

Coffee (*Coffea arabica*): A New Crop for Southern California

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Presentation Overview

- Facts and Figures about Global Coffee Industry
- Coffee Taxonomy and Cultivated varieties
- Coffea Arabica – Typica vs. Bourbon
- Coffee production in Southern California – growing tips
- Coffee harvesting, processing, and storage
- Our coffee research efforts
- Summary and conclusions!

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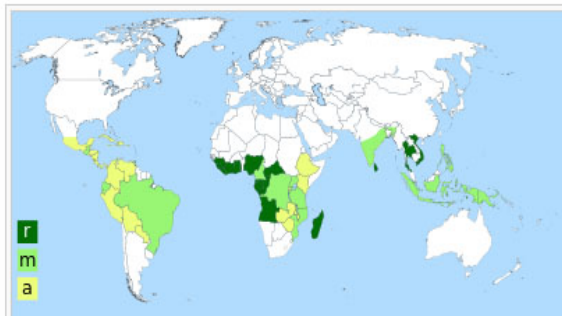
Facts About Global Coffee Industry

- Second only to oil as the world's most traded commodity with a value of more than \$100 billion annually
- 500 billion cups of coffee are drank daily (14 billion Italian espressos)
- Coffee farms support 25 million people worldwide (grown in 50 countries in Asia, Africa, South America, Central America & the Caribbean) with 67 % grown in the Americas.
- There are only two types of coffee...Arabica and Robusta! Despite the different flavors and varieties

Source: Business Insider's 11 Incredible Facts about the Global Coffee Industry <http://www.businessinsider.com/>

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Coffee Producing Regions & Top Producing Countries



Map showing areas of coffee cultivation:
r: *Coffea canephora*
m: *Coffea canephora* and *Coffea arabica*
a: *Coffea arabica*

Top Ten Green Coffee Producers – 2011
(millions of metric tons)

Brazil	2.70
Vietnam	1.28
Indonesia	0.63
Colombia	0.47
Ethiopia	0.37
Peru	0.33
India	0.30
Honduras	0.28
Mexico	0.25
Guatemala	0.24
World Total	8.46

Source:
[UN Food & Agriculture Organisation \(FAO\)\[1\]](#)

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Facts About Global Coffee Industry

- Coffee shops are fastest growing niche in restaurant business with a 7 % annual growth rate (Starbucks is 3rd largest chain in the US)
- 90 % of world coffee production occurs in developing countries, but it is consumed in industrialized nations.
- Finland drinks most coffee per capita in the world...the US ranks 25th per capita but is largest consumer overall
- Fair trade coffee, though a small portion of the market, is most popular fair trade commodity (\$1.26/pound vs. \$0.70 to 0.90/pound)
- 37 coffee producer countries listed in the WWF's 50 countries with the highest deforestation rates

Source: Business Insider's 11 Incredible Facts about the Global Coffee Industry <http://www.businessinsider.com/>

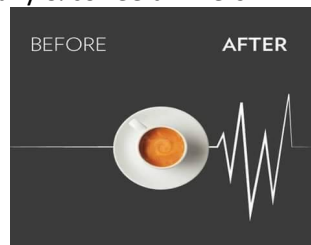
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Facts About Global Coffee Industry

- Top five importing countries (France, Germany, Italy, Japan & the US) consumed about 51.5 million bags in 2013 (49.7 million in 2012)
- Retail value of the US coffee market is \$48 billion (55 % specialty)
- 48 % of US coffee cups perceived by consumer to be specialty coffees
- Daily consumption among 18-24 year olds steady at 35 %, but declining among 25 to 39 year olds from 42 % in 2014 to 36 % in 2015
- US is world's largest single buyer with 27.5 million bags imported in 2014, or about ¼ of global coffee imports
- Over half of Americans over 18 drink coffee daily & coffee drinkers average 3.5 cups a day
- Coffee provides 75 % of America's caffeine

Source: Specialty Coffee Association of America Website <http://www.scaa.org/>

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Facts About Global Coffee Industry

- Brazil (25%), Vietnam (18 %) and Colombia (13 %) account for most coffee imported to the US
- Coffee consumption in producing countries increasing rapidly
- Brazil consumed 21 million bags in 2014, about to replace the US as the single largest coffee consuming market at 23.4 million bags



Source: Specialty Coffee Association of America Website <http://www.scaa.org/>

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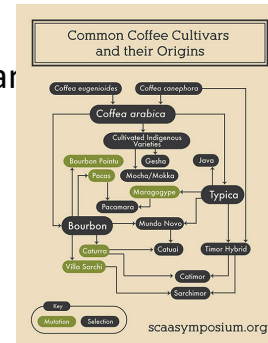
TAXONOMY and VARIETIES



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Taxonomy of Coffee

- Family: Rubiaceae, the coffee or madder family
 - 450 genera and 6500 species worldwide
 - Plants have simple, undivided leaves, opposite each other, usually near a lateral bud or shoot
 - Flowers have both male and female organs
- Genus: *Coffea*, which has about 100 – 120 species identified
- Species: Only three commercially relevant
 - *C. Arabica* – about 70 - 80 % of coffee produced
 - *C. canephora* (Var. Robusta)
 - *C. eugenioides*
 - *C. liberica*



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Taxonomy of Coffee, Continued:

- ***Coffea arabica*** – genus and species for Arabica coffee, originated in the forests of Ethiopia and South Sudan
- ***Coffea eugenioides*** – genus and species for eugenioides coffee, native to highlands of East Africa including D.R. Congo, Rwanda, Uganda, Kenya and Western Tanzania.
 - ✓ One of two diploid parent of *C. arabica*, with lower caffeine content
- ***Coffea canephora*** – genus and species for Robusta coffee, native to Western and Central sub-Saharan Africa.
 - ✓ One of two diploid parent of *C. arabica*, very productive cultivar different from *C. arabica* with much higher caffeine content
- ***Coffea liberica*** – genus and species for Liberica coffee, little value

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Differences Between Arabica and Robusta

- **Taste** – Arabica has the better flavor with Robusta often described as burnt tires or rubbery
- **Caffeine Content** – Robusta has more caffeine (2.7%) than Arabica (1.5 %)
- **Lipid & Sugar Content** – Arabica has about 60% more lipids and almost twice as much sugar than Robusta
- **Price** – Arabica is about twice the price of Robusta
- **Care and Maintenance** – Robusta is much easier to care for and has resistance to leaf rust and some nematodes
- **Plant height and Bean Shape** – Robusta are much taller trees, 4.5 to 6 m, versus 2.5 to 4.5 m for Arabica, Robusta bean are rounder, Arabica are more oval.
- **Chlorogenic Acid (CGA) Content** – This antioxidant and insect deterrent is much higher in Robusta (7-10 %) than Arabica (5.5 – 8 %)
- **Cultivation** – Arabica accounts for 75 % of world's coffee production versus 25 % for Robusta (Brazil and Vietnam are largest producers).

Varieties, Cultivars or Hybrids?

- **Variety** – Taxonomic rank below that of species and subspecies but above that of form. Plants within a variety are very uniform and share many characteristics.
- **Cultivars** - A plant or grouping of plants selected for desirable characteristics that can be maintained by propagation. Most cultivars have arisen in cultivation but a few are special selections from the wild.
- **Hybrids**: Any offspring resulting from the breeding of two genetically distinct individuals, which usually will result in a high degree of heterozygosity.

Coffea arabica: Typica vs. Bourbon

- Indigenous to Ethiopia and taken to Yemen in YEAR and then spread around the world
- Typica coffees known today originated from plants taken from Yemen to Java and neighboring islands
- Bourbon coffees originated from plants taken to the island of Bourbon by the French (now Reunion Island)
- These two cultivars are the basis for most of the coffee varieties cultivated in Latin America and Hawaii

Typica Cultivars:

- Java
- Maragogype
- Kent
- Geisha
- Kona
- Blue Mountain
- Sumatra
- Criollo
- Arabigo
- Pluma Hidalgo
- Bergundal, AKA Garundang
- San Bernardo, AKA Pache
- San Ramon
- Chickumalpur
- Blawan Paumah
- Sidikalang
- K7
- K20
- BMJ
- Guatemala
- Pache Comun
- Pache Colis
- Villalobos
- Amarello de Botucatu

Bourbon Cultivars

- Bourbon Pointu/Laurina
- SL28
- SL34
- Tekisic
- Villa Sarchi
- Pacas
- Pacamara
- Caturra
- Mocha/Mokka
- Batian
- French Mission
- Yellow Bourbon
- Red Bourbon
- Orange Bourbon
- Pink Bourbon
- Mibirizi
- Mayagues
- Bourbon Chocola
- Sempenflorens
- Arusha
- Ibairi
- Cera
- Jackson
- Jackson 2/1257

Typica - BourbonCrosses

- Acaia
- Mundo Novo
- Catuai
- Maracaturra
- Rubi
- Ouro Verde
- Ouro Bronze

The Timor Hybrid

- Naturally occurring cross between *C. canephora* and *C. arabica*, var. *Typica* on the Island of Timor in Southeast Asia
- Known as Arabusta hybrids, they were naturally resistant to leaf rust and became popular in the 1950s
- Different lines of this hybrid have been used in breeding programs to create rust resistance varieties
- Three main variety groups resulted from this effort and are cultivated in Latin America today:
 - ✓ Catimors – Caturra X Timor Hybrid
 - ✓ Sarchimors – Villa Sarchi X Timor Hybrid
 - ✓ Colombia – Yellow Caturra X Timor Hybrid

Cultivars with Timor Hybrid Origins

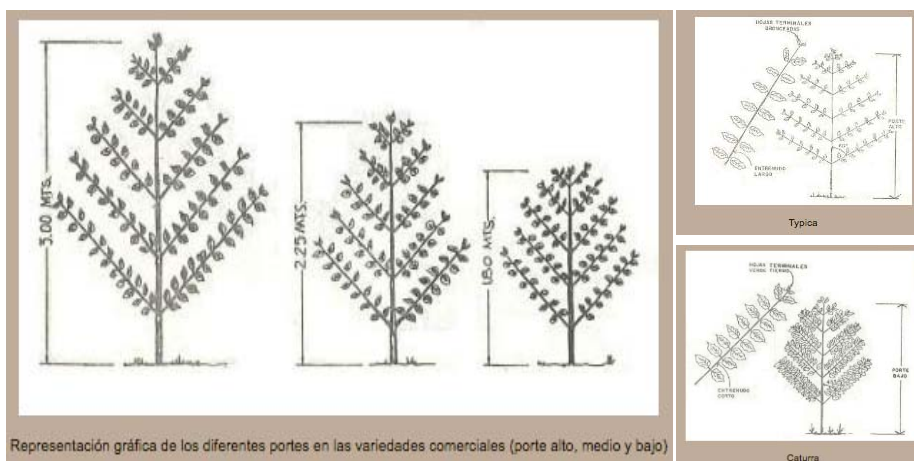
- | | | |
|--------------|-----------------------|---------------|
| • Catimor | • IAPAR 59 | • Paraiso |
| • Colombia | • IAPAR 103 | • Rasuna |
| • Icatu | • IPAR 103 | • Catucaí |
| • Ihcafe90 | • Tabi | • Lempira |
| • Ruiru 11 | • Costa Rica 95/CR 95 | • Maracatu |
| • Anacafe 14 | • Devamachy | • Catiga MG2 |
| • Sarchimor | • Marsellesa | • Selection 9 |
| • Castillo | • Catigua | • Ateng |
| • Oro Azteca | • Bogor Prada | • Parainema |
| • Acaia | • Tupi | • Arla |
| • ICAFE 95 | • Obata | |
| • ICAFE 90 | • Catrenic | |

Ethiopian and Sudanese Coffees

- Geisha
- Harrar
- Sjimma
- Djimma
- Lekempti
- Sidamo
- Agaro
- Mugi
- Wellega
- Melka
- Haru
- Gera
- Mettu
- Awada
- Wenago
- Mechara
- Alghe
- Cioccie S6
- Dalle
- Abyssinia
- Longberry Harrar
- Gawe
- Melko-CH2
- Ababuna
- Tegu
- Rambung
- Tafarikela
- Dega
- Ennarea
- Dilla
- Ghimbi
- USDA 762
- Barbuk Sudan
- Rume Sudan

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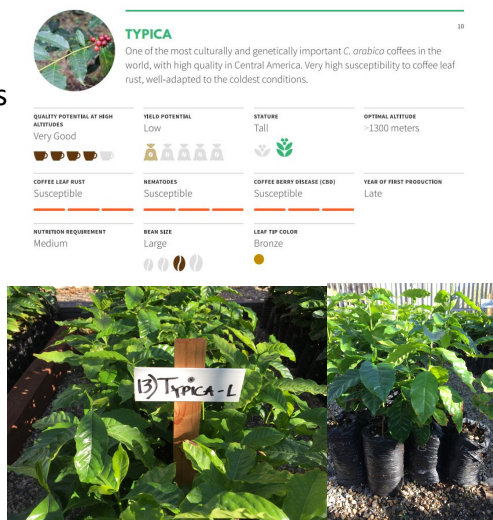
Coffee Plant Structure



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Typica o Arabigo (Etiopia)

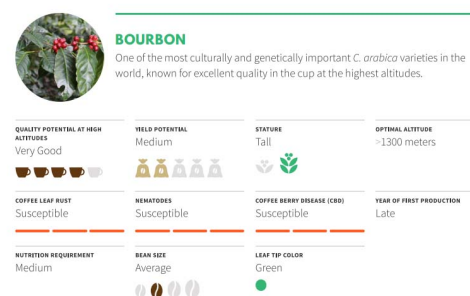
- Tall plant (3.0 mts.)
- Lateral branches for 60 degree angle from main axis
- Long internodes
- Terminal leaves/shoots bronze color
- Narrow and dull colored leaves
- Low productivity
- Low tolerance to wind
- Not usually recommended for planting, but always included as a reference



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Bourbon (Red & Yellow)

- Tall plant (3.0 mts.)
- Lateral branches form 45 degree angle from main axis
- Internodes shorter than Typica.
- Terminal leaves/shoots lime green
- Leaves rounder and shinier/glossier than Typica.
- High producer.
- Low wind resistance



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Robusta (Coffea canephora, Etiopia)

- Flagship variety within the specie
- Cultivated primarily in Asia & Africa
- Tall and vigorous plant (>4 mts)
- Plants have 3-5 vertical axes with moderate inclination
- Lateral branches are long with little secondary branching
- Long internodes with large leaves
- Fruit is small and round, in clusters of 15-25 fruits

NEMAYA ROOTSTOCK			
A Robusta variety used for rootstock grafting because of its high resistance to nematodes. Arabica plants (any variety) can be grafted onto Nemaya rootstock to make the plant resistant to nematodes. Grafting Arabica onto Robusta rootstock has no effect on cup quality.			
QUALITY POTENTIAL AT HIGH ALTITUDES Not applicable	YIELD POTENTIAL Not applicable	STATURE Not applicable	OPTIMAL ALTITUDE 600 meters
COFFEE LEAF RUST Not applicable	NEMATODES Resistant	COFFEE BERRY DISEASE (CBD) Not applicable	YEAR OF FIRST PRODUCTION Not applicable
NUTRITION REQUIREMENT Not applicable	BEAN SIZE Not applicable	LEAF TIP COLOR Not applicable	



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Catuai (Brasil)

- Cross between Mundo Novo and Caturra
- Semi dwarf(2.25 mts.)
- Lateral branches form 45 degree angle from main vertical axis
- Short internodes
- Terminal leaves or shoots are lime Green
- Wind resistant

CATUAI			
A compact plant with high yielding potential of standard quality in Central America. Very high susceptibility to coffee leaf rust.			
QUALITY POTENTIAL AT HIGH ALTITUDES Good	YIELD POTENTIAL Caturra-like	STATURE Dwarf	OPTIMAL ALTITUDE >1300 meters
COFFEE LEAF RUST Susceptible	NEMATODES Susceptible	COFFEE BERRY DISEASE (CBD) Susceptible	YEAR OF FIRST PRODUCTION Average
NUTRITION REQUIREMENT High	BEAN SIZE Average	LEAF TIP COLOR Green	



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Pacamara (El Salvador)

- Cross between Pacas & Maragogype
- Dwarf plant with short internodes
- High productivity
- Terminal leaves/shoots green or bronze
- Leaves and fruit are large
- Variety not homogeneous



PACAMARA
Standard quality in Central America. Very high susceptibility to coffee leaf rust. Variety not homogeneous; plants are not stable from one generation to the next.

QUALITY POTENTIAL AT HIGH ALTITUDES Very Good	YIELD POTENTIAL Caturra-like	STATURE Dwarf	OPTIMAL ALTITUDE ~1300 meters
COFFEE LEAF RUST Susceptible	NEMATODES Susceptible	COFFEE BERRY DISEASE (CBD) Susceptible	YEAR OF FIRST PRODUCTION Average
NUTRITION REQUIREMENT Medium	BEAN SIZE Very Large	LEAF TIP COLOR Green or Bronze	



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Caturra (Brasil)

- Natural Bourbon mutation
- Dwarf, compact plant (1.80 mts.) with short internodes
- Lateral branches form 45 degree angle from main axis
- Terminal leaves or shoots lime green color
- Leaves round and shiny, glossy
- Excellent producer
- Wind resistant



CATUAI
A compact plant with high yielding potential of standard quality in Central America. Very high susceptibility to coffee leaf rust.

QUALITY POTENTIAL AT HIGH ALTITUDES Good	YIELD POTENTIAL Caturra-like	STATURE Dwarf	OPTIMAL ALTITUDE ~1300 meters
COFFEE LEAF RUST Susceptible	NEMATODES Susceptible	COFFEE BERRY DISEASE (CBD) Susceptible	YEAR OF FIRST PRODUCTION Average
NUTRITION REQUIREMENT High	BEAN SIZE Average	LEAF TIP COLOR Green	



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Ihcafe-90 (Honduras)

- Catimor selection
- Dwarf, compact plant with short internodes
- Terminal leaves/shoots are dark bronze color
- High production potential with low cup quality



IHCAFE 90 CATIMOR

High yielding plant adapted to lowest altitudes. Requires high fertilization.

QUALITY POTENTIAL AT HIGH ALTITUDES Very Low	YIELD POTENTIAL High	STATURE Dwarf	OPTIMAL ALTITUDE 600-1000 meters
COFFEE LEAF RUST Resistant	NEMATODES Susceptible	COFFEE BERRY DISEASE (CBD) Susceptible	YEAR OF FIRST PRODUCTION Early
NUTRITION REQUIREMENT Very High	BEAN SIZE Average	LEAF TIP COLOR Dark Bronze	



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Lempira (Honduras)

- Catimor selection
- Dwarf plants with short internodes
- Terminal leaves/shoots are bronze color
- High production potential
- Well adapted to warmer zones and acidic soils



LEMPIRA CATIMOR

High yielding variety adapted to warmest zones and acidic soils.

QUALITY POTENTIAL AT HIGH ALTITUDES Low	YIELD POTENTIAL High	STATURE Dwarf	OPTIMAL ALTITUDE 600-1200 meters
COFFEE LEAF RUST Resistant	NEMATODES Susceptible	COFFEE BERRY DISEASE (CBD) Susceptible	YEAR OF FIRST PRODUCTION Average
NUTRITION REQUIREMENT High	BEAN SIZE Average	LEAF TIP COLOR Bronze	



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Icatu (Brazil)

- Hybrid between C. canephora and red Bourbon
- Tall plant
- Highly productive
- Good resistance to leaf rust
- Better than average cupping quality/flavor profile



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Coffee Production in the US

- Commercial production very limited, few “commercial” growers in California (Santa Barbara and San Diego Counties) since mid 90s
- Coffee has great potential as a house plant and can be grown indoor or outdoor with some protection in frost free zones
- Can be a rewarding experience



Source:
<http://www.gardeningknowhow.com/houseplants/coffee/growing-coffee-plants-indoors.htm>

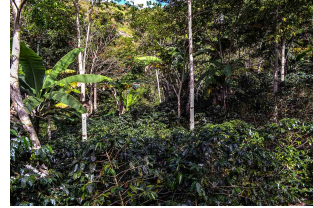


Source :
<http://houseplants.about.com/od/Tropicals/p/Coffee-Growing-Coffee-Plants.htm>

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Climatic Requirements

- Coffee is usually grown under partial shade as an understory crop, but adapts well to full sun
- Optimum temperatures range from 59 to 75 F (15-24 C)
- Coffee plants like high humidity with well defined rainy and dry seasons
- They like protection from winds
- Coffee plants may be damaged or killed by freezing temperatures
- Arabica Coffee grows better at altitudes between 1800-3600 feet; whereas Robusta grows from sea level to 3000 feet.
- Coffee trees must be planted in shady areas to minimize exposure to direct sunlight or near a window if grown indoors



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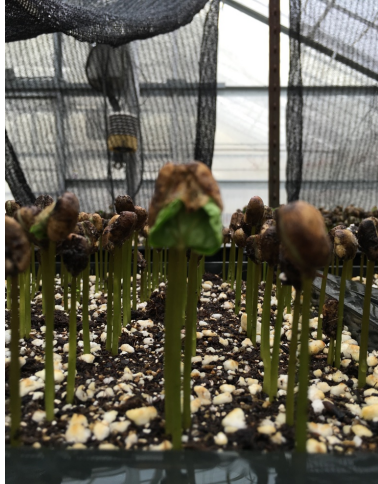
Propagation

- Commonly done from seed, but tissue culture is gaining popularity
- Seed should be selected from the biggest, ripest cherries, and used as soon as possible
- Select the best seeds...avoid triangles, peaberries or any damaged seed
- Germinate seeds in seed beds or in deep trays to foster root growth
- Seeds should be placed face down, covered with 1-2 cms of soil/mix, and shaded
- Mix of peatmoss, perlite and vermiculite works well for seed germination



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Propagation, Cont'd



- Seed beds or trays must be kept moist at all times avoid drying
- Seeds take about 40 days to germinate and start emerging, and seedlings should be ready for transplant after 90 days



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Anatomy of the Coffee Cherry and Beans

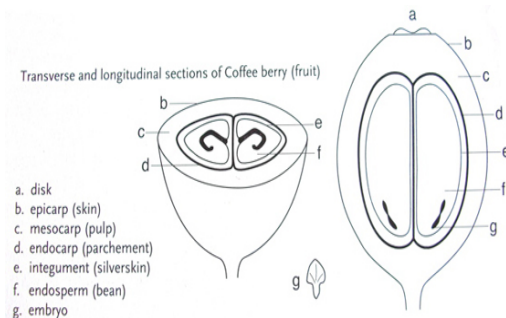
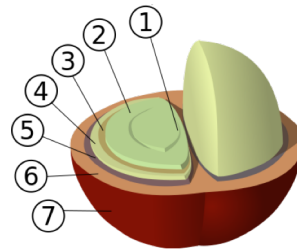


Figure 1.1 Coffee cherry (fruit). From Wintgens, J. N.: Coffee: Growing, Processing, Sustainable Production. Page 4, 2009. Copyright Wiley-VCH Verlag GmbH & Co. KGaA. Reproduced with permission.



Structure of coffee berry and beans:

- 1: Center cut.
- 2: Bean ([endosperm](#)).
- 3: Silver skin (testa, [epidermis](#)).
- 4: Parchment coat (hull, [endocarp](#)).
- 5: [Pectin](#) layer.
- 6: Pulp ([mesocarp](#)).
- 7: Outer skin ([pericarp](#), [exocarp](#)).

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Soil Requirements

- Coffee plant prefer well drained, slightly acidic soils with high organic matter content
- If pH is a problem or drainage are an issue, they must be corrected before planting to encourage proper nutrition and healthy plant growth
- If grown in containers you may want to use a slightly acidic mix and amend as needed with mulch or other source of organic matter
- If grown in containers you must repot your plant to accommodate the root system and promote growth...the larger the pot, the larger and fuller the plant will be
- Azalea mix or any acid loving plant mix could be used but should be amended with organic matter and/or perlite to improve drainage and air porosity

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Transplanting Seedling to Nursery Liners



- Select only healthy, strong seedlings with straight root systems...avoid any root deformities!!
- Seedlings can be transplanted to their final location at this stage but it is better to grow them in nursery liners for 3 to 6 months before transplanting them

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Growing your Nursery Plants



- This is a good time to start acclimating your plants if you will grow them outdoors
- Select only healthy, strong plants, with a straight stem for growing
- You must replot your plants every 2-3 years to accommodate the root systems and promote healthy growth



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Watering & Water Requirements

- Coffee plants like water and do great under high humidity
- Water enough to keep the soil moist, but avoid saturating the soil
- Coffee roots are fibrous and somewhat shallow so higher frequency and shorter irrigations are better
- Overhead irrigation (sprinkler or hose) could be used to keep plant clean, increase humidity and stimulate bud development
- Watering should be reduced to a minimum in the winter and resumed to normal in the spring to induce flowering
- Coffee plants will tell you when they need water (they will wilt)...but this should be avoided to maintain a healthy plant

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Feeding Your Coffee Plants

- Fertilize your plant with a complete formula (NPK) when transplanting from the nursery container to the soil or a larger container
- Young nursery plants should receive a small amount of fertilizer to start and increase amount gradually as the plant grows
- Apply ½ to 1 oz of a complete formula quarterly for the first 2 years, and increase up to 6 oz/year total from year 3 and older
- Coffee plants respond well and benefit from foliar fertilization with both macro and micro nutrients

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Flowers and Flowering

- Flowers are small, fragrant and clustered around the axil of the leaves
- Flowers have 5 white petals and a single ovary
- They open in the morning and last for 2 days
- C. Arabica flowers are self fertile, and mostly self pollinating (about 90% of the flowers are pollinated by the time they open)
- Robusta coffee flowers are self-infertile and need cross pollination
- It takes about 9 and 11 months from bloom to harvest for C. arabica and C. canephora respectively



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Coffee Harvesting

- Coffee is usually harvested by hand, selecting the berries that are fully ripe, full color
- Avoid picking green or overripe berries, they will affect the quality of the coffee
- Sort green or overripe berries and any foreign materials before processing



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Coffee Processing & Storage

- The processing method is one of the most important contributors to the flavor profile of coffee
- Various methods are used in different regions of the world, including:
 - ✓ **Dry or Natural Process** – the cherries are dried whole, resulting in a coffee that is fruity, heavy in body, sweet, smooth and complex.
 - ✓ **Wet Process** - Usually involves removing the outer skin and the pulp, fermenting and washing the coffee to remove the mucilage or pectin layer. The result is a cleaner, brighter and fruitier coffee.
 - ✓ **Pulped Natural** – involves pulping the coffee but omitting the fermentation and the washing to remove the mucilage. This results in a coffee with characteristics of both the dry and wet process.

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Dry & Wet Processing



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Coffee Pests and Diseases

- Insect pests or diseases do not seem to be a problem in the US, but they are a major problems elsewhere:
 - ✓ Coffee Leaf Rust (*Hemileia vastatrix*) -
 - ✓ Coffee Berry Disease (*Colletotrichum kahawae*) – considered a major factor limiting Arabica coffee production in Africa
 - ✓ Bacterial Blight - (*Pseudomonas syringae pv. garcae*) is a disease that occurs where wet and cold conditions prevail
 - ✓ Nematodes - *Meloidogyne exigua*, *M. incognita*, *M. coffeicola*, *Pratylenchus brachyurus*, and *P. coffeae* are the most common species of root-knot coffee nematodes.
 - ✓ Coffee Borer (*Hypothenemus hampei*) – the most damaging pest affecting coffee throughout its history
 - ✓ Other insects – stem borers. Leaf miners, mealy bugs, scales and mites may potentially attack coffee but not an issue yet.

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Coffee Research Project Goals

- Horticultural Component:
 - ✓ Evaluate 12 varieties of coffee at various locations in So. California
 - ✓ Explore the potential for *C. canephora* as a drought tolerant root stock for specialty coffee production in Southern California
 - ✓ Establish a coffee variety garden at South Coast and Hansen RECs for use as demonstration and to produce coffee seed of various cultivars
- Educational Component:
 - ✓ Develop an enterprise budget to assess the economic feasibility as a viable crop alternative for the region
 - ✓ Engage limited resource, small-scale growers in the research and development process by facilitating access to plant material
 - ✓ Organize an annual workshop and field day to disseminate results and distribute plant material to interested parties

Want to get involved in research?

- Potential MG Collaborators may play a key role in assessing the performance of coffee varieties in various micro-climates across San Diego County
- Collaborators will receive a set of plants from different varieties to be grown at their location using technical guidelines and cultural practices recommended
- Collaborators will collect and provide data collected to project PIs to be shared, aggregated and analyzed
- Final result will be more information about growing coffee in Southern California, published in the form of a production guide, trade magazine articles or peer-reviewed publication.

Comments/Questions or to get involved with the project?

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