(1) COFFEE SEED PRODUCTION

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Importance of the Crop (2): Coffee is one of the most important agricultural products in the world market; it is produced in all continents. Major producers are in North and Central America (Mexico, Guatemala, El Salvador and Costa Rica); South America (Brazil and Colombia); Africa (Angola, Ivory Coast, and Uganda), Asia and Oceania (Viet Nam, India, and Indonesia).

(3) The world's largest producers are presented in Table 1 which shows total production and yield for different countries and the world. Brazil is the leader in coffee production and is responsible for 32% of the world production and is 12th in yield producing an average of 1,038 kg/ha.

Country	Production (1000 t)	Country	Yield (kg/ha)
1. Brazil	2,475.8	1. Belize	5,634
2. Viet Nam	834.6	2. Martinique	2,500
3. Indonesia	702.3	3. Tonga	1,875
4. Colombia	663.7	4. Viet Nam	1,697
5. Mexico	310.9	5. China	1,562
6. India	275.0	6. USA	1,370
World	7,761,397	World	760

Table 1. Major world ranking of differing countries for total coffee production and yield for 2004.

(4) Coffee is a perennial dicot in the *Rubiaceae* family in the genus *Coffea*. There are more than 70 described species, but only two are economically important: *Coffea arabica* and *Coffea canephora*.

C. arabica represents 70% of the coffee traded in the world. It produces a better quality drink as determined by consumer preference that results in a higher price for the commodity on the international market. This species is cultivated primarily in Central and South America in higher altitude locations.

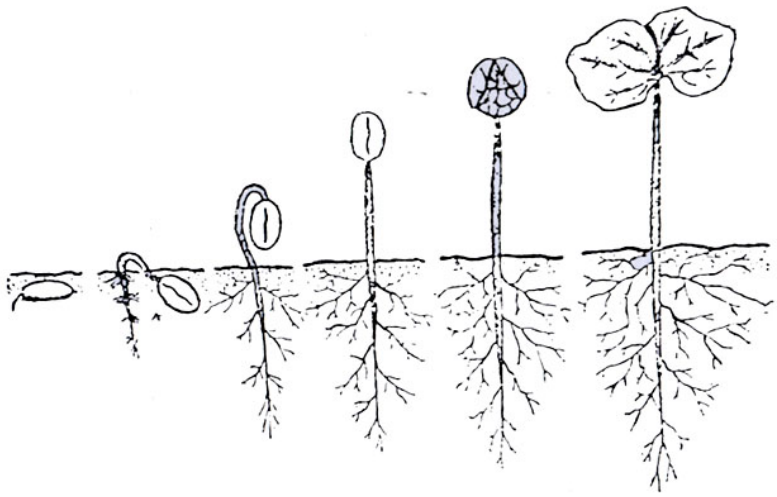
The other important species, *C. canephora*, is usually represented by the coffee variety Robusta. Its geographic distribution is broad, but it is primarily cultivated in lower altitude tropical regions. The most important production areas are in Africa with Guinea, Liberia, Sudan, and Uganda being the primary producers. The drink quality is low compared to *C. arabica*; however, lower market prices and the higher content of soluble solids make this type of coffee attractive to the industry.

(5): Plant Development: Coffee is usually established by sexual reproduction using seeds, but propagation is also possible by grafting and cutting slips. Direct sowing is not recommended because there is a significant lack of uniformity in seed germination. When this occurs, crop development is delayed compared to crops obtained from well developed seedlings that are carefully germinated and transplanted to the field.

(6) Plant Development/germination: Coffee seeds possess slow and asynchronous germination which make it almost impossible to achieve an adequate stand when planted directly in the field.

Primary root protrusion under optimal laboratory conditions is initiated about 6 days after sowing. At 10 to 15 days, most of the seeds have completed germination. In comparison, seedling emergence occurs from 40 to 60 days after planting in the field under favorable environmental conditions (31 - 32^{o}C and regular irrigation). When seeds are exposed to lower temperatures, seedling emergence is delayed even further, taking about 120 days.

Primary root protrusion from coffee seeds is the overall result of embryo growth and endosperm weakening. The first parts of the seed to emerge from the soil or artificial substrate are the cotyledons demonstrating epigeal seedling growth. This occurs about 40 days after sowing and the seedling is classified as a *match seedling* at this stage. After further development, the seedling cotyledons unfold and free themselves from the endocarp or parchment. This occurs about 60 days after sowing and the seedling is classified as a *jaguar ear* at this stage.



Fases da germinação até a "Orelha de Onça". (*Camargo:* O Café no Brasil, Vol. 1, Ministério da Agricultura).

(7) Plant Development: germination/presence of endocarp ("parchment")

This figure shows that the presence of the endocarp inhibits the germination of coffee seeds and reduces the speed of germination as a result of the presence of the inhibitor abscisic acid.

(8) Seedling Production: Different approaches are available for coffee seedling production. The most common is planting coffee seeds directly into plastic bags filled with a carefully prepared artificial substrate. This image sequence illustrates this approach. (9) Forty-day-old *Match* seedlings still retain part of the original seed structure and the 60-day old *jaguar ear* seedlings exhibit unfolded cotyledons. (10) Plant development from the 60-day seedling stage generally consists of the emergence of a pair of leaves on the main stem each succeeding month.

(11) "Half-year" and "One-year" Seedlings: Two types of seedlings are preferred by coffee farmers. First, *half-year seedlings* are used when planting occurs after seed harvest in late autumn to early winter. These seedlings are lower in cost, involve the use of smaller plastic bags, require less substratum, and use fewer greenhouse facilities for less time. Half-year seedlings are transplanted in the following summer when they attain ***4 to 6 pairs of leaves*** on the main stem, depending on the sowing and transplanting times.

Second, *one-year seedlings* are produced when planting occurs in the spring and they are ready for transplant in the following spring. These seedlings are used in re-planting operations caused by deficiencies in stand establishment.

(12) Planting: Seedlings are manually planted in the field following recommended row spacing which varies according to the production system.

(13) Young and Adult Coffee Crop: The adult coffee plant is a tree 2.0 to 4.0 m high, depending on the cultivar, soil type, production system, climate and plant population per area. The main stem produces two types of axillary branches called orthotropic which is vegetative and produces only leaves and plagiotropic branches which are productive and produce the coffee fruits. ***Orthotropic*** branches are produced from axils in the first ten pairs of leaves on the main stem, grow vertically and generate both new orthotropic and plagiotropic branches. The leaves are opposite on the main stem.

The ***plagiotropic*** branches are formed from the 10th and upper main stem nodes. They are long, flexible branches that grow horizontally producing simple and opposite leaves that produce only new plagiotropic branches.

(14) Flowering: Coffee usually has two or three flower induction and initiation periods each year that occur from late winter to early spring as influenced by climatic conditions. Significant floral induction begins after the third year from planting in the field when most plants have surpassed the juvenile stage.

This induction is promoted by a combination of short day photoperiods, rainfall and relatively low temperatures.

Flower buds are formed only in the plagiotropic branches and remain dormant during dry periods. After a significant rainfall event, bud dormancy is overcome and flower initiation occurs. (15) Coffee flowers are hermaphroditic and are arranged in glomerule-type inflorescences. Each flower has white petals and self-pollination occurs at a level of 99%.

(16) Fruit development: Fruit development continues during the warm, rainy season; at the same time, the outer plagiotropic branches maintain vegetative growth. There are different stages of development from the yellow-green to mature red "berry" fruits

(17) The mature fleshy fruit is an oval-elliptical drupe usually containing two seeds. The thick red or yellow exocarp is easily removed; the soft mesocarp or middle layer consists of the moist mucilaginous coffee pulp. The outer cover of the seed possesses a hard, pale brown endocarp that becomes the "parchment" after drying.

The coffee seed is elliptical or egg-shaped, plane-convex possessing a longitudinal furrow on the plane surface. When the second seed does not develop, the smaller and lighter remaining seed is usually round in shape and known as *moca*. Each hemispherical seed has a thin, green testa which is a remnant of the perisperm tissue (the spermoderm). It is known as the "silver skin" after drying. The endosperm, a living tissue in coffee seeds, is composed of polysaccharides, cellulose and hemicelluloses, proteins, lipids, and minerals.

The embryo is very small (3 to 4 mm long) and is composed of an axis (plumule, hypocotyl, radicle) and two adherent cordiform cotyledons.

(18) Plant Development: Adult coffee plants require two main periods of rainfall: 1) a sufficiently high humid period with high temperatures that promotes vegetative and fruit development; 2) a relatively dry period that is necessary for normal flowering and the final stages of seed maturation.

(19) In general, the crop cycle after the plants have surpassed the juvenile period and begun bearing seeds in southeastern Brazil is summarized as follows:

a) Vegetative: spring and summer (October to March)

b) Flowering: late winter and early spring (August to October)

c) Fruit development: spring and summer (October to March)

d) End of maturation: late autumn to early winter (April to June)

e) Harvest: late autumn and winter (May to August)

(2) Seed Maturation: Research has shown that the full development period for coffee seeds is relatively long. *Coffea arabica* seeds mature 210-250 days after ovule fertilization. *Coffea canephora* seeds take 300 to 350 days.

(21) There are four main stages of fruit development known as "pellet", green, yellowish-green and mature or "berry" fruits. (22) Black, dry fruits are over-ripe. Maximum size is attained at the yellowish-green fruit stage.

(23) Maturation: Seed moisture content, dry weight and germination

During the initial stages of coffee fruit development, moisture content is relatively high, around 80% on a fresh weight basis, but decreases with further development. The level of seed desiccation is not as high compared to the desiccation in the dry fruits. Despite this variation, seed moisture content is approximately 50% at the end of maturation compared to 70% in the fruits.

(24) Seed dry weight increases during maturation and is greatest in *Coffea arabica* seeds at 235 days after anthesis. The yellowish-green fruits contain seeds that have completed their full morphological development. Photosynthate accumulation and seed dry matter production increases from the fruit "pellet stage" and remains high until the fruits reach the yellowish-green stage. This is the critical water requirement period necessary for normal fruit and seed growth; water deficits are detrimental to yield and seed physiological potential.

Seed germination is first observed at the green-fruit stage, but maximum germination occurs at the "berry" or mature fruit stage.

(25) Harvest: Coffee seed production fields are harvested when fruits are red or yellow corresponding to the berry-stage. Seed moisture content at this time is approximately 50%.

Coffee seed production is characterized by asynchronous flowering and fruit development since flowering occurs two or three times in each season. The best stage of harvest is identified by the presence of at least 95% mature berry fruits.

(26) "Fingertip" Harvest: Seeds of higher physiological potential are those harvested by the "fingertip" procedure in which only the mature fruits are collected by hand. However, when the berries are collected by hand stripping, this must be followed by separation of the mature fruits from the immature (green and yellowish-green) and over-ripe fruits.

(27) Harvest by Stripping: Manual stripping is the most common coffee fruit harvest procedure in Brazilian seed production areas. This operation must be conducted with extreme care in order to avoid damage to the delicate plagiotropic branches.

(28) Harvest: operation care: Manual stripping requires careful handling of the ends of the plagiotropic (productive) branches that are establishing the next flowers and fruits for subsequent harvests. If these branches are damaged, flower bud development will be negatively affected and fruit production severely reduced.

After harvest, the older parts of each plagiotropic branch become unproductive for the remainder of the trees reproductive life.

(29) Peeling, Fermenting and Drying: After harvest, seed processing requires that the fruit skin and mucilage layer be removed from the seeds, an operation called peeling, for the production of the highest quality seeds. This is a processing step following fruit separation that varies according to the maturation stage of the fruit. To separate the fruits according to specific weight, the fruits are floated in a trough by flowing water and the more dense fruits settle more rapidly in the moving water than the less dense fruits that flow further in the trough. The seeds are then extracted from the fruits and subjected to fermentation to degrade the remaining fruit mucilage. (30) At the end of this process, seeds still enclosed by the endocarp or parchment have been washed, peeled and fermented and are ready for drying and storage.

(31) Coffee Seed Minimum Standards in Brazil: Coffee seed marketing is not as intensive as for grain crops such as maize, soybeans and others. This is because coffee production is based on seedling production in small areas followed by direct transplanting in the field. This process reduces the quantity of seeds necessary to establish the crop.

Nonetheless, the production of vigorous seedlings of the desired cultivar depends of the availability of high quality seeds. As a result, seed production must occur using organized systems that establish minimum seed quality standards. The standards adopted in Brazil are shown in the following table.

Table 2. Brazilian seed standards for coffee.

Factor	Foundation Seeds	Certified Seeds
Pure seed (minimum %)	98	98
Other crop seeds		
- Other species	zero	zero
- Other cultivars	zero	zero
Common weed seeds (Maximum nº /400g)	zero	Zero
Noxious weed seeds (Maximum nº /400g)	zero	Zero
Germination (minimum %)		
C. arabica	70	75
C. canephora	60	65
Moisture content (maximum %)	25	25
Moisture content (maximum %)		
C. arabica	12	12
C. canephora	15	15

(32) Coffee Seed Production in Brazil (Presentation of a DVD)

The production of this DVD was coordinated by the Dept. of Horticulture and Crop Science of the Ohio State University under the leadership of Prof. Miller McDonald and Ken Kulka. Images were captured under the supervision of Prof. Maria Laene Moreira de Carvalho from the Lavras Federal University.

The DVD contents document the following aspects

1. Choosing trees
2. Harvesting
3. Seed processing
    - 3.1. Washing
    - 3.2. Peeling
    - 3.3. Fermentation
    - 3.4. Drying and storage
4. Seed germination testing
5. Tetrazolium choride testing
6. Producing coffee seedlings
7. Conclusion

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