



Barringtonia procera (cutnut)

Lecythidaceae (Brazil nut family)

cutnut (English); *katnat* (Solomon Islands: pidgin); *navele* (Vanuatu); *pao* (Papua New Guinea)

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IN BRIEF

Distribution Indigenous to the Solomon Islands, Vanuatu, and Papua New Guinea.

Size Grows to a typical height of 20 m (66 ft) with crown diameter of about 5 m (16 ft).

Habitat Lowland humid tropical rainforest, at elevations of 0–600 m (0–1970 ft) and uniformly distributed annual rainfall of 1500–4300 mm (60–170 in).

Vegetation Common in old gardens, mature coconut plantations, and coastal villages, and in remnants of secondary lowland rainforests.

Soils Wide range of light to heavy soils with free drainage.

Growth rate Moderate, mean height growth of <1 m/yr (3.3 ft/yr) for the first 10 years.

Agroforestry uses Windbreak, soil stabilization, “living ladder” (climbing tree), and homegardens.

Main products Nut.

Yields Estimated at 10–50 kg (22–110 lb) of fruits/tree/year. At 20 years of age, an annual yield estimate is 2–3 mt (2.2–3.3 t) fresh fruits annually per hectare, or 0.33–0.5 mt (0.37–0.55 t) kernel-in-testa/ha/yr.

Intercropping With proper spacing, it can be interplanted with a variety of shade-tolerant crops.

Invasive potential Does not appear to have potential to become a pest outside its native range.

PHOTO: R. PAUKU



Branching and canopy structure of cutnut.
Poporo, Kolombangara, the Solomon Islands.

INTRODUCTION

Cutnut (*Barringtonia procera*) is a medium size, evergreen, tropical tree found in secondary forests of the Solomon Islands, Vanuatu, and Papua New Guinea. It is grown in homegardens and coconut plantations and is common within the surroundings of both inland and coastal rural villages. The tree has been associated with human settlements since ancient times and is unlikely to occur in a truly wild form. Throughout Melanesian countries, cutnut is well known as a nut tree, and the people have both planted and protected it on their land.

Cutnut prefers light shade, which makes it a good companion to overstory tree species such as vi (*Spondias cyathera*), canarium nut (*Canarium* spp.), and breadfruit (*Artocarpus altilis*). Its open canopy structure allows sufficient light penetration to the ground level for other crops to be interplanted under it. For instance, farmers in Temotu province of the Solomon Islands have used cutnut as a companion and interline tree crop in an improved traditional agroforestry system. On Kolombangara Island, Solomon Islands, it has been used as a trellis tree for the cash crop betel leaf (*Piper betle*), as well as for marking land boundaries and creating windbreaks.

In a homegarden situation, cutnut provides good shade and shelter to root and cereal crops and other understory crops such as sugarcane (*Saccharum officinarum*) and a nutritious native leafy spinach called bele or edible hibiscus (*Abelmoschus manihot*). The species has a well formed lateral root system yet does not appear to cause major impediments during soil preparation for understory crops, e.g., making mounds for the root crops, nor does it seem to compete heavily with understory crops. In tree farming, cutnut may be planted as a shade tree for crops such as cacao (*Theobroma cacao*), joint fir (*Gnetum gnemon*), and betel nut (*Areca catechu*). There is no record of cutnut becoming invasive, and *in situ* observation on the distribution of wildings appears to rule out any potential invasiveness. Since 2002, a program to domesticate this species has been receiving much support from the local community in Kolombangara Island in the Solomon Islands.

DISTRIBUTION

Native range

Cutnut is indigenous to the Solomon Islands, Vanuatu, and Papua New Guinea. It is widespread and common at lower altitudes and is found mainly in villages and food gardens. These areas are characterized as wet tropical lowland rainforest.

Current distribution

Beyond its native range the species has not been widely distributed as an exotic species. However, it has been introduced to Howard Newport in Australia. It is reported to have been introduced into Fiji, although these may be *B. edulis*; without a thorough taxonomic classification, the presence of *B. procera* in Fiji remains uncertain.

BOTANICAL DESCRIPTION

Preferred scientific name

Barringtonia procera (Miers) Knuth

Family

Lecythidaceae (Brazil nut family), or Barringtoniaceae according to some authors

Non-preferred scientific names

B. guppyana Knuth

B. magnifica Laut.

B. schuchartiana K. Schum.

Common names

cutnut (English)

katnat (Solomon Islands: pidgin)

navele (Vanuatu)

pao (Papua New Guinea)

The standard common name in the Pacific is cutnut. In the Solomon Islands, it is a well known tree and has names in many local dialects, including *fala/aikenu* in Kwara'ae (Malaita Is.), *kenu* in To'oabaita (Malaita Is.), *vele* in Varisi (Choiseul Is.), *fara* in Santa Ana (Santa Ana Is.), *kino* in Nduke (Kolombangara Is.), *tinghe* in Roviana (New Georgia Is.), *oneve* in Marovo (New Georgia Is.), *fala* in Maringe (Isabel Is.), *nofe* in Zabana (Isabel Is.)

Size and form

Cutnut is a medium-size tree which can reach a height of 24 m (80 ft). The typical tree height is thought to be in the range of 8–12 m (26–40 ft), with a crown diameter of 0.8–6 m (2.6–20 ft). The diameter of the trunk at breast height of mature fruiting trees ranges from 2 to 45 cm (0.8–11.4 in) (mean = 18 cm [7 in]). The smaller height and trunk diameter measurements refer to a so-called dwarf form. A reasonably clear bole up to one fifth of the tree height is typical, although this varies among individual trees and cultivars. Irregular scars are occasionally found on the trunk as remnants of healed-over branch attachments. Cutnut produces a vigorous framework of branches

resulting from whorls of main branches that fork regularly following the formation of the terminal inflorescences.

Flowers

Cutnut has a racemose inflorescence with a 30–110 cm (12–43 in) long pendulous spike containing up to 150 densely packed flower buds, arranged in spirally alternate pattern, and varying in colors, typically from green to white or red. Flowering is terminal on the shoots. Flower buds are semi-sessile to sessile and are protected by a calyx closed in the bud, which ruptures into two to four pseudolobes. The calyx apical pore varies in diameter, depending on the stage of development of the flower. It is completely closed at very early stage but later opens, making way for fully developed flower buds. Cutnut flowers are bisexual, with male and female reproductive parts occurring on the same flower.

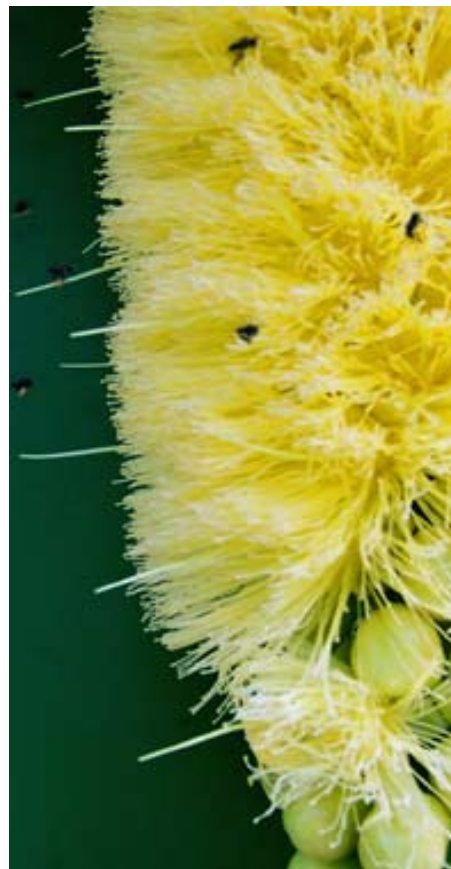
At lower elevations in the Solomon Islands and Papua New Guinea, flowering occurs irregularly two to three times per year. On Kolombangara Island, Solomon Islands, two peak seasons occur in May–June and October–November each year, although low off-season fruiting does occur.

Leaves

The large, simple, lanceolate leaves are arranged in a whorl at each node. Leaf size varies, typically measuring 21.5–66 cm (8.5–26 in) long and 5–20 cm (2–8 in) wide. The upper surface of the leaf is dark green and glossy; the lower surface is slightly paler. Typically, the leaf has a truncated base and an acuminate apex, with undulated margins. Leaf veins are reticulated and vary in number according to leaf size, but there can be up to 34 on each side. The short thick petiole is up to 6 mm (0.25 in) in length with a mean width of 10 mm (0.4) at the basal end.

Fruit

Fruits are multiple, sessile, and borne on a pendulous rachis. At maturity they are indehiscent, but the skin can be easily peeled off when ripe. The elongated, oblong to obovoid fruits taper toward the apex and base. The shape of the fruit at the apex is emarginate-rounded and truncate-rounded at the base. Typical length of a mature fruit is 25–95 mm (1–4 in). Width at apex, mid-section, and base is, respectively, 14–45 mm (0.6–1.8 in), 22–59 mm (1–2.3 in), and 15–50 mm (0.6–2 in). Fruits in Vanuatu are longer and more cylindrical than those in the Solomon Islands. Fruit color



Flowers in white, yellow, and red. Tiny bees can be seen foraging on the flowers. Hunda, Kolombangara, Solomon Islands.
PHOTOS: R. PAUKU



Left and top right: Fruits and kernels. PHOTOS: R. PAUKU **Bottom right: Cutnut variation, green fruit with purplish color of testa and shell.** This type is called Kobakilo in Varisi dialect, Choiseul Province, the Solomon Islands. PHOTO: R. LEAKEY All three photos were taken at Hunda, Kolombangara, the Solomon Islands.

is variable, from grayish green to purplish red. In Vanuatu, fruiting occurs once a year in the wet season (September to March).

Seeds

The seed or kernel is contained in a fibrous, white to purplish, cylindrical, eight-sided endocarp shell (prominent when exocarp and mesocarp are removed). The fleshy mesocarp is food for animals such as cockatoos and flying foxes, and they disperse the seeds. The testa of green fruits in certain varieties can have a reddish/purplish color.

Bark description

The bark is smooth at early the stages of growth but becomes fissured as the trees grow older. Large lenticels up to 5 mm (0.2 in) across are present.

Rooting habit

The tree has a relatively shallow taproot and a well formed network of lateral roots, concentrated in the topsoil layer.

Similar or look-a-like species

The three edible species of *Barringtonia* (all called cutnut) are *B. procera*, *B. edulis*, and *B. novae-hiberniae*. The latter species is clearly distinguishable by its simple, near-entire leaves, and it is largely found in the wild form. The distinction between *B. procera* and *B. edulis* is not easy to identify because of the great variation within each of the species, which means that morphological characteristics can be overlapping, leading to confusion. Typically, however, *B. procera* is recognized as having glossy leaves, very short to sub-sessile petioles, and short to no pedicel.

Comparative morphological characteristics of edible *Barringtonia* species. Source: Payens 1967 and Evans 1999

Species	Leaf length (mm)		Leaf width (mm)		Petiole length (mm)	Pedicel length (mm)	Fruit shape	Calyx in bud
	min	max	min	max				
<i>Barringtonia procera</i>	45–60	48–60	15–24	17–24	Sub-sessile	Sessile	8-gonous	Closed/open
<i>Barringtonia edulis</i>	38–45	55–48	15–16	17–23	Short	Pedicelled	Ovoid	Closed
<i>Barringtonia novae-hiberniae</i>	20–25	23–35	7–10	8–15	Long	Pedicelled	Broad-ovoid	Large apical pore

The leaf and fruit morphology of *B. novae-hiberniae* is different from *B. procera* and *B. edulis*. *B. novae-hiberniae* and *B. procera* occupy overlapping geographic areas (sympatric). *Barringtonia edulis* and *B. procera* often have overlapping ranges, but *B. edulis* is absent in New Britain of Papua New Guinea and is present in Fiji. *B. novae-hiberniae* is largely undomesticated and thus is commonly found in secondary forests, fallow forests, and under coconut plantations but is less abundant around and within village surroundings. In terms of products and agroforestry services, they have similar domestication and market opportunities, but no formal investigations have been conducted on the vegetative propagation of *B. edulis* and *B. novae-hiberniae*. A molecular study is currently in progress to determine the integrity of these three species and whether any hybridization has occurred between them.

GENETICS

Variability of species

As is typical for out-breeding species, there is extensive variation in many morphological characteristics in cutnut, such as flower and fruit colors, etc. For example, fruits can be 20–140 g (0.7–5 oz) (mean = 64 g) in fresh weight; 25–95 mm (1–4 in) (mean = 67 mm) in length; and 14–45 mm (0.6–1.8 in) (mean = 28 mm) (apex), 22–59 mm (0.9–2.3 in) (mean = 39 mm) (mid), and 15–50 mm (0.6–2 in) (mean = 31 mm) (base) in diameter. For kernel-in-testa the fresh weight range is 5–25 g (0.2–1 oz) (mean = 11 g), the range of length is 10–50 mm (0.4–2 in) (mean = 33 mm), and the widths range as follows: 5–33 mm (0.2–1.3 in) (mean = 16.9 mm) (apex), 7–45 mm (0.3–1.8 in) (mean = 21.7 mm) (mid), and 6–37 mm (0.25–1.5 in) (mean = 18.2 mm) (base). The shell weighs 10–70 g (0.35–2.5 oz).

While most tree species such as *Pometia pinnata*, *Inocarpus fagifer*, *Artocarpus altilis*, and *Dacryo-*

des edulis are known for their outbreeding characteristics, it was observed in Kolombangara, Solomon Islands, that at very low levels cutnut might be self-pollinated as well. This observation, however, needs to be validated with further research on the reproductive biology of the species.

Known varieties

Traditionally, people have undertaken intensive selection over many years and have produced identifiable varieties that vary in several characteristics, particularly fruit color, shape, and size. In the Solomon Islands, four varieties of cutnut have been recorded, varying in fruit color, leaf size, and tree height. One of the varieties has a purplish testa and inner shell.

Culturally important related species in the genus

Species of cultural importance include *B. asiatica* and *B. racemosa*. In the Solomon Islands, *B. asiatica* is used for fish poisoning and treating toothache, while *B. racemosa* is



Left to right: Leaves and fruits of *Barringtonia procera* (dwarf tree), *B. edulis*, *B. procera*, and *B. novae-hiberniae*. PHOTO: B. EVANS, REPRODUCED WITH PERMISSION FROM EVANS 1999

a good live fence and is used for the treatment of venereal diseases, such as gonorrhoea.

Genetic resources where collections exist

There has been little formal research on germplasm conservation or improvement of this tree. A provenance trial was set up in 1989 at Avuavu on the south coast of Guadalcanal in the Solomon Islands, and a small clone collection has been developed at Ringgi Cove on Kolombangara Island.

ASSOCIATED PLANT SPECIES

While cutnut is reasonably widely distributed in its native range, it is commonly found in old gardens, mature coconut plantations, and coastal villages. These habitats are remnants of secondary lowland rainforests.

Associated species commonly found in native habitats

Within the natural range of cutnut are other species including canarium nut (*Canarium* spp.), breadfruit (*Artocarpus altilis*), coconut (*Cocos nucifera*), Tahitian chestnut (*Inocarpus fagifer*), poumuli (*Flueggea flexuosa*), sago palm (*Metroxylon salomonense*), Malay apple (*Syzygium malaccense*), *Mangifera minor*, *Ficus* spp., *Macaranga* spp., *Terminalia* spp., and tava (*Pometia pinnata*).

Species commonly associated as aboriginal introductions in Pacific islands

Species commonly associated as aboriginal introductions in Pacific islands include other cutnut species *B. edulis* and *B. novae-hiberniae*, canarium nut, Malay apple, Tahitian chestnut, and *Terminalia* spp.



Left: Seedling root system. PHOTO: R. PAUKU Right: The author examines flowers *B. novae-hiberniae* at Vovohe, Kolombangara Island. PHOTO: R. LEAKEY

BARRINGTONIA ASIATICA

Barringtonia asiatica is a widespread tree, present in coastal India, Africa and southeast Asia to Melanesia, Micronesia, and Polynesia. It can grow up to 25 m (82 ft) in height. *B. asiatica* is morphologically distinct from the edible *Barringtonia* species. Its fruits are inedible and poisonous. Its leaves are large and simple, undulated, and held in rosettes at the ends of branches. The large stamens of the flowers are white with a pinkish color toward the apex. The fruits are four-sided with a conspicuous ridge on the angles, green when immature and yellowish brown when ripe. The fruit floats and the tree is commonly found in coastal locations—sandy and rocky shores. *B. asiatica* is commonly associated with *Intsia bijuga*, *Hibiscus tiliaceus*, and *Calophyllum inophyllum* close to the beach. Because the fruits float and can remain viable for many months, *B. asiatica* may have been introduced to the Pacific islands from southeast Asia. Although the seed is poisonous to humans, other parts of *B. asiatica* have medicinal value and are culturally important. The heated leaves are used to treat stomachache and rheumatism in the Philippines, while an extract of the boiled bark is used for treating toothache in the Solomon Islands. In many countries the leaves, seeds, or bark are used to stun fresh and saltwater fish and prawns. The species serves well in protection of coastal areas.



Flowers and fruits of *B. asiatica*. PHOTOS: C. ELEVITCH

Species commonly associated in modern times or as recent introduction

Species commonly associated with more recent introductions include banana (*Musa* spp.), cacao (*Theobroma cacao*), citrus (*Citrus* spp.), and papaya (*Carica papaya*).

ENVIRONMENTAL PREFERENCES AND TOLERANCES

Climate

Cutnut is commonly found in lowlands of the humid tropics, in areas with warm to hot temperatures throughout the year. The species tolerates the tropical cyclones that usually occur during the wet season from November to March in the Solomon Islands, Papua New Guinea, and Vanuatu. In its natural range, cutnut does not experience a dry season of more than a few months. Its tolerance of a longer dry season is not known. It is adapted to high rainfall up

to 4300 mm (170 in) per annum. In Kolombangara, the Solomon Islands, high rainfall appears to reduce fruit set and thereby lowers fruit production.

Elevation range

0–600 m (0–1970 ft)

Mean annual rainfall

1500–4300 mm (60–170 in)

Rainfall pattern

The tree grows in climates with a uniform rainfall pattern.

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

3–5 months. Monthly rainfall rarely falls below 40 mm in consecutive months in its range.

Mean annual temperature

26.4–27.7°C (80–82°F)

Mean maximum temperature of hottest month

29.4–34.5°C (85–94°F)

Mean minimum temperature of coldest month

20–23°C (68–73°F)

Minimum temperature tolerated

Unknown. Prolonged temperatures below 20°C (68°F) may negatively affect tree growth.

Soils

Cutnut generally grows in coastal coral soils with light to heavy textures. It occurs in soils with medium to high fertility, and it tolerates rocky soils. The tree grows well in coastal soils high in pH (up to 8.5), but it does not tolerate waterlogged soils.

Soil texture

It grows in light to heavy soils (sands, sandy loams, loams, sandy clay loams, sandy clays, clay loams, and clays).

Soil drainage

It prefers soils that have free drainage.

Soil acidity

The tree grows in mildly acid to neutral or mildly alkaline soils (pH 5.1–8.5).

Special soil tolerances

The tree tolerates shallow, saline, and infertile soils.

Tolerances**Drought**

The tree is likely to be intolerant of prolonged drought.

Full sun

Cutnut grows well in full sunlight but is usually found as a sub-canopy species in low-density, mixed-species environments.

Shade

Cutnut tolerates 20–70% shade. Mature trees are more tolerant than young seedlings. In Kolombangara, Solomon Islands, 5-month-old seedlings grown under 30% shade and in full sunlight grew equally well (stem heights were about 34 cm for both) (author's unpublished research).

Fire

It is likely to be intolerant of fire.

Frost

This tropical species does not experience frost and is likely to be sensitive to temperatures below 15–20°C (59–68°F).

Waterlogging

Cutnut does not tolerate waterlogging.

Salt spray

The species is commonly found in coastal villages and sometimes grows a short distance from the sea, indicating some tolerance of salt spray.

Wind

Cutnut has medium to high tolerance of steady and strong winds including cyclones. Branches and twigs do not easily snap, but they may be broken off by strong winds. The trees rarely suffer from windthrow due to their height, open canopy structure, and good lateral rooting system.

ABILITIES**Self-prune**

The tree is naturally self-pruning of lower branches up to about one-fifth of the height of the tree.

Coppice

Trees coppice well and young leafy shoots regrow rapidly following cutting. Stumps as short as 10 cm (4 in) in height coppice well.

Pollard

Pollarded trees resprout well. In Kolombangara, Solomon Islands, one to six shoots per pollarded branch sprouted after 2–3 weeks.

GROWTH AND DEVELOPMENT**Growth rate**

Generally, cutnut grows moderately fast, but this varies significantly depending upon trees and growth conditions. Mean annual increment (MAI) for height of trees up to 5 years is 62 cm (24 in); thereafter the MAI increased about 1 m (3.3 ft) annually for the next 5 years. Thirty-year-old trees had an average MAI of about 1.4 m (4.6 ft). Diameter at breast height appears to be relatively uniform with age. Trees aged 5, 10, 15, and 20 years old have all attained an MAI for diameter at breast height on the order of 1.4–1.6 cm (0.55–0.63 in).

Flowering and fruiting

Trees begin flowering as early as 1.5 years (dwarf variety), although the average is probably 3 years. Flowering occurs two or three times a year in PNG and the Solomon Islands but once a year in Vanuatu. Some trees flower throughout the year in Kolombangara, Solomon Islands.

Reaction to competition

Cutnut does not withstand invasive vines such as *Mikania* and *Merremia* at the seedling stage, but mature trees grow well together with other tree species from their native range in mixed-species plantings. Seedlings generally compete well with grasses and eventually grow out of suppression.

PROPAGATION

The most common method of propagating cutnut is by direct planting of fruits into the field or raising the seedlings in the nursery before transplanting into the field. Vegetative propagation through air-layering and stem cuttings has proved highly successful in the Solomon Islands. Juvenile cuttings set in a non-mist propagator (Leakey et al., 1990) gave 100% rooting in 3 weeks, while 100% of air-layers rooted in 4 weeks.

Propagation by seed

Seed collection

Collect well formed fruits, which fall to the ground when they are ripe. Fruits take about 3 months to reach full size and a further 3–4 weeks to ripen to maturity. Collecting fresh fruits from the tree will result in low germination success if they are immature. Generally, a distinctive die-back of the persistent stigma at the base of the fruit is a good indicator of fruit maturity.

Seed processing

The seeds (nut-in-shell) are extracted from the mature fruits. Cutnut is commonly propagated by sowing the whole fruit. When ripe, the skin splits open along longitudinal grooves, exposing the outer fleshy mesocarp. The mesocarp will rot away within 7–14 days depending on the degree of maturity. The mesocarp of mature fruits can be easily peeled off using a kitchen knife or by hammering the fruit with a stone on a flat base. There are 10–30 (mean = 15) fruits in a kg (2.2 lb). Sow fruits in polyethylene nursery bags or on germination beds composed of river sand, forest soil, or coir.

Seed storage

Seeds are recalcitrant, do not withstand drying, and remain

viable only for short period in dry storage. To maximize storage, it is best to retain the mesocarp on the nut and store the seeds in a shady, cool (19–25°C [66–77°F]), and low-humidity (ca 50%) environment and out of reach of pests such as crabs and rodents.

Pre-planting treatments

There appears to be no special pre-planting treatment for cutnut. Viability of the seeds can be tested by placing them in water. Fruits that float are likely to be non-viable.

Growing area

Seeds may be sown directly into the field or raised in the nursery in polyethylene bags or root trainers (one seed per cell). It is important to avoid direct exposure of seeds to full sunlight. Shade of 30–50% provides adequate protection from direct solar heat for the germinated seeds. Sown seeds must be watered regularly until the first foliage leaves have emerged. Excess watering encourages rotting.

Germination

The seed should be sown 3–5 cm (1.2–2 in) deep in a vertical position with the basal end down—the roots emerge from this end and the shoots emerge from the apex. Seeds from ripe fruits will start to germinate after 7 days. Seeds on their side will take longer to become established. Nearly 100% of viable seeds can be expected to germinate, as there is no seed dormancy. It takes 2–3 months to germinate a ripe fruit. The kernel (embryo) in the shell does not degenerate rapidly but can remain attached to the young developing seedlings up to 5–12 months.

Media

Well drained potting mix, which is light, permeable, and has good water-retention capacity, can be made from topsoil and coir. Coir is derived from decomposed and shredded coconut husk. The coir should be sterilized prior to use by heating it to about 100°C (212°F) for 30–45 minutes.

Time to outplanting

Seedlings are ready for field planting about 2–3 months after germination. Prior to field planting, seedlings should be hardened off by exposing them to increased light intensity (80–90%) for at least 4 weeks. Field planting should be encouraged during wet periods to minimize adverse field effects on the young seedlings.

Approximate size

Ideally, seedlings should be 20–30 cm (8–12 in) tall when they are outplanted. Seedlings 2–3 months old should have already attained such a stem height, actively producing 8–21 true leaves and a crown diameter of 15–33 cm (6–13 in).

Other comments on seedlings

Wildings (volunteer seedlings) can be easily transplanted, and can be stored in a shaded and cool location for up to 2–3 weeks if the seed (nut-in-shell) is left attached.

Guidelines for outplanting

In a small-scale plantation, seedlings may be planted at 5 x 5 m (16 x 16 ft) spacing, or 400 trees/ha (162 trees/ac). In its native range, mature trees were found at low density and extremely uneven spacing (ca. 10–15 trees/ha [4–6 trees/ac]). Seedlings may be planted on cleared land or as line-plantings in secondary forests, in which selective thinning of the forest allows more light to reach the seedlings. Planting cleared land may be more successful and rewarding if other multipurpose trees and crops such as *Canarium* spp., *Gliricidia sepium*, *Pterocarpus indicus*, *Flueggea flexuosa*, and *Musa* spp. are established a year in advance to give some shade and create an agroforest. Planning is required to achieve optimal spacing and configurations, such as those developed by farmers in Temotu islands.

Before planting, seedlings should be sprayed with water to reduce stress through transpiration, especially during transportation. It may also be necessary to trim the leaves to reduce transpiration losses. Coconut fronds or forest branches can also be used to shade seedlings before and after planting to reduce physiological stress.

A planting hole should be dug with a slant-cut digging stick or a digging spade. The hole should be filled with a good mixture of topsoil and organic materials to maximize survival and growth of seedlings. Watering may be necessary if prolonged dry weather is experienced after planting.

Propagation by leafy stem cutting

A relatively inexpensive, watertight enclosure called a poly-propagator is well suited for rooting stem cuttings. In the poly-propagator system, water is supplied through a pipe and retained within layers of sand, stones, pebbles, and growth media. The water keeps the temperature and relative humidity fairly constant inside the propagator; these conditions are maintained by opening the lid only when absolutely necessary. Whenever the enclosure is opened, the cuttings should be sprayed with water before clos-



Germinating seed.

PHOTO: R. PAUKU

ing the lid. The water level should be checked regularly through an observation pipe inserted in the medium, and refilled if low.

Collecting cuttings

Cuttings may be collected from stumps or coppiced trees, seedlings, wildings, or managed stockplants or hedges. To propagate cultivars, a multiplication garden of stockplants originating from selected superior parent trees can be established under the shade of mature forest trees. The multiplication garden should be established close to the nursery for easy access.

The first cuttings should be ready for harvest within 6–12 months from initial planting. At this age in good growing conditions, stock plants should have attained 0.8–1.5 m (2.5–5 ft) in height and will produce cuttings of four to six internodes with stem diameters of 10–15 mm (0.4–0.6 in) and internode lengths of 2–15 cm (0.8–6 in). Cuttings with longer internode lengths root best.

After the first harvest of cuttings it will take about 3–4 months for shoots from recently pruned stockplants to be ready for the next harvest of cuttings. Typically two to six shoots will be produced from individual stumps. To achieve good rooting success, shoots should be harvested when they are about 40–50 cm (16–20 in) in height, with two or three fully elongated internodes.

Harvesting cuttings

Single-node cuttings should be collected in the morning or late afternoon when it is cool. Collect only shoots that are healthy and pest-free. Sever shoots with a clean cut using a sharp knife or hand pruner. Typically, there are two leaves per node. One should be cut off and the other reduced in surface area to about 30 cm² (4.7 in²). If cuttings are being harvested at a distance from the nursery, it may be necessary to store them in a cooler, a sealed polyethylene bag containing wet paper or cloth, or in a bucket of water. In this case, the whole shoot should be kept intact until arrival at the nursery. Cuttings should not be allowed to come into contact with ice when using a cool box. It is important to keep the shoots from each plant or clone separate and to record their identity on labels inside and outside the bag.

Storage of cuttings

For best results, the cuttings should be immediately set in the poly-propagator. Leafy cuttings cannot be stored for more than a few hours. Storage overnight can be done but may result in reduced success.



Left: Stockplants of selected trees in multiplication garden. Right: Poly-propagator system. All photos taken at Ringgi nursery, Kolombangara, Solomon Islands. PHOTOS: R. PAUKU

Treatments

It is not necessary to treat cuttings with fungicide prior to setting. Rooting hormone (indole butyric acid, IBA) has been shown to significantly increase the rate of rooting and number of roots formed, although there is no significant effect on the take rate as compared to using no hormone. A rooting powder with 0.8% IBA has been found to be best. Apply the hormone by dipping the base of the cutting in the rooting powder and then tapping gently to remove excess powder before placing the cutting inside the poly-propagator. Optimal leaf area is 30 cm² (4.7 in²). The stem should be 10–15 mm (0.4–0.6 in) in diameter and 30–55 mm (1.2–2.2 in) in length.

Growing area

A non-mist, airtight, watertight poly-propagator is ideal for propagation from cuttings. It is made of clear plastic sheeting over a wooden frame. The base is filled with stones, which are then saturated with water. A layer of rooting media (10–15 cm [4–6 in] deep), such as sterilized

coir, is placed on top of these stones. The poly-propagator should be placed under shade and protected from wind.

Time for rooting

Rooting starts within 14 days from the time cuttings are set. Preferably the cuttings are left in the propagator for 3–4 weeks, when most cuttings will have produced roots that are strong and well developed. Dead leaves and cuttings should be removed on a daily basis from the propagator, as they are a likely source of fungal infection. Strike rates of 70–100% were obtained in Kolombangara, Solomon Islands.

Media

When cuttings have rooted, they are transplanted into poly-bags (1–2 liters [1–2 quarts]), or other similar containers, filled with a potting medium that is well drained, has good water-retention capacity, and is light (for transportation). Coir has proven excellent, although freely drained garden soil (clay loam or sandy loam), preferably steril-

ized, is also good. Coir must be heated at 100°C (212°F) for 30–45 minutes to prevent potential occurrences of fungal infection, and then left overnight to cool before use. This may be simply done using a 200 liter (50 gal) barrel, cut in half longitudinally, placed over a wood fire. During heating, the coir should be turned over thoroughly four or five times. Well drained garden soil, which may be sterilized as a precaution against soil-borne diseases, also makes a good rooting medium. During routine use, the propagation unit should be treated with fungicide every 1–2 months.

Hardening

Potted cuttings should be weaned progressively from shade to full sun over a period of 2–3 months. Shade of 30–50% is best at first. Plants should be exposed to full sunlight for at least a month before field planting

Approximate size at outplanting

When about 5–6 months old, cuttings should have attained 30–50 cm (12–20 in) in height and are fit for field planting. They will have stem diameters of about 5–10 mm (0.2–0.4 in) and more than five well formed leaves.

Other comments on vegetative reproduction

Propagules can also be obtained from air-layering (air-layering). Air-layering can be done on primary, secondary, or tertiary branches, but this technique is especially suited for propagating mature shoots from pollarded trees that are difficult to root as stem cuttings. In Kolombangara, air-layers made on branches with stem diameter of 10–37 mm (0.4–1.5 in) attained 100% take rate within 30 days. Coir or soil can be used as growth medium in the air-layering process. Use freely drained soils suited to the tree. Wetting the medium before application is vital to the success of the air-layer.

Guidelines for outplanting

There is little if any research or experience on growing cutnut in planted stands, although there is the time-tested experience of farmers growing trees within homegardens and villages. There are no clonal field plantings known.

DISADVANTAGES

Seeds are recalcitrant and can easily lose viability during international transport. This limits germplasm exchange between countries and reduces opportunities for comparative provenances.

Lack of appropriate postharvest extraction, drying, and storage of kernels at village level may be a production constraint. Centralized extraction units may be impractical



Six-month-old clone at Ringgi nursery (KFPL), Kolombangara, Solomon Islands. PHOTO: R. PAUKU

due to unreliable transportation and consequent deterioration of kernels.

The lack of awareness of the potential economic benefits of the species may be limiting the cultivation of cutnut.

Potential for invasiveness

The tree is unlikely to be a major invasive species outside its natural range, and it does not appear to have potential to become a pest.

Diseases and pests

Leaf miners can be a problem at the seedling stage in the nursery. At maturity, foliage damage appears to be minimal, but developing flowers and fruits are quite susceptible to pest and pathogen infection. Overall, cutnut is generally free of major pests and diseases.

Host to crop pests/pathogens

There are no cases reported. However, cockatoo and flying



Top: Air-layer on branch in tree. Bottom: Four-week-old air-layer removed from tree. Hunda, Kolombangara, Solomon Islands. PHOTOS: R. PAUKU

foxes feed on the fruits, and parrots feed on the flowers. Potentially, these animal pests could be drawn to cutnut and thereby introduced to other tree and field crops within the same area.

AGROFORESTRY/ENVIRONMENTAL PRACTICES

Mulch/organic matter

Fallen leaves, flowers, and dead branches enrich the surrounding soil.

Soil stabilization

The tree is rated high (more than 60% of farmers interviewed in Kolombangara, Solomon Islands) for soil stabilization due to a good network of lateral roots.

Crop shade/overstory

With appropriate spacing, the tree can provide medium shade that may be suitable for understory crops such as cocoa (*Theobroma cacao*), joint fir (*Gnetum gnemon*), and betel nut (*Areca catechu*).

Homegardens

A good candidate species for inclusion in the homegarden mix because it is compatible with common field crops such as cabbage, sweetpotato, banana, *Xanthosoma* spp., and cassava.

Living fences

The tree can act as a support for fencing in areas suitable for its growth.

Fence posts

The wood is unsuitable for posts because it is not durable.

Boundary markers

Traditionally, cutnut indicates human settlements and provides proof of land ownership, and therefore can serve as a good boundary marker.

Windbreaks

The tree is a good medium-height windbreak because it tolerates strong winds.

Silvopasture

A low planting density (10–15 trees/ha [4–6 trees/ac]) is recommended to avoid shading of the pasture grass.

Woodlot

The timber is of low quality, and therefore the tree is not grown for this purpose.

Native animal/bird food

Birds (cockatoos, parrots) and flying foxes feed on the fleshy mesocarp of fruits and on the flower nectar.

Wildlife habitat

The tree provides a good wildlife habitat for some nesting bird species.

Host plant trellising

It is a good trellis tree for betel nut vine (*Piper betle*).

Bee forage

Bees forage on its flowers and act as pollinators during the flowering season.

Fish/marine food chain

The fallen kernels and mesocarps are food to some freshwater fish and prawns.

Coastal protection

Being adapted to coastal areas, it provides some coastal protection but is unlikely to tolerate increased saltwater contact.

Ornamental

It is an attractive evergreen tree with bright flowers that beautifies rural villages. It is also planted for shade.

USES AND PRODUCTS

Cutnut is part of the traditional agroforestry practiced by native people in the Melanesian countries of the Solomon Islands, Vanuatu, and Papua New Guinea. The species has been planted or protected along boundaries, in secondary forests, and within the surroundings of human settlements. Like canarium nut (*Canarium* spp.), it traditionally indicated occupation and ownership of tribal lands. Almost every part of the plant has been traditionally useful. Leaves and bark are largely used for medicinal purposes, while fallen branches are used for firewood. Despite its poor quality, the wood is used by some for crafts and temporary light construction. Fruits are harvested either at maturity or collected as they fall to the ground when ripe. The kernel inside the fruit is edible, tasty, and highly nutritious and is eaten as a snack or prepared into dishes for a main meal. Kernels are sold in both domestic and export markets to generate income. Furthermore, the species is interplanted with other tree species and agriculture crops to maximize farm output. In this respect, cutnut provides good environmental services such as soil amelioration, shade, and shelter. It is a good middle-story companion tree species that provides easy access to the top of clear-bole species such



Typical homegarden with cutnut in the background, and banana, cassava, etc. in the foreground. Poroporo, Choiseul, Solomon Islands. PHOTO: R. PAUKU

canarium nut, breadfruit (*Artocarpus altilis*), and sago palm (*Metroxylon salomonense*).

Staple food

The kernel is a highly nutritious seasonal food in the Melanesian countries of origin.

Fruit

The outer flesh (mesocarp) is inedible for humans, but the ripe fruits are attractive and aromatic.

Nut/seed

The nutritious kernels have protein and carbohydrate content of about 10% and 25%, respectively, in their raw form. They are largely eaten fresh as snacks, but in the western Solomon Islands kernels are roasted and baked into puddings together with edible hibiscus (*Abelmoschus manihot*) and coconut cream.

Honey

The tree is a good bee forage.

Medicinal

The leaves were used to treat inflammation of the ear and headaches. Sap from the bark has been used for treating ciguatera poisoning, coughs, and urinary infections, and the red-leafed form is used as a contraceptive and for abortion.

Animal fodder

The kernel and mesocarp are a good feed for free-range chickens.

Flavoring/spice

The mesocarp of a ripe fruit is aromatic and may have potential for flavoring.

Beautiful/fragrant flowers

The racemes of the showy flowers are beautiful and can be used decoratively.

Timber

The wood is of poor quality, is non-durable and is, consequently, unsuitable for manufacturing or construction purposes.

Fuelwood

The fallen branches and felled trees make good firewood.

Craft wood/tools

The wood is sometimes used for making paddles in the Reef Islands, Temotu Province, Solomon Islands.

Wrapping/parcelization

The leaves are traditionally used for wrapping and parcelizing nuts.

Body ornamentation/garlands

The flower buds are potentially attractive for body garlands, but they were not used traditionally.

Cosmetic/soap/perfume

The kernel oil is not widely used in cosmetics or perfumes, although it has potential for cooking and body care products.

URBAN AND COMMUNITY FORESTRY

Cutnut has been found in homegardens throughout its native range. In Temotu province of the Solomon Islands, it was one of the species used in the improved traditional agroforestry systems as a companion and interline tree crop. Being a medium-size tree and providing good shade, it would be suitable as a park or street tree. Its pendulous flowers and fruits are attractive in an urban landscape. Its relative, *B. asiatica*, is planted as a street tree in Cairns, Australia.

Size in an urban environment

It is a medium-size tree with an open canopy structure and is suitable for interplanting with other understory crops.

Rate of growth in a landscape

No data is available, but it is likely to be moderately fast growing.

Root system

Roots of mature trees are not very likely to be invasive but do form a lateral network spreading over a radius of about 5–6 m (16–20 ft). In villages, roots are seen at the soil surface as soil is eroded away.

Products commonly used in a Pacific island household

The kernels are a common snack in households, and in the Solomon Islands and Vanuatu kernels are baked or roasted and incorporated in dishes with edible hibiscus leaves and coconut cream. Leaves, sap, and inner bark have been used for various medicinal purposes. The dry wood is used for firewood and when green for making paddles in the Reef Islands, Solomon Islands.

Light requirements

It is shade tolerant, although more than 70% shade may reduce yields.

Water/soil requirements

Freely draining soil is required. Mature trees can withstand a prolonged dry spell of up to several months.

Life span

The life span is 80–90 years.

Varieties favored for use in a homegardens

Lack of formal recognition of varieties makes it difficult to make recommendations. Dwarf cultivars and others with high fruit production should be preferred.

Hazards

Under normal conditions there are no special treatments for leaf, branch, or fruit drop. Trees that are too tall may be pollarded to reduce height and ensure safety around villages.

Common pest problems

Mature trees appear to have no major pest threats. Occasional attack by borers on flower buds and developing

fruits may be reduced through regular pruning and burning of infected branches.

COMMERCIAL PRODUCTS

The edible kernel is the primary commercial product. In the domestic market, kernels are sold in fresh, dried, boiled, roasted, or in *masimasi* or *lap-lap*, a traditional pudding with edible hibiscus leaves. In the Solomon Islands a parcel of fresh kernels (extracted from 10–12 fruits) is worth about US\$0.15. In terms of international trade, Vanuatu is the only country in the Pacific that exports kernels. The kernels are dried and packed in sealed jars.

Cutnut has potential to become an export commodity, but currently the supply is inadequate and market chains are undeveloped. This suggests that farmers need to be encouraged to increase their cultivation of cutnut, which also requires a domestication program in support of serving commercial markets.

Spacing

Suggested planting spacing is 5–6 x 5–6 m (16–20 x 16–20 ft), which gives 278–400 trees/ha (113–162 trees/ac). Potentially, a 1 hectare (2.5 acre) block will produce 1–1.5 mt (2.2–3.3 t) of fresh fruits per peak season. With two peak seasons per year, production could be up to 2–3 mt (2.2–3.3 t) annually. This amount may be manageable for a household of five or six members, with help sought from extended family members or various community social groups in the peak seasons. A plantation area of 100 ha (247 ac) from one or several farmers could yield 200–300 mt (220–330 t) of fresh fruits per year. Average kernel to fruit ratio is 0.17 or 17%. Thus, the average fruit-to-kernel ratio is 6. Based on this fruit-to-kernel ratio, such yields would provide 33–50 mt (36–55 t) of fresh kernels per year, which is likely to support an export market.

In agroforestry systems mixed with other species, 40 trees/ha (16 trees/ac) is suggested. This is estimated to give about 300 kg (660 lb) fresh fruit or 50 kg (110 lb) fresh kernels per ha.

Management objectives

Pollarding reinvigorates vegetative growth of trees, but fruit set in reproductively mature trees will decline in the year following pruning due to the loss of woody branches. In Kolombangara, some farmers have pollarded tall (> 10 m [33 ft]), mature trees to a height of about 3 m (10 ft) and claim to have induced early flowering. No thinning is necessary if using the suggested spacing unless trees require replacement due to infertility. Weeding is crucial

for the first 2–3 years of growth in the field. As the trees mature, weeding operations may be scaled down to cleaning once a year (largely by removing vines from the trees). The fertilizer requirements are unknown, but application of slow-release fertilizers at the nursery stage should provide nutrients for the seedlings to compete well in their new environment in the first 6 months.

Advantages and disadvantages of growing in polycultures

Cutnut is typically grown under other species such as *Cocos nucifera*, *Canarium* spp., *Artocarpus altilis*, *Pterocarpus indicus*, *Metroxylon salomonense*, and *Flueggea flexuosa* developing as an agroforest. It may also provide easy access for climbers to harvest difficult-to-climb species such as *Metroxylon salomonense*. However, cutnut does not tolerate heavy shading, and so a poorly designed polyculture plot may reduce yield.

Yields

Cutnut has been estimated to yield 10–50 kg (22–110 lb) of fruits per tree per year. Yields begin as early as 2–3 years in dwarf cultivars, but fruiting generally occurs on the fifth year from planting. Thus, yield estimate for 5-year-old trees at a spacing of 278–400 trees/ha (113–162 trees/ac) with two crops per year is 0.5–0.7 mt/ha (0.2–0.3 t/ac) fresh fruits. As trees mature, the yield increases, and with the suggested spacing, 2.7–3.8 mt/ha/yr (1.2–1.7 t/ac/yr) should be achievable for 20 year old trees.

Processing required

The common method for extracting kernels is to cut through the fruit with a sharp knife. This, however, results in split kernels and increases the risk of bacterial contamination in commercial processing. The use of mechanical methods is possible but not practical unless uniformity in fruit size is achieved, and this will only occur through the development of cultivars with desirable fruit and/or kernel qualities. In a commercial sense, farmers would be better off extracting kernels at the farm in order to fetch higher market prices, but this requires appropriate storage facilities located in rural villages.

On-farm processing methods

In addition to kernel extraction, fruits can be dried or smoked to allow storage for several months. Again, the limited shelf life of the product would require the establishment of central processing and storage units within rural communities. This requires personnel training and

enforcement of quality standards to meet export market conditions.

Market

Ideally, plantings should be connected by feeder roads and accessible to reliable transportation links to major market outlets within the region.

More market research is required in order to further develop the already existing international niche markets. Attention needs to be drawn to consistency and continuity of supply, quality product standards, attractive and appropriate packaging, and expansion of market outlets. Organic certification would allow farmers to reach new markets.

INTERPLANTING/FARM APPLICATIONS

Example system 1

Location

Kolombangara Island, Solomon Islands

Description

Following initiatives to domesticate the species in 2002, many farmers in Kolombangara, Solomon Islands, have been seeking to integrate cutnut with exotic timber species such as teak (*Tectona grandis*), Mindanao gum (*Eucalyptus deglupta*), and *Gmelina arborea*. Agricultural crops were also to be planted on the same plot in the early stage of tree growth. When the tree canopies are closed, the growing of annual crops would cease. In this practice, block planting is advocated for the tree species, and the choice of which field crop to plant is crucial. It is too early to evaluate these species combinations. However, farmers are expected to benefit from nut and timber production as well as from the annual crops.

Crop/tree interactions

Given the correct spacing and proper farm design, this practice may result in a positive crop-to-crop interaction. The level of inter- and intraspecies competition for water, light, and soil nutrients is unlikely to be significant as differences in rooting system, tree height, and canopy structure among species prevail. In a block-planting scenario, overstory tree species provide the upper layer structure. In the next adjacent block, understory species (e.g., cutnut) provide the middle layer structure, followed by a block of species tolerant of medium to heavy shade such as *Gnetum gnemon*, *Areca catechu*, and *Theobroma cacao*. Besides its ecological benefits, block planting enables easy access during

harvesting. Unlike fruit trees, the timber trees would be felled at maturity, and planting in separate single-species blocks would ensure minimal damage to the neighboring crops during harvesting.

Spacing

The suggested spacing in a block planting for cutnut is 5–6 x 5–6 m (16–20 x 16–20 ft) or 278–400 trees/ha (113–162 trees/ac). Timber species may be planted at 10 x 10 m (33 x 33 ft) if thinning is not practiced or 5 x 2.5 m (16 x 8 ft) if progressive thinning is to be practiced. The former spacing will give 100 trees/ha (40 trees/ac) and the latter will account for 800 trees/ha (320 trees/ac).

Example system 2

Location

Temotu Province, Solomon Islands.

Description

The Improved Temotu Traditional Agriculture (ITTA) was developed in the eighties. The system uses 23 crop species allocated within a 0.5 ha (1.2 ac) block at appropriate spacing. The choice of which crop species to use at different positions within the planting block is crucial to the inevitable competition among species for water, light, and nutrients. Indeed, this polycultural, mixed-species system has been a success. Comparative yields of tree crops such as *Barringtonia* spp. and *Gnetum gnemon* are 7 kg (15 lb) and 10 kg (22 lb) fresh fruit per tree respectively at age 5–10 years. Yield also varies across different root crop species interplanted with *Barringtonia* spp. Yam production, for example, is 37 mt/ha (16.5 t/ac), compared to 12.3 mt/ha (5.5 t/ac) for giant taro.

Crop/tree interactions

Inevitable crop-to-crop interaction exists among the species in terms of the provision of shade, shelter, and the improvement of soil structure. However, the level of interactive benefits derived from each species in this system is very much dependent upon the appropriateness of planting spacing and the correct choice of crop species planted at different positions within a given area.

Spacing

In-row spacing of 10 m (33 ft) between trees and 5 m (16 ft) between rows has been suggested for *Barringtonia* spp. In a hectare block, this planting spacing gives 200 trees (80 trees/ac). Companion trees should be planted 1 m (3.3 ft) from the established cutnut trees. Spacing for root crops varies with species. Yams were planted at a spacing of 448

mounds per hectare (181 mounds/ac) compared to 392 suckers of giant taro per hectare (159 suckers/ac).

PUBLIC ASSISTANCE AND AGROFORESTRY EXTENSION

Extension offices for agroforestry and forestry in the Pacific:
<http://www.traditionaltree.org/extension.html>

INTERNET

Edible Indigenous Nuts in Papua New Guinea: Their Potential for Commercial Development: <<http://www.new-crops.uq.edu.au/newslett/ncnl5-3.htm>>

One hundred Pacific Island agroforestry trees: <<http://www.unu.edu/unupress/unupbooks/80824e/80824Eop.htm>>

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Traditional Tree Initiative—Species Profiles for Pacific Island Agroforestry (www.traditionaltree.org)

Barringtonia procera (cutnut)

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