Cocos nucifera L. Coconut, Coconut palm, Palma de coco

Palmae Palm family

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Cocos nucifera L., commonly known as coconut, coconut palm, and palma de coco, is perhaps the most widely recognized and one of the most economically important trees of the Tropics. Coconut grows along sandy shorelines throughout the Tropics and in most subtropical regions. A tall, erect palm, usually 10 to 20 m in height, coconut has a slender, curved, or straight trunk, often enlarged and inclined at the base, with slightly cracked gray or brown bark (fig. 1). Coconut is widely planted for fruit and as an ornamental and is used throughout its range as a source of food and drink, oil, fiber, fuel, timber, and numerous other products. It is also used in thatching and in other applications as construction material.

HABITAT

Native and Introduced Ranges

The precise boundaries of coconut's native range are unknown, although most authorities believe it originated within the Indo-Malayan to western Pacific region *(35)* (fig. 2). Throughout its present pantropical range, established coconut stands are probably the direct or indirect result of human cultivation *(13)*. The current view that coconut is of insular Asian-Pacific origin, as opposed to tropical American origin, is based on its high degree of genetic diversity in the Asian-Pacific region relative to tropical America, the presence of highly damaging mammalian predators such as monkeys, bears, and rodents in Asian mainland areas, and the high diversity of host-specific insects associated with coconut in Melanesia *(13, 35)*. Evidence supporting the view that coconut originated in the Melanesian region comes from the discovery of Miocene fossil fruit of *C. zeylandia* in New Zealand, *C. nucifera* fossil remains in New Guinea more than 4,000 years old, and fossil remains in Vanatu more than 5,000 years old *(9)*.

Coconut has been cultivated and widely used in India and continental Southeast Asia for at least 3,000 years *(5, 13)*. Before European colonization of the New World, coconut had been introduced to insular and mainland sites along the Pacific coast of Central America, as evidenced by early 16th century accounts of its use by native people in Panama *(14)*. During the early Spanish and Portuguese colonial periods, coconut was introduced from Asia to the Caribbean, northeastern South America, and Brazil *(13)*. Today, coconut is pantropical and grows on suitable sites between latitudes 26° N. and 26° S. The extreme northern and southern boundaries of its introduced range include Florida, northern India, and Madagascar, although growth in these areas is not robust enough for the tree to be of industrial value *(3)*. The major coconut-producing regions of the world are the Malayan Archipelago, Southeast Asian countries, India, Sri Lanka, the Pacific Islands, east Africa, and Central and South American countries *(35)*. Coconut has been planted throughout the Caribbean and has become naturalized along sandy shores. In Puerto Rico, plantations totaling approximately 4,000 ha have been established, mostly along sandy shores and especially on the northern coast *(24)*.

Climate

The native and introduced ranges of coconut are characterized by a warm, wet tropical climate with a mean annual temperature between 27 and 35 °C and little diurnal variation *(35)*. Annual rainfall in areas with productive coconut plantations generally ranges from 1200 to 2300 mm *(33)*. Coconut can grow well in areas receiving between 1000 and 5000 mm of rainfall, but excessive humidity may limit fruit production *(46)*. In Puerto Rico, coconut grows on sites receiving between 700 and 2500 mm of annual rainfall *(16)*. Although the tree can withstand extreme drought conditions for short periods of time, dry seasons of 5 to 6 months

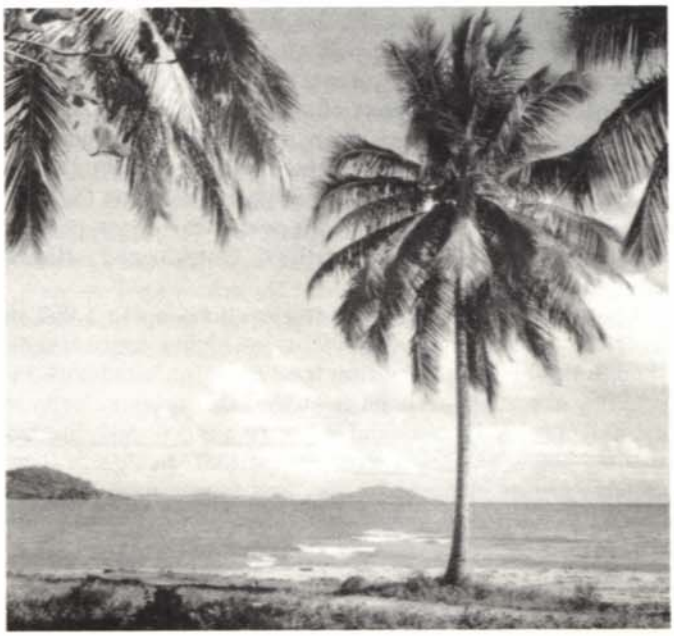

Figure 1. — *Coconut* (Cocos nucifera *L.) in Puerto Rico.*

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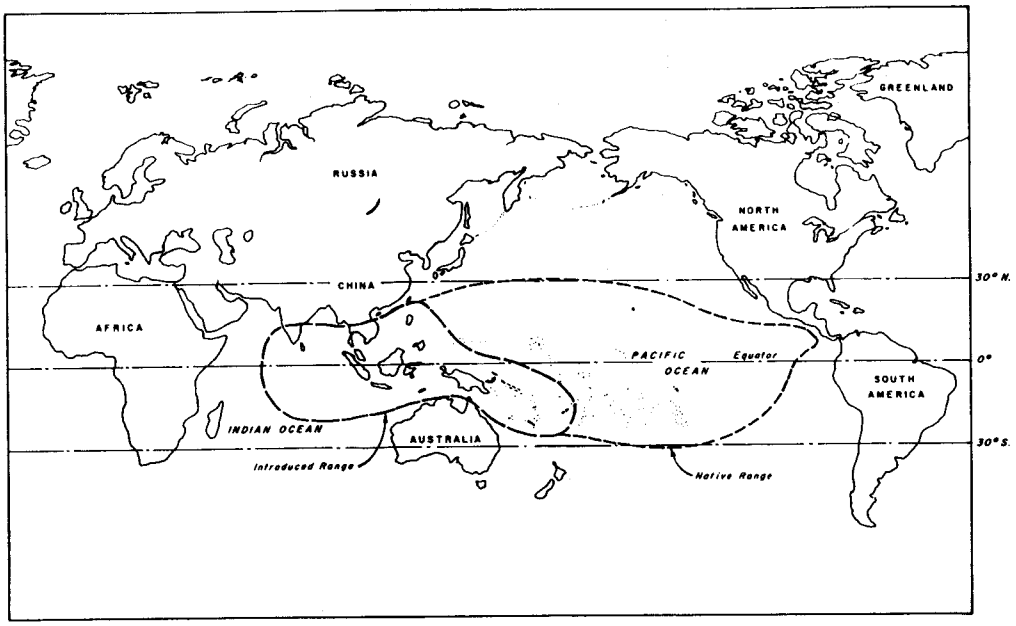

Figure 2. — *Native and pre-Columbian introduced ranges of coconut* (Cocos nucifera *L.). Inner smaller range represents apparent region of origin; Outer larger range represents introduced range before 1500.*

duration can negatively affect fruit production for several years thereafter *(3)*. On most sites, production of leaves, roots, inflorescences, and fruits decline as rainfall becomes less frequent *(13)*. Given sufficient soil moisture to counteract the effect of extremely high transpiration rates in coconut, a moderately dry climate is preferable to a very moist one *(46)*.

Soils and Topography

Coconut grows best along tropical and subtropical shores, on riverbanks, on coastal alluvial plains, and at the bases of foothills where there is subsoil water movement *(33)*. Good growth requires either a water table close to the soil surface or continual replenishment of surface soil moisture. Best growth generally requires deep, well-drained, sandy loam soils high in organic matter, although in some coastal areas good growth does occur on nutrient-poor sands *(35)*. Coconut can tolerate inundation by salt water for short periods without adverse effects on growth *(3)*. Waterlogged soils are unsuitable *(13)*.

Coconut can be cultivated at elevations up to 1,200 m near the equator and up to 900 m at higher latitudes, although flowering and fruiting tend to be inhibited with increasing elevation, perhaps due to increasing irregularity of rainfall *(13, 35)*. Commercial production is generally limited to sites below an elevation of 600 m *(33)*. In Puerto Rico, coconut grows in coastal areas and lower montane sites having well-drained, moist soils ranging in pH from 5.5 to 8.0 *(16)*.

Associated Forest Cover

On the Philippine island of Samar, within the species' native range, wild-type coconut populations have been found growing in mangrove forests. On the seaward portion of these forests, coconut exists as a dispersed population in association with *Ceriops tagal* (Perr.) C.B. Rob., *Rhizophora apiculata* Bl., *R. mucronata* Lamk., *Brughiera sexangula* (Lour.) Poir., *B. gymnorrhiza* (L.) Lamk., and *B. cylindrica* (L.) Bl. Further inland, coconut is associated with thick stands of *Nypa fruticans* Wurmb. *(19)*. On Pacific atolls and in the Philippines, wild coconut populations form pure stands with abundant natural regeneration along the shores of lagoons *(38, 39)*.

In abandoned 40- to 50-year-old plantation stands in Dorado, Puerto Rico, coconut is associated with *Lonchocarpus latifolius* (Willd.) DC., *Amphytecna latifolia* (Miller) A.H. Gentry, *Cordia laevigata* Lam., and *Eugenia monticola* (Sw.) DC. *(15)*. Elsewhere in Puerto Rico, volunteer species invading ungrazed coastal coconut plantations include *Terminalia catappa* L., *Calophyllum brasiliense* Camb., and *Andira inermis* (W.Wright) HBK[1]. In Barbados, where coconut has been introduced in plantations and as an ornamental, it has become naturalized in coastal woodlands in association with *Coccoloba uvifera* (L.) L., *Tabebuia heterophylla* (DC.) Britton, *Thespesia populnea* (L.) Soland. ex Correa, *Terminalia catappa* L., *Cordia sebestena* L., and *C. obliqua* Willd. *(17)*.

[1]Francis, John K. 1992. Personal communication. On file at: International Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Río Piedras, PR 00928.

LIFE HISTORY

Reproduction and Early Growth

Flowering and Fruiting.—Mature coconut crowns consist of 25 to 36 leaves, or fronds, according to variety. Fronds measure from 4.9 to 6.2 m long and have 70 to 100 pairs of leaflets. Average trees produce 12 new fronds each year; the age of a tree may be approximated by dividing the number of ring scars on the stem by 12 *(13, 23, 35)*.

Under good growing conditions, coconut palms (tall varieties) begin flowering at 6 years of age, when they are between 2.5 and 4.5 m tall *(13, 35)*. Mature trees annually produce 40 or more nuts *(23)*. Flowering occurs throughout the year and continues until trees reach a height of 25 to 30 m, when the yield and size of nuts begin to decline, usually at about 60 years *(13, 35)*. Dwarf and hybrid varieties begin to flower earlier, usually at 4 to 5 years *(13)*. Coconut trees are monoecious, with the inflorescence carrying both male and female flowers. A branched inflorescence, 0.9 to 1.2 m long, is produced in each leaf axil and consists of a main axis and 10 to 45 side branches. Female flowers are situated at the base of the main axis or on up to 5 branches; the male flowers grow on side branches with up to 200 flowers per branch *(35)*. Each male flower bears six nectar glands that may attract pollinating agents *(35)*. The male flowers, 3 to 6 mm wide, open between 6 a.m. and 8 a.m. and fall off in the afternoon. The larger female flowers, 30 to 35 mm wide, open about 2 weeks after the male flowers on the same inflorescence and remain receptive for 2 to 4 days *(13)*. The coconut is predominantly cross-pollinated *(21)*. The main pollinating agents are wind and insects, specifically bees, wasps, beetles, ants, and flies *(35)*.

The fruit, or nut, is egg-shaped or elliptical, bluntly three-angled to nearly round, with a light-brown fibrous husk 20 to 30 cm long *(23)*. The fruits grow to nearly full size in 5 to 6 months and ripen when 10 to 13 months old. Abortion of immature fruit is common, at times reaching 65 to 70 percent *(35)*. The elliptical or nearly round inner brown fruit is essentially a large, hollow seed covered by a hairy outer shell. When the nut is only 8 cm wide, the central hollow cavity begins to develop and is filled with the watery embryo-sac juice that increases in quantity until the endosperm is nearly fully developed. The juice then diminishes as the fruit ripens, but it does not disappear completely until germination is underway *(13)*. According to the specific coconut variety, ripe nuts vary in color from green to ochre yellow and orange red but dry to a dull brown on the tree before falling.

Seed Production and Dissemination.—The mature nut can float for 3 to 4 months without losing viability, and thus may be dispersed hundreds or thousands of miles on ocean currents *(13)*. For at least 3,000 years, humans have been an important agent of seed dispersal. For nursery production, nuts should be harvested when perfectly mature (about 12 months after pollination) or else collected from the ground after natural fruitfall *(35)*.

Seedling Development.—Coconuts have no period of dormancy; seedlings sometimes begin to sprout while still attached to the tree *(13)*. In general, however, about 4 months elapse from the falling of the ripe nut to seedling emergence under natural conditions *(13)*. Natural regeneration is abundant in plantation stands in Puerto Rico *(16)* (fig. 3).

Freshly harvested nuts should be stored at room temperature for 3 to 4 weeks before sowing to allow the coconut embryo sufficient time to reach maturity *(35)*. After storage, nuts may be given either or both of the following treatments to aid germination: (1) soaking in water for 1 to 2 weeks and/or (2) cutting the exocarp and mesocarp (husk) from the bottom end of the nut, avoiding damage to the shell or endocarp *(35)*.

Coconut seedbeds are usually narrow, long, and deep, with nuts planted in rows 20 to 30 cm apart and a distance of 20 cm between rows. The pretreated nuts are embedded but not completely buried in planting holes, with the cut end of the nut slightly below the point of attachment to the pedicel *(35)*. Seedbeds should be kept moist and protected from rodent predation. Germination of fully mature nuts occurs 8 to 10 weeks after sowing *(35)*. The coconut embryo, situated under the soft eye embedded in the endosperm, commences germination by elongation of the plumule, or primary bud. The lower part of the cotyledon develops into a spongy absorbent organ, the coconut apple or haustorium, which grows slowly to fill the central cavity. As the haustorium enlarges, adventitious roots develop at the base of the plumule. Both the plumule and the adventitious roots grow through the soft eye while the haustorium absorbs and

Figure 3. — *Natural reproduction of coconut* (Cocos nucifera *L.*) *in abandoned plantations at Dorado, Puerto Rico.*

digests nutrients from the endosperm to feed the plumule and the root system *(35)*.

The seedling develops four to six scale-leaves or leaf-sheaths without blades, followed first by two to six plicate leaves and finally by the pinnate leaves typical of mature trees *(13)*. When seedlings reach the three-to-four leaf stage they are ready for transplanting into the field, usually 25 to 30 weeks after germination *(35)*. Older seedlings, 1 to 2 years old, are sometimes used to establish plantations *(46)*.

Coconut seedlings are commonly planted 60-cm deep in 60-cm diameter planting holes at a 9-m triangular spacing. Seedlings are highly susceptible to damage by rodents during the first few years after establishment and should be protected by fencing around individual stems *(35)*.

Vegetative Reproduction.—Coconut trees sometimes produce small vegetative bulbs (bulbils) on the inflorescence instead of flowers, and young trees occasionally produce suckers *(13)*. Tissue culture plantlets of numerous cultivars have been successfully produced using excised embryos *(2, 22)*. Somatic embryos have been produced from leaf tissues using tissue culture techniques *(36)*.

Sapling and Pole Stage to Maturity

Growth and Yield.—Coconut seedlings require approximately 5 years to form a trunk base *(13)*. The rate of growth and yield vary enormously according to location, cultivation, and fertilization practices. Poor growth in coconut is often attributed to nutrient deficiencies; i.e., potassium, nitrogen, phosphorus, boron, iron, and magnesium *(35)*. Cultivation, mulching, and fertilization within a 2-m radius of stems, as well as the establishment of a leguminous ground cover, have been reported to greatly increase growth and yield in plantations, particularly on very sandy or otherwise nutrient-deficient soils *(35, 46)*.

Mature trees attain maximum heights of 10 to 20 m, rarely growing to 30 m. Stem diameters at the enlarged base of 0.4 to 0.5 m and above the base of 0.2 and 0.3 m are typical *(23)*. Fruit yields increase rapidly until the trees are 20 years old, and under good plantation management, may remain constant up to 70 years. In Sri Lankan plantations, a yield of 30 to 40 nuts per tree is considered a good average annual yield, but 70 to 150 nuts per year are not uncommon. Annual yields of 9,000 nuts per hectare in 15-year-old plantations and 12,000 nuts per hectare in 20-year-old plantations are common in well-managed plantations *(46)*.

Rooting Habit.—Coconut trees produce fibrous, adventitious roots from the swollen base of the stem *(35)*. The root system consists of a large number of adventitious roots radiating outward to a distance of several meters from the underground portion of the stem, with many lateral roots branching at right angles from the main roots *(46)*.

Reaction to Competition.—Optimum growth and nut production in plantations occur at a maximum density of about 100 trees per hectare *(20)*. Coconut trees are susceptible to competition by weeds and also cover crops and should be kept free of competing vegetation within a 2-m radius of the trunk throughout the productive life of the tree *(35)*. Interplanting of annual and perennial crops, including fruit trees and cocoa, is commonly practiced in young coconut plantations with no apparent detrimental impact on tree growth *(1, 3, 25, 40, 41)*. Intercropping experiments in the Côte d'Ivoire have demonstrated beneficial effects on early coconut growth; intercropping with yam, cassava, or maize during the first year of coconut growth, with maize and the leguminous cover crop *Pueraria* spp. during the second year, and with *Pueraria* alone in the third year were recommended as a cropping sequence as a result of these experiments *(48)*. In India, high-density multispecies cropping systems have been developed in 18-year-old coconut plantations established at an 8- by 8-m spacing that include bananas, papayas, yams, and pineapples as understory crops *(4)*. In Panama, coconut is commonly planted in mixed perennial cropping systems with bananas and plantains (*Musa* spp.) and avocados (*Persea americana* Mill.) *(11)*.

Damaging Agents.—In Puerto Rico, a total of 26 insect species, mainly in the orders Coleoptera and Homoptera, have been reported to attack coconut trees *(29)*. The most serious of these pests include *Strategus oblongus* (Palisot de Beauvois) (Coleoptera, Scarabaeidae family), the scale insect *Aspidiotus destructor* Signoret (Homoptera, Diaspididae family), and *Homaledra sabalella* (Chambers) (Lepidoptera, Cosmopterygidae family), an economic pest on palm fronds that is particularly serious in the Dominican Republic where it commonly kills trees in association with *A. destructor*. The mite *Eriophyes guerreronis* Keifer, which often infests plantations in the Americas and Africa, adversely affects the size and copra content of coconut fruits *(28, 31)*.

The most serious disease affecting coconut in the Caribbean is lethal yellowing, caused by mycoplasma-like organisms transmitted by planthoppers *(Myndus crudus) (30)*. The disease spreads rapidly within plantations and kills trees within 5 months after symptoms appear. Lethal yellowing (or a very similar disease) was first reported in Jamaica in the late 1800's, and by the early 20th century it had affected plantations in the Cayman Islands and Haiti, as well as Jamaica. Since the 1950's, the disease has spread to south Florida, the Bahamas (New Providence Island), Cuba, the northern coast of the Dominican Republic, Jamaica, the Cayman Islands, and the Yucatan Peninsula, including Cozumel. The commonly planted Jamaican tall variety is highly susceptible to the disease, whereas the Malayan dwarf variety appears to be resistant.

Several other less serious diseases that affect coconut have been reported in Puerto Rico and elsewhere in the Caribbean *(44, 47)*. These include red ring disease *Aphelenhoides cocophilus* (Cobb) Goodey; a leaf spot caused by *Diplodia epicocos* Cke.; leaf-bitten disease, *Endoconidiophora paradoxa* (Dade) Davidson; gray leaf spot, *Pestalotia palmarum* Cke.; and a bud rot caused by the fungus *Phytophthora palmivora* Butl. A wilt disease caused by the bacteria *Micrococcus roseus* and *Phytomonas* sp. and transmitted by the insects *Oncopeltus cingulifera* and *Mecistorhinus picea* has been reported in Trinidad *(18)*.

In south Florida several insect pests have been reported to cause minor to moderate damage to coconut. These include twig, stem, and root boring insects such as the giant palm weevil *Rhynchophorus cruentatus* and the black twig girdler *Xylosandrus compactus;* sap-sucking insects such as the palm aphid *Cerataphis variabilis,* the coconut mealybug *Nipaecoccus nipae,* and the key whitefly *Aleurodicus dispersus,* which is thought to be one of the vectors of lethal yellowing disease; the scale insects *Pseudaulacopsis cockerelli,*

Ischnapsis longirostris, Chrysomphalus aonidum, and *Eucalymnatus tessellatus;* and defoliating insects such as the palm leaf skeletonizer *Homaledra sabalella* and the palm tortoise beetle *Hemisphaeota cyanea (12).*

In west Africa, coconut is subject to damage by several pathogenic disease and insect pests. The former include the previously mentioned bud rot caused by *Phytophthora palmivora,* red ring disease caused by the eelworm *Rhadinaphelenchus cocophilus,* and the lethal kamicope disease caused by amycoplasm *(35).* Insect pests known to cause severe damage in west African coconut plantations include the rhinocerous beetle *Oryctes monoceros,* the hope beetle *Xylotrupes gideon* and other *Xylotrupes* spp., the red weevil *Rhynchophorus ferrugineus,* the wood borer *Mellitoma insulare,* and several species of butterflies and moths that only rarely cause serious damage *(35).*

In the Indian subcontinent, bud rot caused by *P. palmivora,* a stem-bleeding disease caused by an unidentified agent, and a root disease caused by the fungus *Fomes lucidus* can cause serious damage in plantations *(46).* The rhinocerous beetle *(O. monoceros),* the red weevil *(R. ferrugineus),* and the insects *Opisina arenosella, Leucopholis coneophora, Parasa lepida, Contheyla rotunda, Paradasynus rostratus,* and *Pseudococcus* spp. have also been reported to cause damage in plantations in Sri Lanka *(34)* and elsewhere in the Asian-Pacific region *(13, 46).* In Vanatu, *Myndus taffini* Bonfils (Homoptera, Cixiidae family) and *Lamenia epiensis* Muir have been identified in association with coconut wilt *(8).* The burrowing nematode *Radopholus similis* has been reported to infest coconut roots in southern India *(43)* and is associated with secondary infection by *Cylindrocladium clavatum* Hodges *(42).* Studies conducted in the Philippines showed strong differences among coconut varieties in susceptibility to the mite *Oligonychus velascoi* Rimando *(10).*

Major mammalian pests of coconut include monkeys, wild pigs, porcupines, rats, and flying foxes. Weaver birds are a serious pest in west African plantations *(35).*

Coconut is highly resistant to wind damage; trees are seldom snapped or uprooted except during extreme hurricane conditions.

SPECIAL USES

The main products obtained from coconut are derived from the fruit. The coconut fruit water obtained from the immature coconut fruits is consumed as a refreshing, nutritious beverage. Coconut water contains sugar, enzymes, and vitamins, including ascorbic acid (0.70 to 3.70 mg/100 ml), nicotinic acid (0.64 to 0.70 mg/100 ml), pantothenic acid (0.52 to 0.55 µg/100 ml), biotin (0.02 to 0.025 µg/100 ml), riboflavin (0.01 µg/100 ml), and folic acid (0.003/100 ml) *(35).*

The endosperm of the fresh, mature nut is used in foods either unprocessed or after extraction of the coconut "milk." The fresh, undried endosperm (coconut "meat") contains between 35 and 40 percent oil, 10 percent carbohydrate, 3 percent protein, and approximately 50 percent water *(5).* Coconut milk is rich in plant growth-inducing substances (hormones) and was widely used in early tissue culture research *(45).*

From the copra, or dried endosperm, coconut oil is extracted and used in cooking oil, margarine, cocoa butter, soap, lotion, perfume and other cosmetic products, and candles and as lamp fuel. The residual "cake" obtained from copra after oil extraction is used as a component in livestock feed. Copra is used extensively in local and world confectionery trade. The annual worldwide copra harvest was estimated at 4.9 million tonnes in 1982; in the same year trade in coconut oil was 1.27 million tonnes having a value of about $657 million *(20).* Approximately 75 percent of the annual commercial coconut production is derived from plantations in the Far East *(13, 35).*

Coir, the mesocarp fibers, are used to make mats, mattresses, ropes, carpets, brushes, brooms, and bags. Coir processing produces coir dust, which is used in many regions as a packing material and in the manufacture of fiberboards and insulating material. Coir dust has been reported as a useful alternative to synthetic ion exchange resins for the removal of heavy metal ions in waste water treatment *(27).* The incorporation of coir dust in nursery potting media has been found to induce more rapid root development when compared to the use of other forms of organic matter, and that effect may be attributable to the release of phenolic compounds from the coir dust *(26).*

The coconut shell, or endocarp, can be used to make various utensils such as bowls, cups, spoons and ladles, smoking pipes, ashtrays, vases, boxes, and toys. When used as fuel, the resultant ash is high in potash (30 to 52 percent). The shell also yields a high-quality charcoal used for chemical filters. Finely ground coconut shell "flour" is used industrially in the manufacture of plastics to give luster to molded articles and to improve moisture resistance *(35).*

Coconut fronds are used for thatching, screening, construction of temporary walls, and mats. The midribs of the leaflets are used as brooms. The roots are used in some regions as components of medicinal preparations for the treatment of dysentery, as mouthwashes, and as chewing-sticks *(5, 35).* A sweet, sucrose-rich liquid (toddy) can be obtained by tapping the inflorescence. Toddy is sometimes fermented to produce alcohol or vinegar. The terminal bud, or "cabbage," is eaten as a cooked vegetable in many regions.

Coconut oil has a number of medicinal uses in south Asia *(5).* It is taken in a refined state as a substitute for cod-liver oil, is used externally to soothe fevers and respiratory ailments, and is used as a hair oil to prevent graying. Old, dried endosperm is used as an aphrodisiac ingredient in confections and also as an anthelmintic, specifically to remove tapeworms *(5).* Some coconuts contain the rare coconut pearls, 1 to 3 cm long, which are composed of calcium carbonate. These pearls are highly valued within some cultures.

The outer wood of the stem is close-grained with dark-brown vascular bundles. It works smooth and takes a good polish *(5).* The density, moisture content, and strength of coconut timber increase from the top to the butt portion and from the inner to the peripheral zone. Typical wood densities range from 0.30 to 0.90 g/cm^3 in the outer third of the stem radius and from 0.10 to 0.35 g/cm^3 in the inner third of the stem radius *(20).* Coconut timber tested in the Philippines having a specific gravity of 0.50 g/cm^3 showed an average modulus of rupture in bending of 306 kg/cm^2 *(33).*

The moisture content of the butt and top ends in the core of freshly felled coconut timber was reported as 85 percent and 75 percent (wet-weight basis), respectively *(33)*. Lateral shrinkage in any direction is less than 3 percent when drying green timber to a moisture content of 12 percent *(20)*. Although the natural durability of coconut timber is low, the application of chemical preservatives greatly increases resistance to wood staining, to decaying fungi, and to attack by wood-boring insects *(33)*. Properly treated, coconut timber is an excellent fencepost material and can be used for electric power and communication poles *(20)*. It is a suitable raw material for furniture, novelty products, nonstructural construction elements, particle board, paper pulp, charcoal, and possibly veneer *(33)*. Coconut timber is currently used for frames and fixtures, boxes, household implements, and other purposes throughout its native and introduced ranges. Pulp and paper made from coconut wood have properties similar to those from most hardwoods, although the high proportion of fines greatly reduces overall yields *(20)*.

Coconut timber is difficult to saw with ordinary saw blades, but saws with tungsten carbide teeth can greatly facilitate timber processing *(37)*. In recent decades, coconut stem sawmills have been established in Fiji, Western Samoa, French Polynesia, Vanatu, Tuvalu, Papua New Guinea, India, Indonesia, the People's Republic of China, and Jamaica. These developments have been facilitated by advances in coconut wood processing technologies and the increased availability of coconut timber from senescing plantations *(20)*.

GENETICS

There are several varieties of coconut in Asia, including the tall and dwarf varieties; those with orange-red, ochre-yellow, or green fruits; those with fragrant endosperm; and those with varying proportions of husk, shell, and endosperm *(13)*. The many varieties of coconut are divided into two primary types, known as niu kafa and niu vai *(9)*. The niu kafa types, believed to represent the ancestral, naturally evolved, wild-type coconut, have long, angular fruits up to 15 cm in diameter, with an ovoid nut inside a firm, thick husk. The niu vai types, believed to have been derived by selection for increased endosperm while under cultivation, have a more spherical fruit, up to 25 cm in diameter, with a spherical to oblate nut inside a thin husk. Both types have been cultivated, and intermediate types have developed through introgressive hybridization *(9)*.

Cocos is generally considered a monospecific genus *(13, 32)*, although some authorities include up to 60 species more commonly assigned to the South American genera *Arecastrum, Aricuriroba, Barbosa, Butia, Chrysallidosperma, Lylocaryum, Microcoelum, Rhyticocos,* and *Syagrus;* the Chilean *Jubaea;* the South African *Jubaeopsis;* and the Brazilian *Polyandrococcus (6, 7)*.

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