



## *Inocarpus fagifer* (Tahitian chestnut)

Fabaceae (legume family)

*aila* (Papua New Guinea); *chataignier de Tahiti* (French); *ifi* (Samoa, Tonga, Niue, Horne Islands, 'Uvea); *ibi* (Marquesas); *i'i* (Cooks); *ivi* (Fiji); *mape* (Society Islands); *m̄worop̄w* (Pohnpei); *namambe* (Vanuatu: Bislama); *naqi* (Solomon Islands: Nduke); Tahitian chestnut, Polynesian chestnut (English); *te ibi* (Kiribati)

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### IN BRIEF

**Distribution** Found in many countries of Melanesia, Micronesia, and Polynesia.

**Size** Typically grows to 20 m (66 ft) in height, with a crown diameter of 4–6 m (13–20 ft).

**Habitat** Grows at elevations of 0–500 m (0–1640 ft), although is found most commonly at low elevations along shorelines and rivers; mean annual rainfall 1500–4300 mm (60–170 in).

**Vegetation** Associated with lowland secondary forest, stream banks, swamps and marshes, mangrove areas, and coconut plantations.

**Soils** Grows in a wide range of soils with pH 5–14.

**Growth rate** Moderate, up to 2 m (6.6 ft) per year.

**Main agroforestry uses** Coastal stabilization, soil stabilization, crop shade/overstory.

**Main products** Edible nut, wood.

**Yields** Up to 75 kg (165 lb) fruits/tree/yr for trees 25+ years old.

**Intercropping** Can be used as a component of a multistory planting, both as a middle story or overstory tree.

**Invasive potential** Not considered invasive.



PHOTO: R. LEAKEY

Mature tree, Tututi,  
Kolombangara Island,  
Solomon Islands.

## INTRODUCTION

Tahitian chestnut (*Inocarpus fagifer*) is a medium size, evergreen tropical tree found in secondary forests, homegardens, and coconut plantations. It is most common along riverbanks, in swamps and marshes, and within coastal shorelines. It appears that Tahitian chestnut was cultivated more intensively in the past. Today the species is found mostly in wild form. The native distribution spreads across Melanesia, Micronesia, and Polynesia, extending eastward to Johore in Sarawak and Sabah in Malaysia.

Tahitian chestnut is a leguminous, evergreen tree producing a seed that is edible when cooked and is among the most important nut species in the Pacific. The tree is shade-tolerant, although heavy shading may decrease its yield. It has a dense canopy, which makes it unsuitable for close planting between light-demanding agricultural crops such as sweetpotato (*Ipomoea batatas*), taro (*Colocasia esculenta*), sugarcane (*Saccharum officinarum*), and corn (*Zea mays*). However, it is suitable as a boundary tree to provide shade and shelter for more shade-tolerant crops. Some types are compatible with other trees such as vi (*Spondias cyathera*), canarium nut (*Canarium* spp.), and breadfruit (*Artocarpus altilis*). It also grows together well with cutnut (*Barringtonia* spp.), sago palm (*Metroxylon salomonense*), betel nut palm (*Areca catechu*), and coconut (*Cocos nucifera*). There is no record that suggests Tahitian chestnut is invasive, and this is supported by *in situ* observation.

## DISTRIBUTION

### Native range

Tahitian chestnut is indigenous to many South Pacific countries (from Java in the west to the Marquesas in the east). It is found in Melanesian countries (the Solomon Islands, Vanuatu, Fiji, and Papua New Guinea) where it is believed to be indigenous.

### Current distribution

In parts of Polynesia (Samoa, Tonga, Cook Islands, and French Polynesia) and Micronesia (Pohnpei, Marshall Islands, and Kiribati), the species is believed to be an aboriginal introduction. In Pohnpei, Tahitian chestnut is found growing in coastal locations and in the uplands to an elevation of 200 m (650 ft) and is most common along riverbanks and in giant taro patches (Kostka, pers. comm., 2004). It has been introduced to the Philippines.

## BOTANICAL DESCRIPTION

### Preferred scientific name

*Inocarpus fagifer* (Parkinson ex Zollinger) Fosberg

### Family

Fabaceae (legume family)

### Non-preferred scientific names

*Inocarpus fagiferus* (Park.) Fosb.

*Inocarpus edulis* Forst.

*Aniotum fagiferum* Park.

### Common names

*aila* (Papua New Guinea)

*chataignier de Tahiti* (French)

*ifi* (Samoa, Tonga, Niue, Horne Islands, 'Uvea)

*ihi* (Marquesas)

*i'i* (Cook Islands)

*ivi* (Fiji)

*mape* (Society Islands)

*m̄worop̄w* (Pohnpei)

*naqi* (Solomon Islands: Nduke)

*namambe* (Vanuatu: Bislama)

Tahitian chestnut, Polynesian chestnut (English)

*te ibi* (Kiribati)

In the Solomon Islands it is well known in rural villages in numerous dialects. It is called *ailali* in Kwara'ae (Malaita Is.), *dulafa* in To'obaita (Malaita Is.), *dola* in Varisi (Choiseul Is.), *m̄wage* in Santa Ana (Santa Ana Is.), *naqi* in Nduke (Kolombangara Is.), *ivi* in Roviana (New Georgia Is.), Marovo (New Georgia Is.), *julapa* in Bugotu (Isabel Is.), and *zulapa* in Zabana (Isabel Is.).

### Size and form

Tahitian chestnut is a medium size tree reaching a typical height of 20 m (66 ft). Some trees in Santa Cruz, Vanuatu, grow to less than 10 m (33 ft) in height and trees in Choiseul and Kolombangara in the Solomon Islands reach 30 m (100 ft) tall. Mature fruiting trees have a typical crown diameter of 4–6 m (13–20 ft). The trunk diameter at breast height (dbh) of mature trees ranges from 7 to 90 cm (3–35 in) and is typically 30 cm (12 in). The trees have a distinctive, short, thick, irregular, and very fluted bole. Branches have a spirally alternate arrangement. Secondary branching creates a network of branches within the dense canopy.

### Flowers

The flowers are fragrant and clustered along a short rachis found at the apex of branches, stems, and twigs. They are

about 1 cm (0.4 in) long and have five petals that vary from white to yellowish. Trees begin flowering at an age of 3–5 years in the Solomon Islands. Flowering is seasonal and in most cases occurs in November–December, with fruiting in January–February of the following year. A similar pattern is found in PNG and Vanuatu.

### Leaves

The leaves are simple, oblong, alternately arranged, dark green, and leathery to the touch. They are 16–39 cm (6.3–15 in) long and 7–13 cm (2.8–5.1 in) in width, and the petiole is 0.5–2.5 cm (0.2–1 in) long. The leaf apex is slightly pointed, the base lobed, and the margin entire. Leaf veins are opposite, yellow, and conspicuously arranged along the mid-vein.

### Fruit

The fruits are ovoid but irregular, slightly flattened, and rounded or oblong with a flange down one end. They are produced either singly or in clusters. Fruits weigh 50–110 g (1.8–3.9 oz) and measure 46–130 mm (1.8–5.1 in) in length, 34–120 mm (1.3–4.7 in) in width, and 40 mm (1.6 in) in thickness. The skin is smooth and covers a fibrous shell encasing the kernel. Young fruits usually are green, but as they ripen the color usually changes from green to orange-brown. However, in some types the fruits remain green even when ripe. At maturity the fruits are usually indehiscent, although there are some dehiscent types. The division of the shell is visible when the mesocarp is removed. Tahitian chestnut generally fruits once a year. In Vanuatu fruits reach maturity between January and April. In the Milne Bay region of PNG and parts of the Solomon Islands, especially in Choiseul and Kolombangara Island, fruiting occurs from November to February. In Fiji two seasons per year have been reported (January–March and May–July), although fruiting is more pronounced in the former. Considerable year-to-year variation in the fruiting season has been reported in Fiji and the Solomon Islands.

### Seeds

The white, kidney-shaped seed or kernel is contained in a fibrous, brownish, relatively thin (about 2–3 mm [0.08 in] thick) shell. Kernels (seeds) are large, each weighing 5–50 g (0.2–1.8 oz), and measuring 20–70 mm (0.7–2.8 in) in length by 16–40 mm (0.6–1.4 in) in width. The kernel is edible when cooked but is highly perishable and has a short shelf life. It rapidly changes color from white to reddish brown after being extracted from the shell. The fleshy mesocarp, or pulp, is eaten by flying foxes and cockatoos. These animals bite off fruits and fly with them to other

trees, dispersing the seeds. The kernel (seed) must remain encased inside the shell to be viable.

### Bark

The bark is rough and flaky and varies from brown to grayish. The grayish color is more common in older trees. Other bark characteristics appear relatively constant with age.

### Rooting habit

The tree has a shallow taproot and well formed network of lateral roots that are most prevalent in the topsoil layer. At the base of the trunk are 3–4 thin buttresses that extend up the trunk up to a height of 1 m (3.3 ft) and reach laterally, snake-like, for a long distance. Sometimes lateral roots extending from the buttresses are exposed on the soil surface (not buried in the soil); this could well be due to soil erosion.

## GENETICS

### Variability of species

Tahitian chestnut displays a variety of forms. There is great diversity in leaf and fruit size, shape, and color. In Vanuatu, four morphotypes can be distinguished mainly by fruit shape and color—the most common morphotype bears broadly rounded or quadrangular fruits that are green or brown at maturity. Significant intraspecific variation was observed in fruit shape and color in the Solomon Islands, but a quantitative characterization study is needed to accurately determine the extent to which this occurs elsewhere. Typically, the species has buttresses at the base of the trunk, but a type found in the east of Johore, Sarawak, and Sabah does not form these.

### Known varieties

Given the great diversity in the size, shape, color, and form of the tree and its leaves, flowers, and fruits and its long history of cultivation, it is highly likely that Tahitian chestnut has a number of farmer-selected cultivars that have not been formally recognized or described.

### Culturally important related species in the genus

Currently, Tahitian chestnut is the only edible and culturally important species in the genus *Inocarpus*.

## ASSOCIATED PLANT SPECIES

Tahitian chestnut appears to have been cultivated more frequently in the past, and today the wild type is widely



Left and top right: Leaves, fruits on tree, 'Upolu, Samoa. PHOTOS: C. ELEVITCH Bottom right: Kernels of varying sizes, Babarego, Choiseul, Solomon Islands. PHOTO: R. PAUKU

distributed in its native range. It is commonly found in lowland woody regrowth, edges of old gardens, along rivers and streams, in swamps and marshes, along shorelines, and in coastal locations including mangrove areas and coconut plantations.

#### **Associated species commonly found in native habitats**

Other species that are found within the natural range of Tahitian chestnut include canarium nut (*Canarium* spp.), breadfruit (*Artocarpus altilis*), coconut (*Cocos nucifera*), cutnut (*Barringtonia* spp.), *Flueggea flexuosa*, sago palm (*Metroxylon salomonense*), Malay apple (*Syzygium malaccense*), *Mangifera minor*, *Ficus* spp., beach hibiscus (*Hibiscus tiliaceus*), beach she-oak (*Casuarina equisetifolia*), *Intsia bijuga*, *Terminalia* spp., and narra (*Pterocarpus indicus*). In Choiseul, Solomon Islands, Tahitian chestnut is commonly naturalized together with coconut in coastal locations and in woody secondary regrowth. The species occurs with mangrove on muddy shorelines in Kolombangara,

Solomon Islands. It is also found naturalized east of Johore in Sarawak and Sabah.

In its native range, mature trees of Tahitian chestnut are found scattered with varying density. In Veratalevu, Fiji, for example, 206 trees/ha (83 trees/ac) have been found, compared with an estimated density of 10–20 trees/ha (4–8 trees/ac) in Kolombangara, Solomon Islands.

#### **Species commonly associated as aboriginal introductions in Pacific islands**

Commonly associated aboriginal introductions in the Pacific islands include canarium nut, Malay apple, cutnut, *Burckella obovata*, and several mangrove species.

#### **Species commonly associated in modern times or as recent introduction**

Species commonly associated as more recent introductions include banana and plantain (*Musa* spp.) and coconut.

## ENVIRONMENTAL PREFERENCES AND TOLERANCES

### Climate

The tree grows in the lowland humid tropics with moderate to high, uniformly distributed rainfall.

### Elevation range

0–500 m (0–1640 ft)

### Mean annual rainfall

1500–4300 mm (60–170 in)

### Rainfall pattern

The tree grows in climates with summer or uniform rainfall patterns.

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

Up to 1 month.

### 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

No data available. Prolonged temperatures below 20°C (68°F) may negatively affect tree growth.

### Soils

The tree has been classified as a beach-forest species and is often found in swamps, marshes, waterlogged areas, and highly alkaline soils along shorelines. It also grows along the banks of rivers and streams, at the edges of villages, and in homegardens. Tahitian chestnut generally grows in a wide range of soils that include highly calcareous and saline soils and poorly drained seasonal to permanently waterlogged valleys, swamps, and marshes. It occurs in soils with medium to very low fertility rating. It can grow in mildly acidic to very alkaline coastal soils.

### Soil texture

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

### Soil drainage

The tree grows in soils that have free or impeded drainage as well as seasonally waterlogged or even continually waterlogged soils.

### Soil acidity

It can grow in mildly acid to alkaline soils (pH 5–14). Trees are found along shorelines, river banks, and even in estuaries and are frequently found in high-calcium soils with pH up to 14.

### Special soil tolerances

The tree tolerates shallow, saline, and infertile soils.

### Tolerances

#### Drought

Prolonged drought of more than several months duration may not be tolerated.

#### Full sun

Tahitian chestnut is commonly found in areas with full sunlight, although seedlings can grow up through the understory, i.e., in partial shade.



Growth in a swampy area, 'Upolu, Samoa. PHOTO: C. ELEVITCH

### Shade

It can tolerate 20–80% shade. Heavy shading appears to slow down growth of seedlings. Mature trees are likely to be less sensitive to shade than young seedlings.

### Fire

As a swamp species, Tahitian chestnut rarely experiences fire and is likely to be intolerant.

### Frost

Its natural range is frost free.

### Waterlogging

Tahitian chestnut tolerates and is adapted to permanent and seasonal waterlogging.

### Salt spray

The species is tolerant of salt as it naturally grows close to the sea.

### Wind

It has medium to high tolerance of steady and strong winds. The tree tolerates tropical cyclones that usually occur during the wettest months of November to March in the Solomon Islands. Branches and twigs do not easily break, but they may be sheared off during strong winds. The trees are windfirm due to a strong lateral root system including buttresses. The medium height of the tree contributes to its windfirm character.

### Abilities

#### Fix nitrogen

Tahitian chestnut is a leguminous species and may fix atmospheric nitrogen. Nodulation with *Rhizobium* bacteria has been found, although nitrogen fixation has yet to be confirmed. The tree is reported to improve soil fertility in Fiji and the Cook Islands.

#### Regenerate rapidly

Seedlings commonly regenerate only below the canopy of the parent tree unless the fruits are distributed by animals or by rolling down a slope. Therefore, the tree is generally not a colonizer of open areas.

#### Self-prune

Self-pruning of side branches occurs naturally. Trees normally have a single trunk clear of branches to 3–4 m.

#### Coppice

Trees coppice well, usually producing new leafy shoots

even from stumps. Some large trees are known to have regrown after cutting, while others have died.

### Pollard

Pollarded trees of Tahitian chestnut regrow well. In Kolombangara, Solomon Islands, one to four shoots per pollarded branch of mature fruiting trees resprouted after 3–4 weeks.



**Nodules on root system.** PHOTO: R. PAUKU

## GROWTH AND DEVELOPMENT

### Growth rate

Generally, Tahitian chestnut growth is moderate, but this varies significantly among trees. Seedlings can reach 1–2 m (3.3–6.6 ft) in the first year in ideal conditions. The tree is reported as a fast growing tree in Fiji and the Cook Islands.

### Reaction to competition

At early stages of growth, Tahitian chestnut can be smothered by rapidly growing vines such as *Mikania* and *Merremia*, but mature trees compete well with other tree

species within their native range. Generally, reduced vegetation is found beneath the canopy of mature trees, although seedlings are usually abundant under the canopy.

## PROPAGATION

The common method of propagating Tahitian chestnut is by direct-seeding into the field or by raising seedlings in the nursery before transplanting into the field. Vegetative propagation techniques such as air-layering (marcott) and stem cuttings have proved successful and promising for re-production of preferred clones.

### Propagation by seed

#### Seed collection

Fruits mature in about 3 months from flowering and take at least a month to ripen. Fruits fall when they are ripe; collect well formed ones from the ground. Collecting fruits directly from the tree requires that fruits be judged correctly for ripeness. Mature fruits that are harvested prior to ripening will take longer to germinate. Generally, ripe fruits are those that have changed color from green to yellowish brown or yellowish red. For some trees, how fibrous the mesocarp has become can also be used to judge fruit maturity.

#### Seed processing

No processing is necessary. The exocarp can be artificially removed by cutting along the split in the fibrous pericarp, but it is unnecessary to do so. The most appropriate way of sowing seed is as a whole fruit, i.e., including the mesocarp. The fruits are large; there are about 10–20 fruits/kg (5–10 fruits/lb).

#### Seed storage

The seeds are recalcitrant, do not withstand drying, and do not remain viable for more than a few weeks. It is best to keep the fruit intact (nut-in-shell) and store them in a shady, cool (19–25°C, 66–77°F) area with low humidity (<20%) if storage is necessary. Fruits need to be protected from pests such as crabs and rodents.

#### Pre-planting treatments

There is no information on special pre-planting treatments for the seeds. Seed viability can be tested by placing the seeds in water. Fruits that float are usually non-viable (although some non-viable fruits will sink together with viable seeds).

#### Growing area

Seeds may be sown directly into the field or raised in the

nursery in polyethylene bags or root-training containers. In both cases, it is important to avoid direct exposure of seeds to full sunlight. Shade of 30–50% provides adequate protection for the germinated seeds from direct solar heat. Sown seeds must be watered regularly until the first leaves emerge. Excess watering may encourage secondary fungal infection and rotting. When direct-seeding, only one seed is required per planting hole.

#### Germination

Depending on the stage of fruit ripening, seed germination may start as early as 7 days from sowing. Fruits usually ripen and then fall to the ground. Fruits also may fall unripe but already mature due to wind and animals (flying foxes, etc.). Mature seeds that fall to the ground or are picked unripe will take longer to germinate than ripe seeds.

Seeds should be buried in the media at a depth of 3–5 cm (1.2–2 in). Placing the seed flat on its side is acceptable, but it may take longer for the young roots to get established in the ground. It is best to plant the seeds with the radicle pointing down. The nut does not degenerate rapidly and can remain intact on the young developing seedlings for up to 6 months.

#### Media

Well drained soils, potting mix, or coir are ideal. Coir (shredded, decomposed coconut husk) is light, permeable, and has good water retention capacity. Coir should be sterilized prior to use (100°C [212°F] for 30–45 minutes).

#### Time to outplanting

Seedlings are ready for field planting about 1–2 months after germination. They should be weaned from shade by exposing them to increasing light intensity (80–100%) over a couple of weeks. Transplanting to the field should be carried out during wet periods to minimize adverse field effects on the young seedlings.

#### Approximate size

Ideally, seedlings are 20–30 cm (8–12 in) tall and have more than five true leaves when they are outplanted. Under good nursery management, seedlings take 1–2 months to reach this size.

#### Other comments on seedlings

Wildings (natural seedlings) can be transplanted. Ensuring the seed remains attached to the seedling during transplanting assures survival. Wildings whose seed is detached at a young age must be treated with special care in order to maintain vigor and viability. Holding wildings with their

roots in water in a shady and cool environment was found successful for overnight storage.

### **Guidelines for outplanting**

Spacing of 10 x 10 m (33 x 33 ft) along the boundaries of a polycultural farming system has been used (Reef Islands, the Solomon Islands). In an orchard planting a spacing of 5 x 5 m (16 x 16 ft) is suggested. Seedlings may be planted in the open or as line plantings in secondary forests. As the seedlings grow older and their demand for space and light increases, other trees and shrubs can be selectively removed. Open plantings should ideally be in mixtures with other multipurpose trees and crops such as canarium nut, gliricidia (*Gliricidia sepium*), narra, *Flueggea flexuosa*, coconut, and *Musa* spp. These are incorporated to provide shade as well as to diversify production and minimize risk. Ideally, these other species should be planted a year in advance of the Tahitian chestnut. This requires planning so that correct final spacing is achieved.

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. Temporary shade made of 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 5–10 cm (2–4 in) diameter with a slant-cut digging stick or a digging spade and be filled with a good mixture of topsoil and organic materials such as compost to maximize survival and growth of seedlings. Watering may be necessary if prolonged dry weather is experienced in the weeks following planting.

### **Propagation by leafy stem cutting**

A relatively inexpensive, air- and water-tight enclosure called a poly-propagator (Leakey et al. 1990) is well suited for starting cuttings of Tahitian chestnut. After about 3 weeks the cuttings will have developed a strong enough root system to be transplanted into individual containers for growing in open conditions.

### **Collecting cuttings**

Cuttings may be collected from stumps or pollarded trees and branches. They may also be collected from wildings or seedlings raised in the nursery. Ideally, a multiplication garden of stock plants (wildings, seedlings, and clones) from selected superior parent trees is established under moderate shade of mixed species in secondary forest. The multiplication garden should be established at close proximity to the nursery for easy access.

A crop of cuttings can be taken from stock plants in the

multiplication garden within 6–12 months of initial planting. By this time the trees should have attained 0.5–1.5 m (1.6–5 ft) in height and produce six to nine single-node cuttings with varying diameter (2–5 mm, 0.08–0.2 in) and length (2–10 cm, 0.8–4 in).

At first harvest, the seedling should be trimmed back to a height of 20–50 cm (8–20 in) leaving side branches intact on the main stem. After pruning, new shoots will rapidly emerge from axillary buds on the stem, and seedling generally makes a full recovery after harvesting cuttings from it. Harvesting cuttings can be done about every 4–6 weeks during the growing season. This period can be lengthened, but leaving new shoots too long will result in increased lignification and a decline in rooting ability. Regularly cropped stock plants can be managed as a hedge. Side branches along the main stem should be trimmed to encourage top shoot production.

When collecting from stumps and pollarded mature trees rather than seedlings in a stock plant garden, coppices and sprouts are ready for harvest within 3–6 months of cutting. About two to five shoots are produced from individual stumps or managed stock plants. A shoot or secondary branch reaching 20–30 cm (8–12 in) in stem length generally has up to nine internodes.

### **Harvesting cuttings**

Single-node cuttings should be collected in the morning or late afternoon when it is cool. Harvest young, six- to nine-node shoots that are healthy, disease-free, and have 5–10 cm (2–4 in) internodes. Sever shoots with a clean cut using a sharp pair of pruning shears, and avoid damaging the stem. It may be necessary to reduce the number of leaves to one per internode and to trim them down by half before transporting the plants back to the nursery. Place the shoots in a bucket filled with water. Alternatively, wrap them with a moist piece of cloth or paper and place them in a closed polyethylene bag for transport.

### **Storage of cuttings**

For best results, the cuttings should be immediately set in the poly-propagator. Leaving cuttings overnight in water or under high humidity (i.e., in a sealed plastic bag) is acceptable but may result in a reduced strike rate due to the increase in leaf abscission.

### **Treatments**

It is unnecessary to treat cuttings with fungicide prior to setting. However, it may be necessary to disinfect the poly-propagator with conventional fungicide as a precautionary measure. Cuttings may be treated with rooting hormone. The need for auxin treatment on cuttings is not critical, but

it enhances the number of roots formed. To treat, dip the base of the cutting in the rooting powder and tap gently to remove excess powder before placing the cutting inside the poly-propagator. An auxin concentration of 0.8% IBA gives the best results.

### Growing area

The poly-propagator is made of clear plastic sheeting and wood. The base is filled with layers of sand, stones, and pebbles that are saturated with water. A layer of rooting medium such as sterilized coir 10–15 cm [4–6 in] deep is placed on top of these layers. Coir provides a good rooting medium for the cuttings because it is easy to work with during transplanting. Well drained garden soil, which may be sterilized as a precaution against soil-borne diseases, also makes a good rooting medium. Water is supplied through a pipe and retained within the underlying layers. 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 closing the lid. The water level is checked regularly through an observation pipe inserted in the medium and refilled if low. The poly-propagator should be placed under shade, protected from wind, and treated with fungicide every 1–2 months.

### Time for rooting

Rooting occurs 14 days from the time cuttings are set. Preferably the cuttings are left in the propagator for 3 weeks, by which time most cuttings will have produced root systems that are strong enough for transplanting. Dead leaves and cuttings should be removed immediately from the propagator, as they are a source of fungal infection. A strike rate of 95–100% was obtained in Kolombangara, Solomon Islands.

### Media

Rooted cuttings can be transplanted into 1–2 l (1–2 qt) polyethylene nursery bags or other similar containers filled with a potting medium that is well drained, has good water retention capacity, and is light in weight for ease of transport. Coir has proven to be excellent for this purpose, although freely drained garden soil (clay loam



**Top down: Multiplication garden of stock plants of selected trees at Ringgi, Kolombangara, Solomon Islands. Poly-propagator system, Ringgi nursery, Kolombangara, Solomon Islands. PHOTOS: R. PAUKU**



Six month old clone propagated from cutting, Ringgi nursery, Kolombangara, the Solomon Islands. PHOTO: R. PAUKU

or sandy loam), which may be sterilized, is also good. Coir must be heated to 100°C (212°F) for 30–45 minutes to prevent potential occurrence of fungal infection, and left overnight to cool down before use. This may be done using a 200 l (55 gal) barrel cut in half lengthwise and placed over a wood fire. During heating, the coir must be turned over thoroughly four or five times to ensure thorough heating throughout.

### Hardening

Potted cuttings are weaned progressively from shade to full-sun over a period of 2–3 months. A shade level 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 usually have attained 30–50 cm (12–20 in) in height and are fit for field planting. Such plants have stem diameters of 4–5 mm (0.16–0.2 in) and more than five well formed leaves.

### Other comments on vegetative reproduction

Propagules can also be obtained from 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, Solomon Islands, air-layers made on branches with a stem diameter of 5–14 mm (0.2–0.6 in) attained a 86% strike rate in 2–3 months. Coir or freely drained soil can be used as growth medium in the air-layering process.

### Guidelines for outplanting

There is little if any research or experience on growing Tahitian chestnut 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

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

The lack of appropriate postharvest extraction, drying, and storage of kernels at the village level may be a production constraint. Centralized extraction units may be impractical due to unreliable transportation. Deterioration of kernel quality before reaching market is of major concern. Lack of awareness of the potential economic benefits of the species may be limiting the cultivation of Tahitian chestnut.

### Potential for invasiveness

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

### Diseases and pests

Very moderate infestation of leaf miners was found on seedlings at Ringgi nursery on Kolombangara Island, Solomon Islands. No major pests or diseases are known that attack mature foliage, although developing flowers and fruits are susceptible to fruit flies. The fruit flies lay eggs on the skin of immature fruits. As the eggs hatch the larvae burrow into the fleshy mesocarp and feed on the kernel, which deteriorates the eating quality. Severe fruit fly infestation may result in 100% loss of the edible kernel. Some types are more resistant to fruit fly infestation than others.



**Top: Four-week-old air-layer on tree. Bottom: Rooted end after removal from the tree. Tututi, Kolombangara, the Solomon Islands.** PHOTO: R. PAUKU

### Host to crop pests/pathogens

No cases have been reported in the literature. However, fruit flies as well as cockatoos and flying foxes that feed on the mesocarp of fruits could potentially be drawn to other tree and field crops that are interplanted with Tahitian chestnut.

### Other disadvantages or design considerations

Flatulence caused by eating the cooked kernels has a very offensive odor.

## AGROFORESTRY/ENVIRONMENTAL PRACTICES

Tahitian chestnut is important in traditional agroforestry in Melanesia, Micronesia, and Polynesia. The tree grows well among other trees such as canarium nut (*Canarium* spp.), cutnut (*Barringtonia* spp.), oceanic lychee (*Pometia*

*pinnata*), sea almond (*Terminalia catappa*), *Burckella obovata*, Malay apple (*Syzygium malaccense*), and other multi-purpose trees that are either planted or protected in land boundaries, secondary forests, homegardens, and within the surroundings of human settlements. Although yet to be confirmed, it is probably a nitrogen-fixing tree that makes atmospheric nitrogen available within agroecosystems. Tahitian chestnut provides good shade and shelter.

### Mulch/organic matter

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

### Soil stabilization

The tree is rated high (by more than 60% of farmers interviewed in Kolombangara, Solomon Islands) for soil stabilization due to a good network of lateral roots including three or four structured buttresses at the base of the trunk. In Pohnpei, it was found that Tahitian chestnut stabilizes soils along the riverbanks and prevents rapid erosion (Kostka, pers. comm., 2004).

### Crop shade/overstory

With appropriate spacing, the tree can provide medium shade that may be suitable for understory crops such as cocoa (*Theobroma cacao*), *Gnetum gnemon*, and betel nut (*Areca catechu*). It is also a good support tree for betel vine (*Piper betle*). Tahitian chestnut was reported in Pohnpei to provide suitable shade for the shade-loving giant taro (*Alocasia macrorrhiza*) (Kostka, pers. comm., 2004).

### Homegardens

The tree is a good candidate species for inclusion in homegardens, particularly as a boundary line species for shade, windbreak, and a companion crop.

### Improved fallows

Unlikely to be of importance for short-duration, high-density fallows.

### Living fences

Highly suitable, especially for a rural pig fence at early stages of growth. The buttresses can be chipped off to accommodate the fencing.

### Fence posts

Rated moderately suitable for fence posts because it is fairly durable as poles (10–15 cm [4–6 in] diameter). As sawn timber it may be more susceptible to termites.

### Boundary markers

It makes a good boundary marker, although was less common traditionally than cutnut and canarium nut.

### Windbreaks

The tree is a good medium-height tree for windbreaks because it tolerates strong winds and resists breakage.

### Silvopasture

It ameliorates soils and recycles nutrients within silvopastoral systems and is probably a nitrogen-fixing species that can benefit grass pastures. A low planting density (10–15 trees/ha, 4–6 trees/ac) is recommended to avoid too much shading of pasture grass.

### Woodlot

It is adaptable for mixed or single-stand species woodlots for the provision of edible nuts, medicinal products, and wood for handicrafts.

### Native animal/bird food

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

### Wildlife habitat

The tree provides a good wildlife habitat for some nesting bird species. It also provides habitat for red ants (*Oecophylla smaragdina*) that are a biological control of *Amplypelta cocophaga* (Hemiptera), a major pest of cocoa in the Solomon Islands.



Young tree growing in homegarden, Tongatapu, Tonga. PHOTO: C. ELEVITCH

### Host plant trellising

It is a good trellis tree for betel vine and other lianas.

### Bee forage

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

### Fish/marine food chain

The fallen kernels and mesocarps are food to some freshwater fish and prawns and potentially can be useful in fish farming.

### Coastal protection

It was found in Choiseul, Solomon Islands, to provide very good coastal protection, especially for slowing down the shoreline erosion created by rise in tides. This has been observed, for example, along beaches and shorelines in Choiseul and the Kolombangara Islands.

### Ornamental

Tahitian chestnut is an attractive evergreen tree with potential for use in urban centers for beautification while also providing shade and shelter. It is planted and protected in rural villages for such functions as well.

### Other

Traditionally there are many ways of climbing huge trees with lengthy clear boles to harvest their fruits, nuts, or leaves. One method is to use neighboring trees that are easier to climb. As climbers reach the top of the companion tree, they can easily reach a branch of the taller tree or make a transfer by rope. Tahitian chestnut is a good medium-story companion tree that can provide access to the top of taller clear-bole species such as canarium nut (*Canarium* spp.), breadfruit (*Artocarpus altilis*), and sago palm (*Metroxylon salomonense*).

## USES AND PRODUCTS

Almost every part of the plant has been used traditionally. Leaves and bark are mainly used for medicinal purposes, while fallen branches are used for firewood. Even green wood is burned to dry copra. The wood is also used for crafts, tool handles, canoes, and light construction.

### Fruit

The fleshy mesocarp is inedible for humans.

### **Nut/seed**

The edible kernel is an important indigenous food in many island countries in the Pacific. It is available in Vanuatu between the two yam seasons. The kernel is an important traditional supplemental staple in Fiji, although today its importance has declined in favor of cassava and imported rice.

The kernel must be cooked to make it edible. The nutritious kernels have protein and carbohydrate contents of about 5% and 22% respectively. It is prepared in many different ways, including roasting, grilling, boiling, baking, and mashed in pudding in PNG, Fiji, the Solomon Islands, Vanuatu, and Polynesia. Well known dishes include lap lap (Vanuatu), koko (Fiji), and masimasi or robe (the western Solomon Islands). Fruits are harvested either directly from the tree at maturity or from the ground after ripening. The kernels have been sold mainly in domestic markets.

### **Medicinal**

The bark was grated and mixed with coconut milk or bark sap to treat urinary infections in the Solomon Islands. The juice from the mesocarp of green fruits was used in Tonga to treat insect bites and burns. In Fiji, all parts of the tree (roots, stem, bark, and leaves) were thought to have various medicinal properties.

### **Animal fodder**

The kernel is a good feed for free-range chickens.

### **Beautiful/fragrant flowers**

The flower buds can be used in short-term decorations.

### **Timber**

The wood is of moderate quality and reported to be used for flooring in Temotu, Solomon Islands. Treating the wood with appropriate preservatives may provide protection against wood borers and increase its suitability for light construction purposes.

### **Fuelwood**

Fallen branches and felled trees are good firewood when dried. Green wood also burns well and is used in Choiseul, Solomon Islands, for firewood to dry copra.

### **Craft wood/tools**

The wood is used for carvings and tool handles in Fiji, the Solomon Islands, Vanuatu, and Tonga. The buttress is used in the Reef Islands (Solomon Islands) as a platform for dancing; when placed over a hole it provides a resounding tone.



**Cooked nuts on skewers for sale at Nuku'alofa market, Tongatapu, Tonga.** PHOTO: C. ELEVITCH

### **Canoe/boat/raft making**

The wood is used for making canoes in Rennell and Bellona, the Solomon Islands. In Wallis, the leaves were sewn together to make sails for boats.

### **Wrapping/parcelization**

The large leaves were traditionally used for wrapping and parceling throughout the Pacific islands. In Fiji, cooked kernels were wrapped with the leaves when sold in the market. In Tonga, the leaves were used for making belts.

### **Thatch/roofing/mats**

In Tonga, the leaves were once used to cover the ground beneath mats.

## **URBAN AND COMMUNITY FORESTRY**

Tahitian chestnut is rarely found in abundance in homegardens in the Solomon Islands. In Temotu province

## LORE

In Samoa, it was believed that the human race originated from Tahitian chestnut (Kramer 1906 cited in Walter and Sam 2002). In Vanuatu, there is a myth that a man was emasculated and became the first woman after having hot Tahitian chestnut leaves applied to his genitals (Walter and Sam 2002). A myth in Choiseul (Varisi), Solomon Islands, relates Tahitian chestnut to the death of a man named Porana, who betrayed the Chief of a particular tribe. The people ate large quantities of the cooked kernels and the ensuing flatulence suffocated Porana in a packed meeting room from which he could not escape.

of the Solomon Islands, this species has been grown with other species such as mango (*Mangifera indica*) and sea almond (*Terminalia catappa*) as boundary-line crops in the Improved Temotu Traditional Agriculture (ITTA). The tree's medium stature makes it suitable for providing shade for parks and streets.

### Size in an urban environment

It is a medium-size tree, typically growing to a mature height of 20 m (66 ft).

### Rate of growth in a landscape

Seedlings can potentially reach 1–2 m (3.3–6.6 ft) height within a year in optimal growing conditions.

### Root system

Roots of mature trees are unlikely to be invasive. However, it has a well developed lateral root system and, in old trees especially, the thin buttresses can extend for long distances. Surface roots are occasionally partly exposed as the soil erodes. Large lateral roots may interfere with other plantings within its surroundings.

### Products commonly used in a Pacific island household

The nuts are widely used for food in many Pacific island countries. Leaves, bark, and sap are important traditional medicines. The wood is used for making tool handles and canoes, and in a dry form as firewood. Green wood is also used for firewood, mainly for drying copra.

### Light requirements

It is mid-story tree tolerant of light to moderate shade. Heavy shading is detrimental to growth and yield. Its dense foliage prevents other species from growing directly under its canopy.

### Water/soil requirements

The tree is adapted to poorly drained soils and even permanently waterlogged locations, although it grows even in soils with low water retention capacity (e.g., sandy soils). Mature trees may withstand a prolonged dry spell but may never experience one in their native habitat.

### Life span

The life span is 80–90 years.

### Varieties favored for use in a homegardens

None.

### Maintenance requirements

Mulching may be necessary at the early seedling stage. In mature trees, it is not required. Tall and old trees may be pruned to rejuvenate the tree physiologically and encourage new vegetative growth, but fruit production is initially greatly decreased.



The tree is very suitable for urban areas where people make use of the fruit. Tongatapu, Tonga. PHOTO: C. ELEVITCH

## Hazards

Under normal circumstances there are no hazards from leaf, branch, or fruit drop. Trees that are considered to be too tall for a particular situation may be pollarded to reduce height and ensure safety around homes and in villages. The kernel is toxic raw and must be cooked to be edible. If not attentive, a person could slip and fall by stepping on a fruit.

## Common pest problems

No major pests and diseases affect young seedlings. However, fruits can be severely attacked by fruit flies, resulting in low kernel production per tree. Fruit fly traps containing a lure (pheromone) and impregnated with insecticide may be placed at random on trees 50–100 m (165–330 ft) apart. The technique is expensive but reasonably effective in the Solomon Islands against melon fly. Encouraging farmers to plant less susceptible varieties is recommended for locations suffering from fruit fly infestation.

## COMMERCIAL PRODUCTS

The kernel is the primary commercial product. In Fiji it is estimated that around 35 mt (38.5 t) are sold in domestic markets annually, fetching about US\$28,000 or US\$0.80/kg (US\$0.36/lb). In the Solomon Islands, kernels are sold fresh for US\$0.15 to US\$0.30 per kg (US\$0.07–0.14/lb) during peak seasons. The domestic market for the product of this species can be increased if processing technology to improve the shelf life of the kernel is developed. A market study in Fiji revealed export opportunities to Polynesian communities in Australia, New Zealand, and the U.S. However, while export markets may be an option, success cannot be fully realized without additional research in postharvest processing, storage, conservation, and tree improvement.

Farmers should plant new trees instead of relying solely on wild populations for increased food security and meeting market demand. Research into developing superior cultivars should be a priority to maximize benefits to farmers in terms of monetary return and sustainable supply of edible kernels for household consumption.

## Spacing

Suggested spacing is 5 x 5 m (16 x 16 ft) or 400 trees/ha (162 trees/ac). A 1-hectare block (2.5 ac) can potentially produce 4–30 mt (4.4–33 t) of fresh fruits per peak season. A plantation area of 100 ha (250 ac) from one farm or several combined could yield 400–3000 mt (440–3300 t) of fresh fruits per year. Based on a kernel to fruit ratio of 60%, such a

quantity would provide 240–1800 mt (264–1980 t) of fresh kernels per year and is likely to support an export market.

In agroforestry systems, 40 trees/ha (16 trees/ac) interplanted with other species is suggested. This is estimated to give about 0.4–3 mt (0.44–3.3 t) fresh fruits or 0.2–1.8 mt (0.22–2.0 t) fresh kernels per ha (2.5 ac).

## Management objectives

Pollarding stimulates vegetative growth of trees, but fruit set in reproductively mature trees will drop in the following year due to loss of the woody framework. No thinning is necessary if wide enough spacing is used, unless trees require replacement due to infertility. Weeding is crucial at an early age (first 2–3 years in the field). As the trees mature, weeding operations may be scaled down to once a year (mostly vine removal). The requirements for field fertilization 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

The tree has been grown under other overstory species, such as coconut (*Cocos nucifera*), canarium nut (*Canarium* spp.), breadfruit (*Artocarpus altilis*), narra (*Pterocarpus indicus*), sago palm (*Metroxylon salomonense*), and *Flueggea flexuosa*, and it provides a balanced ecosystem through soil amelioration and consolidation. It may also provide easy access for climbers to harvest difficult-to-climb species such as sago palm. Older trees are not always easy to climb, because they sometimes have fluted or clear boles up to half their height. When incorporating Tahitian chestnut into a polycultural system, careful consideration is needed to take into account potential interference from the lateral root system and shade.

## Yields

Based on limited data, the potential yield for trees in the Solomon Islands is 4–30 mt/ha (1.8–13.4 t/ac) fresh fruit annually at a density of 400 stems/ha (162 stems/ac). Annual yields are estimated to increase with age. For example, a 5–10-year-old tree is estimated to produce 10 kg (2.2 lb) fresh fruits per tree, increasing to 75 kg (165 lb) fruits per tree older than 25 years. Usually, fruiting begins after 5 years, but some plants bear fruits on the third year from planting. Thus, yield estimates for 5–10-year-old trees at a spacing of 400 stems/ha (162 stems/ac) is 4 mt (4.4 t) of fresh fruits. With that planting density, the yield is estimated to increase up to eight-fold by the time the trees reach 25 years

old. Because fresh kernel is about 60% of fruit weight, the potential annual kernel production is 5 mt (5.5 t) in a 1-ha (2.5 ac) block of 5–10-year-old trees.

### Processing required

The common method for extracting kernels is to cut through the fruit with a sharp knife. The use of mechanical methods is possible but cannot be done 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 on-farm in order to fetch a higher market price, but this requires appropriate storage facilities located in rural villages.

### On-farm processing methods

In Vanuatu, fruits are dried on bamboo racks in darkness and stored for several months. These fruits are turned regularly, and as they become dry the kernels are removed. Also in Vanuatu, the fruits may be buried or stored between layers of grass. In Fiji, the Solomon Islands, and Polynesia, fruits are smoked and roasted for longer storage. Extracted kernels that have been boiled or roasted do not store longer than a few days. Limited shelf life of the product necessitates the establishment of central processing and storage units within a rural setting accessible to farmers. This requires personnel training and enforcement of quality standards to meet export market requirements.

### Market

Ideally, plantings should be connected by feeder roads and accessible to reliable transportation links to major markets within the area. Strengthening domestic markets for Tahitian chestnut products is more logical and feasible than vigorously pursuing export markets. On the other hand, more market research is required in order to develop niche international markets for the long term. Potential export markets to Polynesian communities in New Zealand, Australia, and the U.S. could be a market opportunity. Greater attention needs to be drawn to the rapid deterioration of the kernel and how it can be preserved to meet export market qualities and standards. Other issues of concern are consistency and continuity of supply, high-quality end-products, and packaging. There may be opportunities in the future for organic certification to diversify export markets.

## INTERPLANTING/FARM APPLICATIONS

In general, Tahitian chestnut is not extensively cultivated in

the Pacific, although it is commonly found in homegardens and within coconut plantations on many Pacific islands. The species has a well formed lateral root system that could cause some impediments during soil preparation for understory crops, e.g., during plowing or mounding.

### Example system

#### Location

Temotu, Solomon Islands.

#### Description

The Improved Temotu Traditional Agriculture (ITTA) system was developed in the 1980s. The system uses 23 different crop species within a 0.5 ha (1.25 ac) block at appropriate spacing. The placement of crops at different positions within the planting block is crucial due to the inevitable competition between species for water, light, and nutrients. For example, boundary-line tree crops such as Tahitian chestnut and sea almond (*Terminalia catappa*) over 25 years old yielded 75 kg and 60 kg (165 lb and 132 lb) fresh fruit per tree, respectively. In the space between the planting rows and the boundary line, tree crops such as *Barringtonia* spp. and *Gnetum gnemon* of about the same age yielded 13 kg and 25 kg (29 lb and 55 lb) of fresh fruits per tree, respectively. Yield also varies for different root crop species interplanted in the system. Yam (*Dioscorea* spp.) production, for example, is 37 mt/ha (16.5 t/ac) compared to 12.3 mt/ha (5.5 t/ac) of giant taro (*Alocasia macrorrhiza*).

#### Crop/tree interactions

Crop-to-crop interaction exists between the species in terms 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 correct spacing and species choice.

#### Spacing

Spacing of 10 x 10 m (33 x 33 ft) or 100 trees/ha (40 trees/ac) between trees has been suggested. The spacing varies with species and the appropriate placement of different crops within different planting rows. For example, companion crops are usually planted at least 1 m (3.3 ft) from the main tree.

## GENETIC RESOURCES

A few clones have been developed at Ringgi, Kolombangara Island, in the Solomon Islands, by the author.

## PUBLIC ASSISTANCE AND AGROFORESTRY EXTENSION

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

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Traditional Tree Initiative—Species Profiles for Pacific Island Agroforestry ([www.traditionaltree.org](http://www.traditionaltree.org))

## *Inocarpus fagifer* (Tahitian chestnut)

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