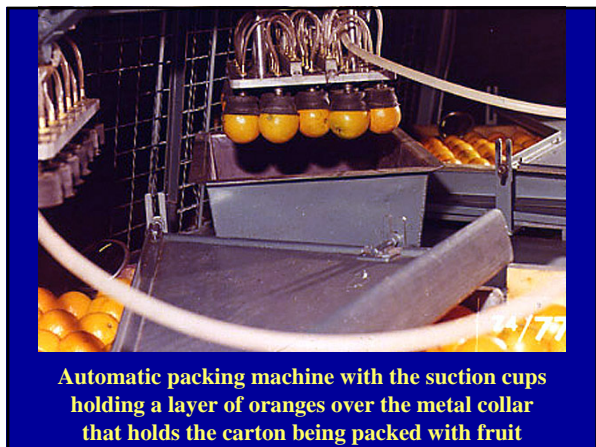




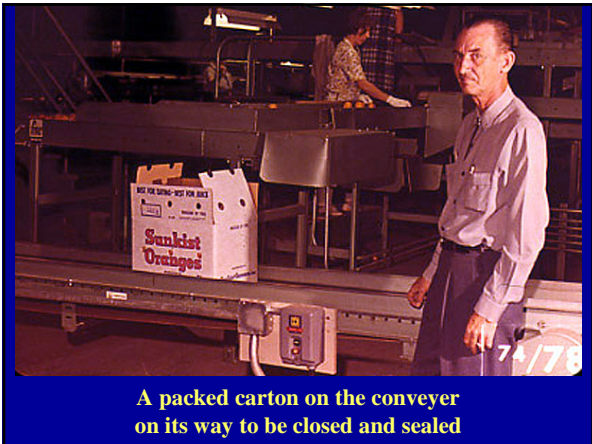
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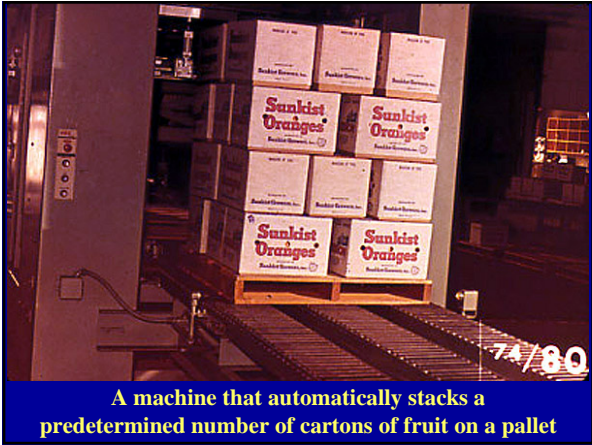






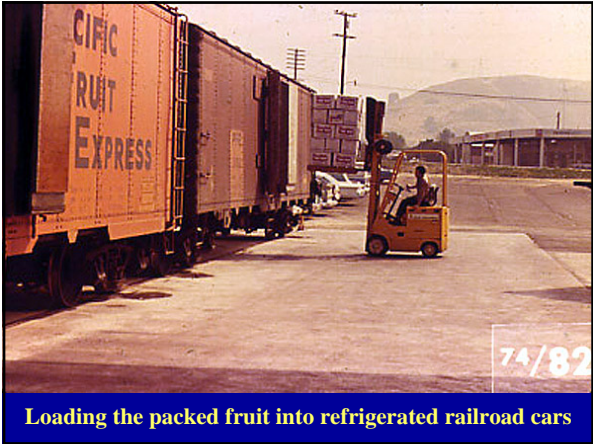
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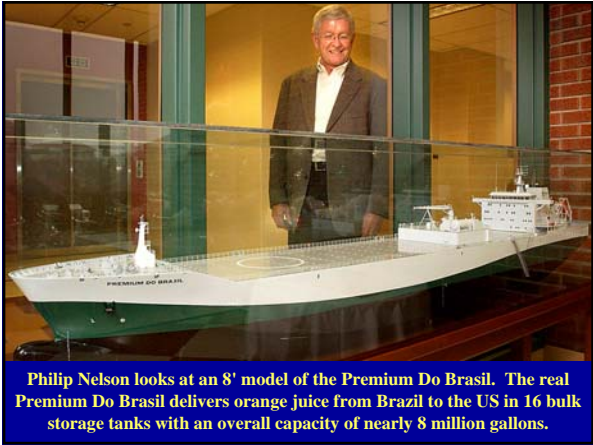




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Loading the packed fruit into refrigerated railroad cars



Philip Nelson looks at an 8' model of the Premium Do Brasil. The real Premium Do Brasil delivers orange juice from Brazil to the US in 16 bulk storage tanks with an overall capacity of nearly 8 million gallons.
