



Areca catechu (betel nut palm)

Arecaceae (Arecoideae), palm family

betel nut palm, areca, areca-nut (English); *pugua* (Guam), *poc* (Pohnpei), *pu* (Chuuk), *bu* (Yap), *bua* (Palau), *buai* (New Ireland: Kuanua), *buei* (New Ireland: Pala), *vua* (New Ireland: Lamekot)

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IN BRIEF

Distribution Widely distributed in East Africa, South Asia, and Pacific islands.

Size Slender palm typically reaching 10–20 m (33–66 ft) tall; can reach 30 m (100 ft).

Habitat Tropical everwet climates with evenly distributed rainfall of 1500–5000 mm (60–200 in); prefers elevations 0–900 m (0–2950 ft).

Vegetation Generally found in cultivation together with other cultivated species or semi-wild together with wet climate flora.

Soils Adapted to a wide range of soil types, although thorough drainage and high moisture-holding capacity are required.

Growth rate Moderate, about 0.5 m/yr (20 in/yr).

Main agroforestry uses Crop shade, homegarden.

Main products Seeds (masticant).

Yields Kernel yield is estimated at 2.5–8 kg per palm (5.5–17.6 lb/palm) annually.

Intercropping Frequently grown together with short- and long-term crops.

Invasive potential Although it can spread by seed, it is not considered to be an invasive species.



Betel nut in homegarden near Angkor Wat, Cambodia.

INTRODUCTION

Betel nut (*Areca catechu*) is a slender, single-trunked palm that can grow to 30 m (100 ft). It is cultivated from East Africa and the Arabian Peninsula across tropical Asia and Indonesia to the central Pacific and New Guinea. The “nut” (actually the seed endosperm) is chewed as a stimulant masticatory by 5% of the world’s population, making it more popular than chewing gum but not as popular as tobacco. Use of betel nut is often culturally or socially ritualized, and there are elaborate ceremonies attending its use in various Asian and Pacific cultures. At the same time, betel chewing is stigmatized by Western cultures that find the red saliva and blackened teeth resulting from regular use (not to mention the spitting out of the copious red saliva) to be esthetically disgusting.

In the Pacific, betel nut is grown for local consumption and is a significant item in intra- and interisland trade. Pacific-grown betel nut does not, however, reach the large markets of South Asia and for this reason could not be considered a commercial export of international importance.

Chewing betel nut is a popular pastime in some of the Pacific islands such as in Micronesia, Fiji, Solomon Islands, etc. It is an old tradition, enjoyed by islanders of both genders, that provides mild stimulation and a sweetening of the breath.

On the island of Guam, for example, betel nuts are typically gathered from semi-wild trees in ravine forests and distributed through extended families or sold in village stores. Commercial demand for the nuts is increasing as this traditional supply dwindles. This easily grown palm has the potential for being a profitable crop for farmers as well as backyard gardeners.

In India and Pakistan, by comparison, betel nut is consumed in quantities greater than local production can supply, and it is imported in large quantities annually. The annual commercial value (circa mid-1990s) was estimated in the hundreds of millions of dollars. The palms require an environment with evenly distributed rainfall (or irrigation), and even temperatures within 15.5–38°C (55–100°F). The palms are unable to withstand extreme temperatures or wide variance of daily temperature. Betel nut is now grown worldwide: where it is not used as a stimulant, the palms are grown as ornamentals. Although not recommended for use due to health risks, the plant nevertheless has a long history of cultural importance in many parts of the world, and this will likely continue.

DISTRIBUTION

Native range

Unknown in the wild, betel nut is a cultigen that exists only where humans grow it. An origin in the Philippines has been postulated. Many other areas have been suggested as the original homeland, including South or Southeast Asia.

Current distribution

From SE Asia, betel nut was distributed by indigenous peoples throughout tropical Asia as far as East Africa and the Pacific well before the arrival of Europeans in the region. The palm was distributed to the Pacific islands aboard sailing canoes by the prehistoric ancestors of the Micronesians who explored and settled the islands of the western Pacific.

Betel nut is today grown in East Africa, Madagascar, Arabian Peninsula, India, Sri Lanka, Bangladesh, Myanmar, Thailand, Cambodia, Laos, Vietnam, southern China, Malaysia, Indonesia, Taiwan, and the Philippines. In the Pacific Basin it is grown in Papua New Guinea, Solomon Islands, Fiji, Micronesia (Guam, Palau, Pohnpei, Saipan, Tinian, Rota, Chuuk, Yap), and Vanuatu. It can also be found on some atolls such as Mwoakilloa in Pohnpei State. In the CNMI it is also found on Pagan, Agrigan, Alamagan, and Anatahan. It has also been recorded as being present on Jaluit Atoll in the Marshall Islands. In Hawai‘i it is grown mainly as an ornamental.

BOTANICAL DESCRIPTION

Preferred scientific name

Areca catechu Linnaeus

Family

Areaceae (Palmae), palm family

Subfamily

Arecoideae

Non-preferred scientific names (synonyms)

Areca cathecu Burman, *Areca faufel* Gaertner, *Areca hortensis* Loureiro, *Areca himalayana* H. Wendland, *Areca nigra* H. Wendland

Common names

betel nut, areca, or areca-nut palm (English)

pugua (Guam)

poc (Pohnpei)

pu (Chuuk)

bu (Yap)
bua (Palau)
buai (New Ireland: Kuanua)
buei (New Ireland: Pala)
vua (New Ireland: Lamekot)
angiro (Solomon Islands: Kwar'ae)

Several of the common names in the Pacific are derived from the widespread pidgin English name *buai*.

Common names in other regions include:

arec cachou, Arequier (French)
Betelnusspalme (German)
boa (Bali)
boá, boñga, buá, buñga, lúyos, takobtob (Philippines)
palma catechou (Spanish)
pan (India)
puak (Sri Lanka)

Description

Betel nut is a slender, single-trunked, monoecious palm with a prominent crown shaft.

Size

The palm reaches a mature height of 10–20 m (33–66 ft) (exceptionally up to 30 m [100 ft]), with a trunk 25–40 cm (10–16 in) in diameter. Typhoons and tropical storms usually prevent the trees from reaching their maximum height. The canopy is typically 2.5–3 m (8–10 ft) in diameter and consists of 8–12 fronds.

Flowers

Flowers are unisexual, with both male (=staminate) and female (=pistillate) flowers borne in the same inflorescence. Inflorescences are crowded, much-branched panicles borne below the leaves. Each terminal branch has a few female flowers borne at the base and numerous male flowers extending from there out to the branch tip. Flowers of both sexes have six tepals, are stalkless (=sessile), creamy-white, fragrant; male flowers are minute, deciduous, have six stamens, arrowhead-shaped anthers, rudimentary ovary; female flowers are larger (1.2–2 cm [0.5–0.8 in] long), with six small sterile stamens and a three-celled ovary bearing a triangular stigma with three points at the apex.

Leaves

Fronds are even-pinnately compound, 1–1.5 m (3.3–5 ft) long; pinnae (leaflets) 30–50, lanceolate, 30–70 x 3–7 cm (12–28 x 1.2–2.8 in), longest near middle of frond; frond base sheathing, encircling trunk and forming a green crown shaft, ca. 55 x 15 cm (22 x 6 in).



Top: Inflorescence. PHOTO: M. MERLIN **Bottom: New inflorescence showing both female (large) and male (small) flower buds.** PHOTO: E. BURSON

Fruit

A fibrous, ovoid drupe, 5–10 x 3–5 cm (2–4 x 1.2–2 in), yellow to orange or red when ripe; pericarp fibrous, ca. 6 mm thick. Seed usually 1, ovoid, globose, or ellipsoidal, 3–4 x 2–4 cm (1.2–1.6 x 0.8–1.6 in), base sometimes flattened; endosperm ruminant (with hard reddish tissue from inner integument extending horizontally into pale brown endosperm); embryo conical, located at seed base.

How to distinguish from similar species/look-alikes

Betel nut has a single, slender trunk, green aging to gray, with prominent white leaf scars, bright green crown shaft, pinnately compound fronds, and red–orange fruits.

The Chinese betel nut or Manila palm (*Veitchia merrillii*) is often confused with *Areca catechu*. The Chinese betel nut palm differs from *Areca catechu* in having a thicker trunk and dense clusters of bright red fruits. It is a popular landscaping tree and can be commonly seen in parks, along roadways, and in homegardens. The fruits can be used for chewing when ripe, although they are an inferior substitute for betel nut.



Ripe fruits with U.S. quarter dollar for scale. PHOTO: R. BAK-

GENETICS

Variability of species

Betel nut shows considerable variation. Several botanical varieties have been described. No breeding work has been done to select for improved cultivated varieties.

Known varieties

In the Pacific islands, betel nut palms are grouped into two cultivars: red and white. In the Northern Mariana Islands and Guam, these two cultivars are called ugam (red) and changnga (or changan) (white). There are similar locally used vernacular names referring to variants in form, size, and color of the nuts throughout the area where betel nut is grown, but no formal cultivar nomenclature exists. The colors refer to the seed kernel colors. Red seed varies from red to deep purple in kernel color. White seed varies from off-white to deep tan kernel color. The roots of white types have a reddish/pinkish tinge beneath the inner root bark. The red is preferred for chewing and commands a higher price in the market. The white is much less desirable. The red and white seeds come from seemingly identical trees, i.e., except for differences in the seed kernel and root sap colors, it is virtually impossible to distinguish between the two types. Growers considering planting of betel nuts for should plant seeds from confirmed red types.

Culturally important related species in the genus

There are more than 50 species of *Areca*, and some produce



Characteristic leaf scars of betel nut palm trunk. PHOTO: C. ELEVITCH

useful products such as edible palm cabbage, and a number of species are horticulturally valuable. The seeds of many other palms, including at least eight species of *Areca*, are used as inferior substitutes for *Areca catechu*. No other culturally significant species are known in the genus *Areca*.

Genetic resources where collections exist

“The Regional Station of the Central Plantation Crops Institute, Vittal, India, maintains a germplasm collection of *A. catechu* and related species from within the country as well as from Sri Lanka, southern China, Thailand, Malaysia, Singapore, Indonesia, the Philippines, Fiji, Solomon Islands, and Mauritius. Sixteen exotic accessions have been evaluated for yield in a long-term comparative trial, from which three accessions with high yield potential were released. None of the available cultivars has shown tolerance of yellow leaf disease, which makes identification of disease-tolerant genotypes a priority.” (Brotonegro et al. 2000).

No germplasm collections have been established for betel nut palm in the Pacific. Little selection or improvement work has been documented. The palms are open-pollinated and rather variable, with most growers selecting seed from trees with desirable qualities for propagation purposes. Efforts at interspecific hybridization (*A. catechu* × *A. triandra*) failed because the hybrid progeny were sterile and it proved impossible to establish forms with desired characteristics of both parent species.

Associated plant species

Betel nut palm was introduced to the Pacific before the advent of Europeans. It is grown around homesteads and farms or in plantations where it is associated with other cultivated plants or those typically found in disturbed sites.

A very important associated species is betel pepper vine (*Piper betle*), which is grown for its leaves. The leaves of the betel vine are used as the wrapper when preparing a quid of betel nut with lime, tobacco, or other ingredients.

ENVIRONMENTAL PREFERENCES AND TOLERANCES

Climate

Betel nut palm is ideally suited for tropical everwet climates (humid tropical lowland, maritime tropical, subtropical wet, tropical wet forest) with high rainfall that is evenly distributed throughout the year. In areas with a seasonal dry period, irrigation must be provided to assure evenly distributed moisture year-round. These palms are unable to



Leaves of betel vine (*Piper betle*). PHOTO: C. ELEVITCH

withstand extreme temperatures or a wide variance of daily temperatures. They thrive best at low altitudes; above 900 m (2950 ft), flowering and fruit production are adversely affected.

Elevation range

0–900 m (0–2950 ft)

Mean annual rainfall

1500–5000 mm (60–200 in)

Rainfall pattern

It prefers uniform distribution of rainfall throughout the year.

Dry season duration (consecutive months with <40 mm [1.6 in] rainfall)

None, it requires uniform moisture year-round.

Mean annual temperature

21–28°C (70–82°F)

Mean maximum temperature of hottest month

38°C (100°F)

Mean minimum temperature of coldest month

16°C (60°F)

Minimum temperature tolerated

Unknown, very cold sensitive

Soils

Betel nut palm grows in many types of soils varying in texture from laterite to loamy, provided the soil has thorough drainage, yet has the ability to retain optimum moisture. It

thrives on deep (3 m [10 ft]) clay loams, often in valley bottoms where topsoil accumulates along water courses. Light and sandy soils are unsuitable unless copiously irrigated and manured.

In the Pacific islands, the palm does best in volcanic clays but can also be grown in coralline soils. Natural fertility is not a critical factor. More important is the soil's capacity for thorough drainage during the wet season. The most desirable soils are rich in organic matter.

On Mwoakilloa Atoll, the species is grown in sands heavily mulched with organic matter.

Soil texture

Betel nut palm prefers soils with medium texture, loams and sandy clay loams.

Soil drainage

Thorough drainage with high moisture retention is essential.

Soil acidity

Betel nut palm thrives in a pH range of 5.0–8.0 (mildly acidic to weakly alkaline).

Other soil tolerances

In the Northern Mariana Islands (Saipan, Tinian) betel nut palm is grown in soils as shallow as 30–60 cm (1–2 ft) deep, over solid limestone. While not ideal for growth and nut production, trees will grow and bear if the grower provides adequate moisture, fertilizer, and spacing.

Tolerances

Drought

Betel nut has poor drought tolerance.

Full sun

The palm requires full sun once out of the juvenile phase.

Shade

Seedlings require 50% or more shade to protect from sunburn. Juvenile palms are often planted out under bananas, which provide sun protection until the palms grow taller than the bananas.

Waterlogging

Despite a strong ecological preference for moist to wet environments, betel nut palm does not tolerate waterlogged soils.

Salt spray

Betel nut is not salt tolerant.

Wind

It has low tolerance for wind.

Abilities

Self-prune

Mature fronds are shed after 2 years; betel nut palm is considered a “self-pruning” palm species.

Coppice

Palms are incapable of regeneration: if the terminal bud is cut off, the palm dies.

GROWTH AND DEVELOPMENT

Germination is complete by 90 days after planting seeds; at this time seedlings have the first bifid (forked) leaf and five roots. A 1-year-old seedling has 4 or 5 leaves. Growth rates vary, and it requires 3–24 months (rarely up to 4 years) before seedlings are ready to transplant to nursery beds. A trunk is formed in the third year. An adult palm produces about six new leaves per year, carries a crown of 8–12 leaves, and drops a mature leaf after a life span of about 2 years. The rate of growth in height is about 0.5 m/yr (20 in/yr). The life span of a betel nut palm is 60–100 years.

Flowering and fruiting

Flowering begins at 4–6 years of age; trees begin to bear at 7–8 years, reach full bearing at 10–15 years, continue to yield until ca. 40 years, then persist in a sterile state until death. The first inflorescences may contain only male flowers and consequently do not produce nuts. A mature tree in full bearing can have inflorescences containing up to 644 female and 15–48,000 male flowers (Murthy 1977). The male flowers open first. Their sweet scent attracts honeybees and other insects, but these insects do not frequent the female flowers and thus their role as pollinators is doubtful. Several days after the last male flower is shed, the female flowers open. They are fertilized by pollen that is wind-transported from neighboring trees.

Seasonality of flowering depends on location: in Malesia the palms flower year-round; in India they flower November–February. No data are recorded on seasonality of flowering in the Pacific.

Rooting habit

The root system is dense, fibrous, with most roots concentrated in a 1 m (3.3 ft) radius from the trunk and in the top 60 cm (2 ft) of soil. Primary roots are ca. 1.4 cm (0.6 in) in diameter, turning dark brown with age, and branch to give secondary and tertiary roots. Root hairs are absent; absorp-

tion takes place through thin-walled cells behind the root cap. Aerial (adventitious) roots are occasionally produced from the base of the trunk. In plantation culture adventitious (“prop”) roots are encouraged by deep-planting seedlings (90 cm [3 ft] below ground level), then gradually adding earth around the base of the palm, inducing root formation at the buried nodes.

Reaction to competition

Newly-planted trees compete poorly with weeds. For this reason, early weed management is extremely important in establishing new plantings.

PROPAGATION

Betel nut palm is only propagated by seed, and while the same basic requirements are involved, the methods depend on the number of palms desired. Large plantations of betel nut palm are grown in India and Taiwan, where mother tree and seed selection are apt to be practiced, and mass propagation is organized. Carefully selected seeds are planted in shaded beds or pits until they germinate, then seedlings are transplanted to nursery areas for growing on. Seedlings with five or more leaves are planted out at an age of 12–24 months. Seedlings require shade initially, so intercropping with banana or other crops is often practiced.

In Indonesia, Malaysia, SE Asia, the Philippines (and presumably most Pacific islands), betel nut is most often cultivated around homesteads in field borders and along irrigation channels. In Indonesia, villagers often collect volunteer seedlings from fruits dropped by bats and squirrels or by digging and transplanting seedlings from around established trees. The same practices may be followed by Pacific islanders growing betel nut palm for home consumption.

Propagation by seed

Seed collection

Betel nut palms are always propagated from mature fruits. The best seed comes from healthy trees with a history of producing desirable nuts. Only the largest, fully-ripened fruits should be planted. It is best to cut open several kernels (endosperm of the seed) to ensure they possess the red flesh preferred for chewing.

Fruits are harvested when bright red or yellow to yellow orange in some regions (such as Guam). Fruits are harvested either by climbing the tree and cutting the fruit cluster off, or by using a long bamboo pole with a sharp knife attached. Fully mature, heavy fruits that float vertically in water with the calyx end upward give a high germination rate and vig-

orous seedlings. In places where selection is practiced, the choice of mother tree is believed critical, criteria of importance are early and regular bearing, large number of leaves in the crown, short internodes in the trunk, and high fruit set. In Saipan it is critical to avoid mother trees that show any symptoms of bacterial or viral diseases; these can be passed on to offspring through propagation. In southern India and Malaysia, fruits are gathered from 25–30-year-old trees. In some cases the middle bunch of fruits is chosen for seed; in other cases the last bunch of the season is preferred.

Seed processing

Mature seeds of betel nut palm are sown as whole fruits. In some places the whole fruit is planted immediately after harvesting; in others the fruit is dried in sun for 1–2 days; in others the fruits are dried in shade for 3–7 days.

Seed storage

Like many tropical species, betel nut palm seed cannot be stored for more than a few days without losing viability. Planting within 7 days after harvest is the norm.

Pre-planting treatments

No pre-planting treatment is practiced. Fruits are planted whole, with the husk. Drying fruits before planting does not increase seed germination rates. There is no mention in the literature of scarification, hormone treatments, or fungicide use.

Growing area

Betel nut palm is rarely direct-seeded in the ground. The normal practice is to sow seeds in shaded germination areas, then transplant the germinated seedlings into nurseries for 1–2(–4) years before final planting out in the field. Seeds may be sown in groups of 20–50 in shallow pits, 2.5 cm (1 in) apart and covered with sand; in rows 15–22 cm (6–9 in) apart; or tied up in plantain leaves in rich moist soil and germinated.

In Saipan and Tinian the recommended technique is to sow seed in flat boxes sandwiched between layers of coconut husk with daily watering. Once seedling leaves appear above the husk medium, transplant into individual plastic bags using potting soil as a medium. Nursery areas are often located under established bananas, which shade the betel nut seedlings.

Germination

Germination is completed about 90 days after sowing, at which time the seedlings have one bifid (forked) leaf and five roots. The germination rate is usually over 90%.



Left: Seedlings of betel nut palm from Pohnpei Island, Micronesia. Right: Seedlings of betel nut palm with mature betel palms in background, India. PHOTOS: M. MERLIN

Media/containers

Seeds may be sown in sand, coconut husk, or rich moist soil. When planted individually or in small groups, containers made from plantain leaf or plastic bags are used. When mass-sown, beds or pits dug in the ground are more efficient. Seedlings are transplanted after sprouting into nursery beds or individual gallon plastic bags, in soil. Nursery beds are typically 30 x 30 cm (12 x 12 in) wide with three rows per bed.

Time to outplanting

Growth rates of seedlings are variable. Transplanting from nursery bed to field typically takes place at 1–2 years (although this ranges from 3 months to 4 years). Seedlings should be selected for quick germination and vigor; it is best to cull out slow-growing seedlings.

Approximate size at time of outplanting

Seedlings should bear five leaves at the time they are planted out in the field; no trunk is present at this early stage. A ball of earth around the roots is transplanted from nursery bed to field.

Other comments on propagation

Nursery beds may be located under banana, which shade seedlings until they reach a size suitable for planting out. Newly established beds are mulched with leaves, cattle manure, wood ashes, or groundnut (peanut) cake. Likewise in the field, intercropping with banana (or other crops) provides shade; otherwise coconut palm fronds are propped up around the seedlings to protect from sun scorch until they are established. Volunteer seedlings, if available, can be carefully transplanted.

Guidelines for outplanting

At 12–18 months of age, seedlings are transplanted into the field at the start of the wet season. The hole should be at least 50 cm (18 in) deep and 50 cm (18 in) wide. The bottom portion of the hole should be filled with a mixture of 2.3–4.6 kg (5–10 lb) of organic matter in the form of compost or composted chicken manure, one-half pound of fertilizer rich in phosphorus, such as 10:30:10, and top soil. Deep-planting seedlings—at a depth of 90 cm (3 ft)—allows for gradual piling of earth around the trunk base; the covered nodes produce adventitious roots resulting in firmer anchorage and larger root volume.

The desired spacing between palms is 2.7 x 2.7 m (9 x 9 ft) (Bhat 1978) or 2.4 x 3 m (8 x 10 ft) (Shetty 1949). These spacings will result in 1130–1350 palms/ha (538–545 palms/ac). Proper spacing is important, as it allows air circulation between trees, which discourages diseases which can attack the emerging flowers or developing fruits. Young plantings require regular weeding and mulching as well as fertilization with organic matter, compost, or cattle manure. Outplanting is carried out in the rainy season unless irrigation is available to assure a steady water supply during establishment. In windy areas, windbreaks should be planted along orchard boundaries to minimize wind damage and sun scorch.

DISADVANTAGES

Betel nut use as a stimulant presents significant health risks. Growing betel nut as a cash crop instead of food or other commercial crops has been criticized. There are significant problems in matching supply and demand: the greatest consumption of betel nut occurs in India and Pak-

istan, which are net importers of fresh and processed nuts. Pacific growers have no ready access to this market and probably they cannot fill their own domestic or regional demand.

Potential for invasiveness

Betel nut is not invasive, although it is often spontaneous and occurs in secondary forests, but never far from cultivation or sites where the palms were formerly cultivated. In Sri Lanka it persists in moist valleys near former habitations, where it forms naturalized groves. It does not spread readily, likely due to lack of a suitable dispersal agent for the large fruits and seeds.

Susceptibility to pests/pathogens

Yield is directly linked to the health and number of female flowers. These flowers are very susceptible to insect pests and diseases. The delicate flowers and newly forming fruits are most susceptible in the weeks following pollination. Growers are encouraged to regularly survey emerging flower clusters and to identify the pests and pathogens that threaten them. Minor threats can be tolerated, but serious threats may require the application of insecticides and fungicides.

The two most serious fungal diseases are *Phytophthora arecae* (or *P. omnivorum* var. *arecae*, Koleroga disease, a fruit rot), and *Ganoderma lucidum* (foot rot). Other fungal diseases include *Alternaria tenuis*, *Aspergillus niger arecae*, *Botryodiplodia theobromae*, *Brachysporium arecae*, *Ceratostomella paradoxa*, *Colletotrichum acutatum* (= *C. catechu*, anthracnose), *Coniothyrium arecae*, *Dendryphium catechu*, *Exosporium arecae*, *Gloeosporium catechu*, *Lenzites striata*, *Lichenophoma arecae*, *Melanocomium palmarum*, *Montagnellina catechu*, *Mycosphaerella* sp., *Nigrospora sphaerica*, *Phomopsis* sp., *Phyllosticta arecae*, *Polyporus ostreiformis*, *P. zonalis*, *Stagonospora arecae*, *Theilaviopsis paradoxa*, *Torula herbarum*, *Ustilina zonata*. The bacterium *Xanthosomas vasculorum* attacks betel nut palm. Nematodes that attack betel nut include *Rotylenchus* sp., *Tylenchorhynchus dactylarus*, *Tylenchus* sp., and *Xiphinema insigne*. Insect pests include *Orcytes rhinoceros* (rhinoceros beetle), *Nephantis serinapa* (leaf-eating caterpillar), *Arceerns fasciculatus* (borer), *Rhabdoscelus obscurus* (New Guinea sugarcane borer), *Aspidiotus destructor* (coconut scale), spiraling whitefly, coconut hispine beetle or brontispa beetle, caseworm or bagworm, mealybugs; white ants and mites cause minor damage.

Host to crop pests/pathogens

Several pests of betel nut palm also attack other crop plants, among them coconut rhinoceros beetle (affects coconut palm, date palm, sago palm), coconut scale (banana, pa-

paya, guava, avocado, cacao, cassava, tea, breadfruit, sugarcane, cotton, rubber), and New Guinea sugarcane weevil (sugarcane, coconut, papaya).

Other disadvantages

Heavy use of betel among humans causes serious health problems including permanent discoloration of the teeth, oral leucoplakia, submucous fibrosis, and squamous cell carcinoma (Norton 1997).

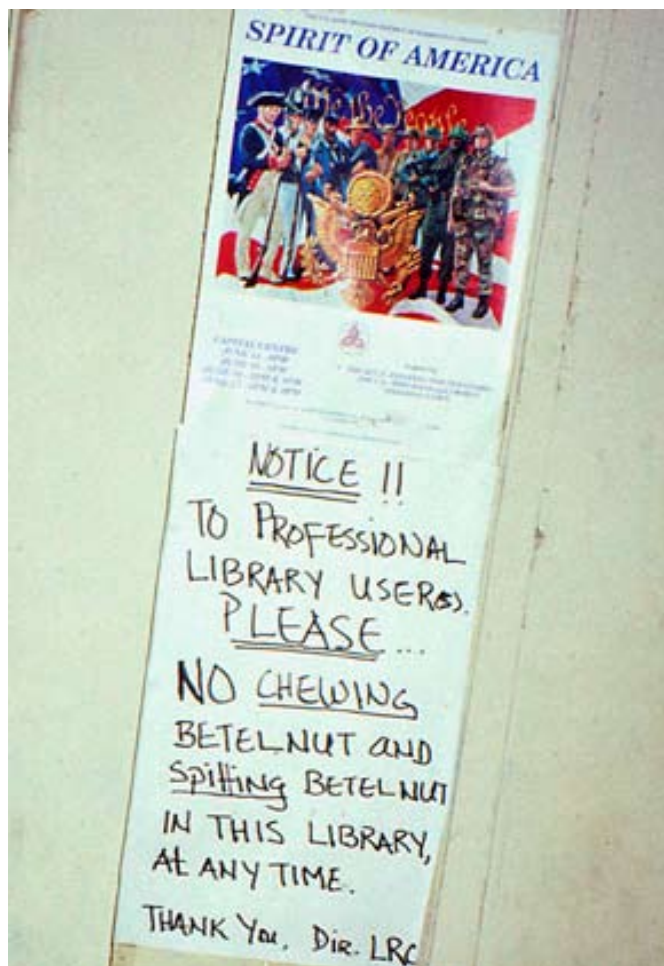
AGROFORESTRY/ENVIRONMENTAL PRACTICES

Mulch/organic matter

In Taiwan fallen, dried fronds and flower spathes are burned in the margin of plantations, where the ashes renew the soil.

Pest control

Betel nut is used as a vermifuge in humans and animals.



Library sign, College of Micronesia Library, Pohnpei. PHOTO: M. MERLIN

Crop shade/overstory

A variety of crops are grown under betel nut palm: annuals and biennials in short-term rotation; cardamom, cacao, banana, and fruit trees in permanent rows between palms. It is customary to interplant betel nut seedlings among 20-year-old palms so that a new generation will replace older palms as they stop bearing; if this practice is repeated several times without thinning, an old plantation may contain as many as 2500 palms/ha (1000 palms/ac).

Homegardens

In many parts of the world betel nut palm is planted around homesteads for home consumption of nuts. It is often interplanted with fruit trees at the margins of fields and along paths and irrigation channels.

Boundary markers

In Sri Lanka betel nut palms are often grown as boundary markers.

Animal fodder

Grasses (e.g., Guinea grass [*Panicum maximum*]) are sometimes interplanted with betel nut palm for animal fodder.

Woodlot

Thinning old betel nut palms provides a source of trunks for fuel and for crude construction.

Host plant trellising

Black pepper (*Piper nigrum*) or betel pepper (*P. betle*) vines are often trained on the trunks of betel nut palms in India.

Bee forage

The male flowers are visited by bees.

Ornamental

In southernmost Florida, Hawai'i, and many tropical places the palms are grown as ornamentals.



Left: Betel nut palms serving as trellis for *Piper betle*. Betel nut palm research center in Kerala, India. PHOTO: M. MERLIN Right: Young palms growing on the border of a vegetable garden. Kona, Hawai'i. PHOTO: C. ELEVITCH

USES AND PRODUCTS

Betel nut palm yields diverse products that are used throughout its range. In addition to the well known stimulant properties, the seed is used medicinally in numerous internal and external preparations. The husks, shoots, buds, leaves, and roots also have local medicinal uses. The fibrous fruit husks stripped from the seed have many uses, including as a home fuel source. The trunks of culled trees are used for crude construction; the fallen fronds are used in making alcohol; the spathes and leaf sheaths are used in wrapping, packing, and as hats and sandals. The inflorescences and flowers are used ceremonially in diverse cultures.

Nut/seed

This provides, fresh or dried, ripe or unripe, the betel nut that is chewed as a stimulant narcotic. Betel nut is commercially important in South Asia and locally important in the Pacific and many other tropical Old World areas.

Leaf vegetable

The terminal bud (palm cabbage or palm heart) is edible, although bitter. In Java it is eaten as *lalab* or made into pickles. In the Philippines the cabbage is eaten raw as salad, or cooked. The tender shoots are eaten after cooking in syrup.

Other vegetable

In the Philippines the flowers are sometimes added to salads.

Medicinal

The nuts, husks, young shoots, buds, leaves, and roots are used in various medicinal preparations.

Masticant/stimulant

The fresh or dried endosperm of the seed is the betel nut of commerce. The betel quid (wad of chewable ingredients) includes the fresh or dried seed of betel nut, a fresh leaf of betel pepper (*Piper betle*), a dab of slaked lime, and various flavorings (cutch, cardamom, clove, tobacco, or gambier). Eight closely related alkaloids are responsible for the stimulant effect; the alkaloid levels are highest in the unripe fruit and this may be why some cultures prefer the unripe nuts for consumption: they give a better buzz. Note that when chewed for the stimulant effect betel quid is never swallowed and the copious saliva resulting is spat out. However, when used medicinally betel nut may be taken internally. One of its effects is a powerful stimulus to intestinal peristalsis; betel nut is used to treat a long list of ailments. The Indian pan (pronounced pon) is a common



House made from betel nut palm in grove; all parts of the house are made out of betel nut palm, including trunks for posts and beams. Photo taken at a betel nut palm research center in Kerala, India. PHOTO: M. MERLIN

after-dinner treat, acting against post-meal lethargy and as a digestif.

Beautiful/fragrant flowers

The fragrant flowers are used in weddings and funerals in some SE Asian countries.

Timber

The trunks of culled trees provide a source of construction material. Either split or whole they are used for rafters and for wattle in house construction; they are used in constructing elaborate crematory and temporary structures.

Fuelwood

Fallen fronds, bracts, inflorescences could be used for fuel; culled trees could be used as firewood. In practice, the husks removed from the fruits during processing are used as domestic fuel after drying.

Fiber/weaving/clothing

The tough leaf bases are used in hats, inner soles for slippers, and is an excellent paper pulp source. Husks are used for insulating wool, boards, and for manufacturing furfural (a solvent). In the Philippines the husk is used to make toothbrushes.

Wrapping/parcelization

The leaf sheaths and spathes are used as wrapping and as a substitute for cardboard packing material. In the Philippines the leaf sheaths are used to make book covers. In Sri Lanka the leaf sheaths are used as plates, bags, and for wrapping.

Tannin/dye

Tannins are a by-product of boiling the nuts during processing the commercial product. An extract of betel nut makes black and red dyes.

Oil/lubricant

Fat from the betel nut is used as an extender for cocoa butter.

Ceremonial/religious importance

Betel nut chewing is culturally important in many Asian and Pacific societies, and the literature on the subject is extensive. In the early twentieth century it was postulated that Pacific island societies could be labeled as either kava cultures or betel cultures, based on which substance they consumed (Norton 1998). Betel nut is the preferred stimulant today in the Pacific nations of Papua New Guinea, the Solomon Islands, Fiji, Vanuatu, Palau, Guam, Yap, much of Micronesia, Taiwan, the Philippines, as well as in Malaysia, Indonesia, Thailand, Laos, Cambodia, and Vietnam. Only in Pohnpei, capital of the Federated States of Micronesia, and in Port Moresby, capital of Papua New Guinea, do people use both kava and betel nut regularly (Norton 1998). This is likely due to urban migrations of people from dissimilar rural backgrounds and cultural practices.

Furthermore, the whole inflorescences are used in religious rituals in Sri Lanka and are displayed on the front of vehicles during pilgrimages, to bring good luck. The trunks are used to construct crematory and temporary ceremonial structures in several Asian countries.

COMMERCIAL PRODUCTS

The dried nuts, whole or sliced, are the primary commercial product in international trade. Fresh nuts, either ripe or unripe, are an item in local commerce only, as they do not ship well. The commercial product is prepared from ripe



Female monk putting quid in her mouth, Ankor Wat, Cambodia. PHOTO: M. MERLIN

or unripe fruits that are first husked; then the seeds, whole, split, or sliced, are dried in various ways (sunlight, with artificial heat, by smoking). Boiling the nuts before drying reduces the tannin content of the final product. The nuts are boiled in water to which some of the liquid from previous boilings has been added.

In the Pacific islands the ripe, recently harvested nut is the primary item of local commerce. Fresh nuts are consumed in both the fully ripe and unripe stages. In Taiwan the unripe nuts are used in the betel quid. In Indonesia unripe fruits are preferred for home consumption, whereas fully ripe fruits are harvested for local sale. In Guam the fruits of the *changnga* (white) variety are harvested immature and soft; the fruits of the *ugam* (red) variety are preferred at the fully mature and hard stage.

Spacing for commercial production

Minimum spacing is about 2.7 x 2.7 m (9 x 9 ft) on deep, fertile, moisture retentive but well drained soils. On shallower or poorer soils the spacing should be increased to 3.7 m (12 ft) or even more. If interplanted with banana the distance may be 4–5 m (16–20 ft) between rows and 2.7 m (9 ft) between plants in a row.

Management techniques for thinning, pruning, fertilizing, weed control, etc.

Betel nut palms grow best where high rainfall is evenly distributed throughout the year (Sadanandan 1973). Since this weather pattern does not prevail on most Pacific islands, irrigation becomes a critical factor in betel palm husbandry. In dry periods, water deficiency can cause flower abortions even when the inflorescence is still enclosed in the protective boat-shaped spathe. Flower abortions in the dry season reduce yields and limit harvests to certain months. Irrigation is often essential for growers interested in avoiding flower abortions and maintaining vigorous growth and fruit production during the dry months. Where irrigation is required, drip systems are recommended. Backyard growers can water by hand or sprinkler. The ideal is to thoroughly soak the root zone every 3–9 days (Sadanandan 1973).

A recommended fertilizer rate is 0.9 kg (2 lb) of 10:5:22 per palm per year (Mohapatra 1977). One half is applied before the wet season and the other half after.

Dried chicken manure and composted plant remains are prime sources of organic matter and micronutrients, such as iron and zinc. Manures and composts can be applied at rates of 10 kg (22 lb) per palm per year (Sannamrappa et al. 1976).

Mulching with organic materials such as grass or tree prunings can help maintain soil moisture, halt erosion, and slowly add nutrients to the soil.

Design considerations

Some factors to consider in the layout of an orchard are:

- The flower clusters and developing nuts are susceptible to fungal rots and mildews. Thus, the tree spacing should allow air circulation between the trees, discouraging fungal and bacterial diseases.
- The tree has a fibrous root system near the soil surface that extends to the drip line of the canopy. For this reason mechanical cultivation with tractors is not done in the orchard. Hand tools are used to incorporate manures or compost into the soil.
- The tall trees are easily damaged by wind and storms. Windbreaks should be planted to minimize this threat. The palms can also be grown within a framework of wind resistant trees.

In India plantations are closely and evenly spaced, which enables trained harvesters to climb a palm and cut off the fruit clusters, lowering them to the ground with a rope to avoid any damage, then move laterally to the crown of the next palm.

Advantages and disadvantages of growing in polycultures

New betel nut plantings are often intercropped with banana, tapioca, yam, or sweetpotato. Growing a crop of annuals, biennials, or short-lived perennials between rows of betel nut palms increases the per unit area yield by making better use of the land and light and provides revenue while the palms are immature, without decreasing their future yield. The intercrops are usually phased out as the palms come of bearing age.

Yields

Yields can vary considerably depending on the vigor of the trees and absence or presence of pathogens and pests. A palm produces two to six bunches of fruit per year, each bunch with 50–400 fruits. It is estimated that on Guam in 1982 an average palm yielded two to four bunches per year, each containing 50–100 nuts. Larger fruit size is correlated with a lower number of fruits per bunch. Climatic conditions at flowering time affect the percentage of female flowers pollinated in this wind-pollinated species. Yield increases gradually with age until the palms reach full maturity at 10–15 years, then continues until the palms stop bearing at 40(–60) years of age. Soil quality and fertility affect bearing: deeper, water-retentive soils produce higher yield; marginal soils require application of manure, green leaves and twigs, or compost. In India an annual application of 100 g (3.5 oz) N, 40 g (1.8 oz) P₂O₅, and 140 g (5 oz) K₂O is recommended; yield in 1955 was ca. 800 kg (1760 lb) dry nuts per ha; in 1990 this increased to 1200 kg (2640 lb) dry nuts per ha (Brotonegro et al. 2000). Calculated annual mean yield of ripe nuts is about 2.5 kg per palm (5.5 lb/palm), with some farmers recording yields of 8 kg per palm (17.6 lb/palm); the highest yield ever recorded is 30 kg/palm/yr (66 lb/palm/yr) (Brotonegro et al. 2000).

On-farm processing

Processing is generally not practiced in the Pacific islands, as the nut is typically used fresh.

Where processing is practiced, it involves husking fruits, removing embryos, drying nuts in sun or with artificial heat or sometimes smoking. Dried product is graded on stage of harvest, color, shape, and size of nuts. Nuts may first be boiled in water containing concentrated liquid from previous boilings to reduce tannin content of nuts; they are then dried.

Markets

In the Pacific islands, harvested nuts are distributed



Left: Betel nut for sale in main market, Honiara, Guadalcanal, Solomon Islands. PHOTO: M. MERLIN Right: Fruits for sale, Rayong, Thailand. PHOTO: C. ELEVITCH



through extended-family networks or sold in village stores or farmer markets.

The primary export market is in South Asia (India, Pakistan, Sri Lanka); India is a net importer of betel nut despite being the world's largest producer (250,000 mt [275,000 t] in 1990). Malaysia, Indonesia (21,800 mt [24,000 t] in 1993), and Thailand (5200 mt [5700 t] in 1991) produce more betel nut than they consume.

URBAN AND COMMUNITY FORESTRY

The majority of betel nut palm grown for nut production is in homegardens, so the species is eminently suitable for this purpose. In fact, like all cultigens, betel nut palm depends on human care for its survival. Where nut consumption is not the primary reason for growing this palm, it is esteemed for its ornamental qualities. There are no special varieties or types favored for use in urban environments.

The betel nut palm, although an attractive tree, is not recommended for landscaping of parks or other public facilities in the Pacific islands where the nut is used. The ripe nuts are of intense interest to chewers, and this can invite theft and other criminal activity. In a survey of betel nut growers on Guam in 1983, security or theft prevention was a high priority for producers. Theft problems begin in the nursery with the propagation of new trees. A good seed for planting is also a good nut for chewing. For the first 12 months in the nursery, the seed can still be uprooted by thieves and chewed, and theft of seedlings for chewing is a major problem in the nursery. Bearing trees whose ownership is not clearly identified can become the subject of disputes over the nuts.

Size considerations

Reaching 10–20 m (33–66 ft), mature betel nut palms are far too tall to be effective ornamentals in today's downsized residential properties. However, young palms are suitable for landscaping and can be replaced every 10–20

years when they grow too tall. Canopy spread is estimated at 3 m (10 ft), which is a good size for landscaping. Juvenile betel nut palms are sometimes used indoors as foliage plants. Also, because of their eventual height, care should be taken regarding planting beneath overhead wires or near a driveway or patio where falling fronds may cause damage or injury.

Rate of growth in a landscape

The growth rate is moderate in landscape settings.

Roots

The fibrous root system rarely presents any problems in an urban setting.

Products commonly used in a household

Aside from the uses outlined above, whole clusters of ripe fruits and leaf sheaths are sometimes used in large floral arrangements.

Special light requirements

Juvenile palms require shade until they grow above the surrounding vegetation, then full sun is necessary.

Life span

The life span is 60–100 years. In homegardens the palm will outgrow the landscape in 10–20 years or be replaced before then by a garden renovation.

Maintenance

Mulching or heaping soil around the trunk base will encourage adventitious root growth, which aids stability and plant vigor. This solitary palm does not branch or require any thinning, and fronds drop as they age, so no pruning is required unless the crown is close to electrical or telephone wires.

Special considerations regarding leaf, branch, and fruit drop

Considered a self-pruning palm, betel nut palm drops old fronds (ca 2 m [6.6 ft] long) throughout the year as new fronds emerge. Falling fronds may damage groundcovers or other plantings beneath the canopy as well as cars, patio furniture, awnings, or people. Storm winds do not normally tear healthy fronds from the crown, but they will dislodge any nearly deciduous old fronds; these may be a hazard in high winds.

Nuisance issues: poisonous parts, thorns/spines, foul smell

None.

Common pest problems

None of significance. Only foot rot fungus (*Ganoderma*) is mentioned as affecting ornamental plantings of betel nut palm.

INTERPLANTING/FARM APPLICATIONS

Crop/tree interactions

Permanent intercropping takes place using bananas, cacao, cardamom, fruit trees (guava, jackfruit, mango, orange, papaya, plantain, coconut), or guinea grass as fodder. In India pepper vines (betel pepper, *Piper betle*) or black pepper (*P. nigrum*) are often trained onto the trunks of betel nut palms.



Betel nut palms in polyculture on Yap Island, Micronesia.

PHOTO: M. MERLIN

Short-term intercropping with annual or biennial crops is also practiced when betel nut plantations are young.

Benefits of interplanting

Intercropping in general makes better use of the land and light by producing an income-generating crop before the palms begin bearing. Intercropping with banana provides shade essential for establishment of young areca palms after they are transplanted from nursery beds to the field. In the Mariana Islands, the banana intercrop improves soil chemistry and soil fertility. When betel pepper is grown together with betel nut palm, the two main ingredients of quid (betel nut and betel pepper leaf) are readily available for consumption or sale. In homegardens, intercropping with fruit trees provides a variety of useful products for home consumption.

Potential drawbacks of interplanting

The main problems of intercropping are competition for nutrients, sunlight, and water between the betel nut palms and the intercrop. Too close spacing is the primary cause of these problems.



Leaf underside. PHOTO: C. ELEVITCH

PUBLIC ASSISTANCE

Central Plantation Crops Research Institute, Kasaragod, Kerala, India, <<http://www.bioinfpcrri.org/>>.

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Areca catechu (betel nut palm)

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