Persea americana Mill.

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LAURACEAE (LAUREL FAMILY)

Laurus indica Siebmann, *Persea gratissima* Gaerthner, *P. praecox* Poep. (Pérez 1956)

Aguacate, aguacatillo, alligator, curo, palto, pear (Pérez 1956)

Persea americana originated in the Americas and grows from Chile to Mexico and in the Caribbean Islands. Although concentrated in the Latin American countries, the tree is now cultivated in the Philippines, New Zealand, Australia, South Africa, Kenya, the Ivory Coast, Morocco, Israel, the Canary Islands, and Spain.

Persea americana is a plant of periodic growth where growth rates are affected by local conditions. In areas of constant humidity, *P. americana* grows all year. In drier or cold regions, the tree can go through four annual growth stages and during certain periods can lose a lot of foliage; the main stage usually coincides with flowering. The new growth of shoots or sprigs occurs only on certain parts of the tree. In years with greater growth, the fruit harvest will be reduced; and in several cultivars the yield is markedly biennial. The shoots or sprigs are cylindrical or prismatic and have alternative leaves which have axillary buds. The shape of the leaves varies considerably depending on the position. Wild species can reach 20 m in height. It grows well in soils that are loose, well-drained, slightly acid, and rich in organic matter (Tokura and others 1996). The tree grows at elevations from sea level to 2400 m, with average temperatures of 16 to 24 °C and annual precipitation of 800 to 1700 mm. Wild trees have a spherical crown, while cultivated trees, originating from grafts and subjected to pruning, have a very different appearance.

Persea americana is a very polymorphous species. Certain clonal traits, such as the shape and color of the foliage, contribute to creating a very extensive range of types, and cultivated types can be separated into three groups or races: Mexican, Guatemalan, and West Indian (León 1987). Additional information about these races is presented in the last section of this description.

Persea americana is commercially important as a fruit species. The fruit has very high nutritional qualities; its caloric index is similar to that of the banana. It contains between 5 and 35 percent fat, fundamentally oleic acid, with an index similar to that of the olive. The digestibility coefficient of the fat is similar to that of the fat of cows. The seed has a high content of tannins, and the cortex has vermifuge properties (Gózman 1989).

The flowers emerge in panicles that sprout from the new growth on the apex of the sprigs or from the axil of the leaves. The axis of the panicle is strong and pubescent and carries several deciduous bracts. *Persea americana* yields many thousands of flowers per plant. The panicles open up for long periods of weeks or months. However, the number of flowers that yield fruit is 5 percent or more. The characteristics of the fruit are very changeable, depending on the race and the variety. Pear-shaped fruits predominate, but spherical and ovoid fruits also exist. They are usually asymmetrical, and the side with more fibers or vascular bundles is thicker. The pericarp is made up of a cortex whose thickness and color vary from yellowish green to purple or almost black; the surface varies from smooth and shiny to corrugated and opaque. The mesocarp is a pulpy, soft mass, yellowish-greenish-white in color, with green pigmentation close to the cortex. The ovoid seed occupies a large part of the fruit; it is made up of two pulpy cotyledons and a small embryo; it contains no endosperm. The coat is made up of one to five exterior layers of sclerenchyma and several layers of parenchyma. The outermost layer of parenchyma, next to the sclerenchyma, is stuffed with tannins, which give it the characteristic dark color. The cotyledons consist primarily of parenchyma containing starch and tannins (León 1987).

The time between flowering and harvesting of fruits depends on the race: for the West Indian race it is between 5 and 6 months, for the Guatemalan race between 8 and 10 months, and for the Mexican race between 7 and 10 months

(Gózman 1989). The fruits are collected manually using ladders and scissors or knives. Pulling the fruit off can injure and damage it. Because the fruits are delicate, they should not be put on the ground without protection. The stem should be cut close to the fruit to prevent damage to other fruits when packed. Fruits harvested early should be placed in the dark and refrigerated.

The humidity content in seeds with harvest ripeness is approximately 65 percent. The seeds are recalcitrant and lose their viability 2 to 3 weeks after removal from the fruit. However, the fruits can be stored for periods of more than 8 months in a dry room at 5 °C (Halma and Frolich 1949, Spalding and others 1976). Viability can also be maintained for several months by covering the seeds with a powdered fungicide and storing them in wet sawdust or peat in polyethylene bags at 4 to 5 °C (Verheij and Coronel 1991). The critical humidity content (the point to which one can lower the humidity of the seed without losing its viability) is 57.6 percent for slow drying and 57.4 percent for fast drying (Boyce 1989, Grabe 1989).

The seeds should be pretreated by immersion in water at room temperature for 24 hours (Trujillo 1986). About 70 percent of the seeds germinate underground in an average of 21 days (Tokura and others 1996).

Persea americana may be propagated by seedling or grafting. Grafting is recommended for commercial plantings because the fruits of grafted trees have uniform characteristics in size and shape. The terminal bud graft is the easiest and most successful. To produce healthy and vigorous trees, seeds should be selected from good-sized fruits. These seeds should have a higher coefficient of germination and the subsequent seedlings should grow faster. To prevent dehydration, seeds should be planted immediately after extraction from the fruits. Seeds may be preserved in wooden trays with humid sand between 5 and 7 °C. To prevent disease, seeds should be disinfected in hot water (49 °C for 15 minutes); the ground should be treated with water vapor (90 °C for 4 hours or 60 °C for 6 hours); and all tools should be treated, possibly with sodium hypochlorite (Gózman 1989). *Persea americana* is frequently cultivated on hillsides because minimum temperatures are higher than those on flat ground (Gustafson 1997).

ADDITIONAL INFORMATION

Leaves in the upper part, centered around the apical point of the growth, have bracteal shapes. Farther down the sprig, the internodes are longer and the leaves are more developed. The elongation of a *P. americana* shoot begins after a rest period. The bracts that cover the apex of the growth come loose and the shoot lengthens by first forming leaves in the shape of a bract, separated by short internodes, then forming normal leaves and longer internodes, and finally forming small leaves and shorter internodes. In the axils of the basal leaves, lateral buds can develop. On these, the first internode is excessively long. The shape, color, and pubescence of the leaves vary according to the cultivar. The lamina is ovate-oblong to obovate-oblong, from 5 to 20 cm long by 3 to 12 cm wide; the pubescence changes according to the age of the leaf. The foliage and the new sprigs are densely pubescent; the old leaves are smooth and shiny on the top and pubescent underneath. Leaf color varies by race from dark to green-yellow. The species has a powerful root system that lacks absorbing hairs.

The flowers are hermaphroditic, actinomorphic, greenish-whitish, with short and pubescent pedicels. The perianth is made up of one involucrum, which has interpreted itself as a calyx consisting of six parts that are acute, yellow, pubescent on both surfaces, and arranged in two groups of three. The exterior parts are the largest. It is in fact three sepals and three petals of very similar appearance. There are 12 stamens in four cycles; the first two are external and simple filaments whose anthers open up through four pores located toward the center of the flower. The third cycle consists of three stamens with the pores opened outward; its filaments have, at the base, an orange gland or nectary. The fourth cycle, the innermost one, is made up of staminodia. The pistil is made up of an ovoid, monocarpic, superior, monospermic, unilocular, white, and pubescent ovary, which ends in a short style with a globose stigma.

Low fruit yield occurs because the stigmatia receive a few grains of fecundating pollen when the stamens and the pistils in each flower do not mature uniformly. Cross pollination is essential to reproduction.

Persea americana is a perennial that can produce fruit for 18 to 25 years when it is managed well. The life cycle of the species is divided into four periods. During the period of youth, usually 18 to 24 months, the seedling remains in the nursery. When outplanted, *P. americana* enters the period when growth is accelerated and flowers begin to appear. Between the fourth and fifth year, the plant reaches the full yield period, characterized by high flowering and fruit yield. In the fourth and final period, the fruit yield stabilizes and plantation managers must work to prevent mortality by diseases such as *Phytophthora cinnamoni* Rand (Gózman 1989).

The fruits remain hard on the tree and soften only after collection. Mature fruits soften uniformly while immature fruits shrink, wrinkle, and do not soften properly. Different varieties mature at different rates. Oil content is used to determine fruit maturity for Mexican and Guatemalan varieties; size and weight are used for West Indian varieties. Sometimes the fruit's appearance while on the tree represents the degree of maturity. For the varieties with green skin, a yellow color in the skin and stem and loss of shine indicate maturity. The condi-

tion of the seed cover is another useful guide for determining the grade of maturity. If the seed cover is tender and light brown in color, the fruit is mature. To determine when the fruit is soft enough to eat, the button of the stem can be removed and a stick inserted in the opening. If the pulp is soft, the fruit is ready to eat. This test is especially useful for determining the softness of varieties with hard and leathery skin (Gustafson 1997).

The three cultivated races of *P. americana* are West Indian, Guatemalan, and Mexican. The West Indian race is native to Central America and grows at elevations between 0 and 550 m. It is widespread from Florida to Brazil. The race is very sensitive to cold. When the leaves are rubbed, they do not give off an anise smell. The fruits ripen 5 to 6 months after flowering. They are dark green, vary in size according to variety, have an oval shape, weigh from 150 g to 1 kg, and measure between 8 and 30 cm in length. The penduncle is short and conical. The skin is thin but strong, with a thickness of 1.5 to 2 mm, and the surface is shiny and viscous. The pulp varies from soft green to reddish yellow in color and has a fatty content of approximately 5 to 16 percent. Because the seed comes loose from the pulp when the fruit ripens, consumption must occur shortly after harvest.

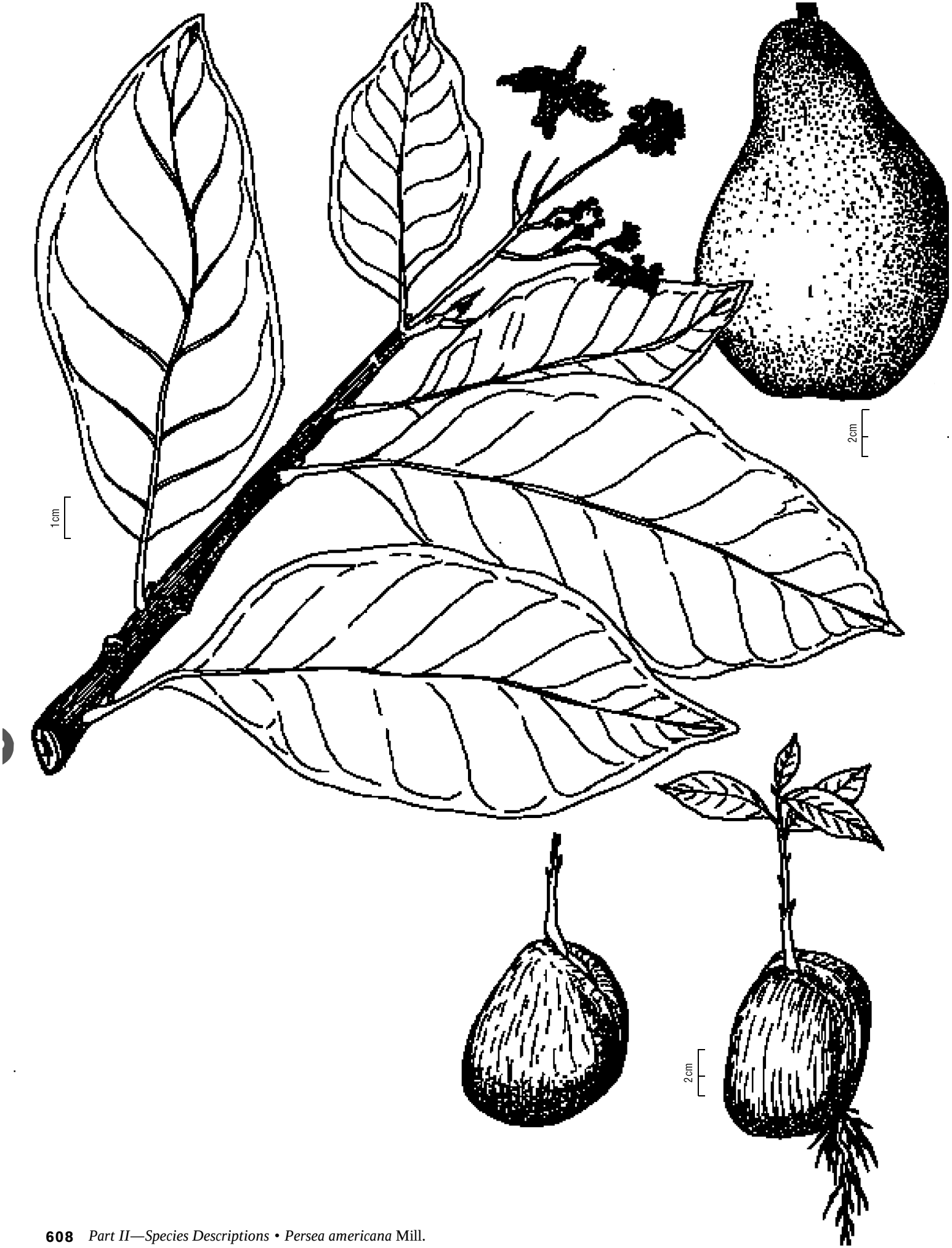
The most important commercial varieties of the West Indian race include the Pollock, the Walden, and the Fuchsia. The Pollock is the most cultivated variety in Venezuela. It was developed in the United States (Florida) with seeds from Cuba. The fruit can be harvested 5 to 6 months after flowering. The variety produces pear-shaped fruits with a smooth, thin peel. The fruit weighs between 858 and 1400 g, has a yellowish pulp with no fibers, and has a fatty content of 2.5 to 5 percent. The seed has a conical shape. The Pollock is adaptable to harsh and temperate climates and to elevations ranging from 400 to 1300 m. The Walden variety yields medium-sized fruits with a smooth, thin, pale green peel, a yellowish pulp with a fatty content of 5 to 10 percent, and weights that range from 250 to 850 g. Plants of the Walden and Fuchsia varieties produce high yields of fruit. The Fuchsia variety has glassy-green fruits with smooth peels and weights ranging between 350 to 550 g.

The Guatemalan race of *P. americana* comes from Central America, Mexico, and Nicaragua at elevations from 500 to 1000 m. It is sensitive to temperate climates because its large, deep green leaves lack essential glands; the leaves also do not give off the anise smell when rubbed. The fruits ripen 8 to 10 months after flowering. They weigh between 100 and 130 g, are generally round, and are attached to the branch by a very long peduncle. Skin thickness varies between 3 and 10 mm; it has a viscous and ligneous consistency and ranges from green to purple to dark colors as it ripens. The pulp has an approximate fatty content of 15 to 20 percent. The seed is very large and round and does not come loose from its cavity, making it possible to preserve the fruit for a relatively long time between harvest and consumption.

Important commercial varieties of the Guatemalan race include the Chouette and the Lola. The Chouette is a hybrid obtained by crossing the West Indian and Guatemalan races; it grows well in the agroecological conditions of Venezuela at altitudes ranging between 500 and 1500 m. The plants yield oval fruits with a harsh peel and wrinkled skin. The fruit can be harvested 8 to 11 months after flowering. The Lola variety adapts well to harsh climates and yields fruit weighing between 250 and 550 g with smooth skin and a fatty content of approximately 18 to 20 percent. Other varieties in this race include the Hass, the Trap, the Hickson, and the Macarthur.

The Mexican race of *P. americana* comes from the cities of Atlixo and Puebla, at altitudes ranging from 1100 to 1950 m. It shows a pronounced resistance to temperate climates. The leaves, smaller than those of the other races, have glands that give off a strong anise smell when the leaves are rubbed. Generally, the flowering occurs during the last months of the year. The fruits ripen 7 to 8 months after flowering and are relatively small, with a weight of 200 to 250 g and a length of 40 to 90 mm. In pubescent flowers, the peduncle is thin, with a uniform diameter throughout its length. The skin is thin, 0.9 to 1.5 mm, with a smooth external surface. The normally light-green skin has dark tonalities depending on variety. The pulp is a little fibrous and has a fatty content ranging from 22 to 25 percent. Given the multiple characteristic traits of this race, many botanists consider it a different variety of *P. americana* (*Drimifolia*).

In Mexico, the Fuerte, the Puebla, and the Gottfriel are important commercial varieties of *P. americana*. The Fuerte is a hybrid of the Mexican and Guatemalan races; it produces medium-sized fruits with a fatty content of 25 to 35 percent. It adapts well to temperate climates at altitudes over 1500 m. The variety Puebla produces medium-sized fruits with an ovoidal shape, a smooth and glossy peel, and a fatty content of 18 to 20 percent. The variety Gottfriel produces pear-shaped, elongated fruits with a purple peel and a thin consistency; it grows well at elevations ranging from 500 to 1500 m.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