



## *Fagraea berteriana* (pua kenikeni)

Gentianaceae (gentian family)

*ksid* (Palau); *mbua*, *mbua ndina*, *mbua ni Viti*, *mbua ni veikua*, *kandisa* (Fiji); *peengas*, *seewur peengas* (Chuuk); *pua* (Tonga, Horne Islands, Uvea, Niue, Cooks, Societies, Australs, Rapa, Marquesas); *pua Tonga* (Tonga); *pua kenikeni* (Hawai'i); *pualulu* (Samoa); *pʻwur*, *seir pʻwur* (Pohnpei)

W. Arthur Whistler and Craig R. Elevitch

### IN BRIEF

**Distribution** Found on most of the high islands of the Pacific.

**Size** Typically a small shrub or tree to about 5 m (16 ft) but can reach 15 m (50 ft).

**Habitat** Wide range of cultivated environments, such as lava flows and cloud forests; humid and subhumid tropics and subtropics.

**Vegetation** Associated with many plants found in cultivation.

**Soils** Wide variety of soils, such as calcareous, fresh lava, weathered clay, and as an epiphyte without soil.

**Growth rate** Slow, 0.3–0.5 m/yr (12–20 in).

**Main agroforestry uses** Homegardens, wild-life habitat, ornamental.

**Main products** Flowers, wood.

**Yields** No data available.

**Intercropping** Grows well in mixed gardens.

**Invasive potential** Not considered invasive.



PHOTO: C. ELEVITCH

This specimen tree is about 4 m (13 ft) tall and has a typical shrubby form with many stems.

## INTRODUCTION

*Pua kenikeni* is indigenous from Northern Australia and the Caroline Islands eastward to the Marquesas and is found on most of the high islands of this region. It is occasionally to commonly found in lowland to montane forests, particularly on lowland lava flows (as in Samoa), on narrow ridges (as on Rarotonga), and in montane and cloud forests (where it is often an epiphyte or strangler). *Pua kenikeni* ranges from near sea level to 1060 m (3500 ft) or higher elevations. In some places it is found mostly in cultivation, such as in Tonga, where it is probably native, and Hawai'i, where it is a modern introduction. It is grown commercially in nurseries in Hawai'i as a popular ornamental. Where it is native, it is spread by birds (typically starlings) and bats, which ingest the orange pulp that contains the tiny black seeds. It apparently does not become naturalized in places where it is introduced, and it is not considered to be invasive.

The tree is often more of a shrub, but it can reach 15 m (50 ft) in height. It is esteemed mostly for its fragrant, white flowers, as a garden ornamental, and for its timber. The long-tubed blossoms are widely worn, singly over the ear or strung into fragrant leis. They are also highly favored for making scented coconut oil. The durable, light brown, fine-grained wood is of good quality and can be smoothed into a high polish. The wood was much valued for making tool handles, tools, house posts, furniture, drums, and in modern times, handicrafts. Its relatively small size does not give it much potential for timber. Today it is mainly cultivated as a garden ornamental and for its fragrant flowers used in personal adornment.

## DISTRIBUTION

Indigenous from New Guinea and northern Australia north to the Marianas, eastward to the Marquesas, it is found on most of the high islands of this area. It is occasional to common in lowland to montane forests, particularly on lowland lava flows (as in Samoa) and on narrow ridges (as on Rarotonga). *Pua kenikeni* is cultivated in Hawai'i, but not naturalized.

## BOTANICAL DESCRIPTION

### Preferred scientific name

*Fagraea berteriana* A. Gray ex Benth.

### Family

Gentianaceae (formerly Loganiaceae), (gentian family)

### Subfamily

Potalieae (tribe)

### Non-preferred scientific names

*Fagraea berteriana* (a common misspelling)

*Fragraea berteriana* (a common misspelling)

*Fagraea galilae*

*Fagraea grandis*

*Fagraea kusaiana*

*Fagraea sair*

*Fagraea samoensis*

*Fagraea vitiensis*

### Common names

*ksid* (Palau)

*mbua*, *mbua ndina*, *mbua ni Viti*, *mbua ni veikua*, *kandisa* (Fiji)

*peengas*, *seewur peengas* (Chuuk)

*pua* (Tonga, Horn Islands, 'Uvea, Niue, Cooks, Tahiti, Australs, Rapa, Marquesas)

*pua Tonga* (Tonga)

*pua kenikeni* (Hawai'i)

*pualulu* (Samoa)

*pwur*, *seir pwur* (Pohnpei)

### Size

Up to 15 m (50 ft) in height, but often much shorter, especially when growing in the open and as a strangler; trunk often many-branched at the base, with a spreading crown.

### Flowers

Inflorescence a terminal, many-flowered (mostly 9–25 flowers) cyme usually branched at the base, on a rachis up to 11 cm (4.2 inches) long, with small, paired ovate bracts at the nodes; calyx urn-shaped, 9–16 mm (0.4–0.6 inches) long, divided about one third of its length into 5 ovate sepals, on a pedicel up to 1 cm long; corolla trumpet-shaped, white aging to yellow or pale orange, tube 4–11 cm (1.6–4.4 inches) long, limb divided into 5 oblong, contorted lobes 1.7–3.6 cm (0.7–1.4 inches) long; ovary superior, style as long as the tube, with a bifid stigma; stamens 5, epipetalous, with long anthers included at the top of the throat; flowering may occur anytime during the year, and sometimes continuously.

### Leaves

Simple, opposite, blade fleshy, mostly elliptic to obovate, 8–22 cm (3.3–8.7 inches) long, acute to cuneate at the base, shortly acuminate at the tip; surfaces glabrous, veins indistinct, upper side darker; margins entire; petiole 1.5–5 cm (0.6–2 inches) long; stipules forming a fleshy, notched structure (ocrea) in the leaf axil.



**Fruit and flowers.** PHOTO: W. A. WHISTLER

### Fruit

Orange, ellipsoid berry 3.5–5 cm (1.4–2 inches) long borne on a thickened stalk. The fruits may be collected throughout the year, and the seeds are mature when the fruit turns orange.

### Seeds

Many, tiny, black, irregularly angled, dispersed when the orange pulp in which they are imbedded is eaten by birds.

### Rooting habit

No data available.

### Similar species

It is a rather distinct tree. Similar to *Fagraea ksid* of Palau, which, however, may not be a separate species.

### How to distinguish from similar species/look-alikes

Distinguishable by its medium-sized tree habit, trunk often branching at the base or starting as an epiphyte, op-

posite leaves with a notched structure in the axil (the angle between the leaf and the stem), long, showy white, trumpet-shaped flowers that age to pale orange or yellow, and a large, orange, many-seeded berry.

## GENETICS

### Variability of species

Pua kenikeni is variable from island to island, mostly in the length of the flower “throat.”

### Known varieties

The Micronesian population of the species was divided into several varieties by Fosberg et al. (1979): var. *galilai* (Palau), var. *kusiana* (Kosrae), var. *ladronica* (Guam and the Northern Marianas), var. *pogas* (Chuuk), and var. *sair* (Pohnpei and Kosrae), but these are of questionable value, because this kind of separation, based mostly on minor and variable characteristics, has not been done elsewhere over the range of the species.



**Large-flowered specimen, Ho‘omaluhia Gardens, O‘ahu, Hawai‘i.** PHOTO: C. ELEVITCH

## ASSOCIATED PLANT SPECIES

It is associated with numerous species since it has such a wide ecological range. It dominates lowland lava flows on Savai‘i, where only a few other species occur, such as *Glochidion ramiflorum*, *Rhus taitensis*, and *Wikstroemia foetida*.

### Species commonly associated in modern times

The plant is found in a wide range of cultivated environments, such as lava flows and cloud forests in Samoa, and

ridge forests on Rarotonga. It is commonly cultivated in villages and around in houses in Tonga and especially Hawai'i.

## ENVIRONMENTAL PREFERENCES AND TOLERANCES

### Climate

It grows in the humid and subhumid tropics and subtropics. It would not do well in dry places or in cooler latitudes.

### Elevation range

Lower: near sea level.  
Upper: 1060 m (3475 ft).

### Mean annual rainfall

Lower: 1500 mm (60 in) or less, but can be grown in drier areas with irrigation.  
Upper: 6200 mm (244 in) or more.

### Rainfall pattern

It prefers summer or uniform rainfall patterns.

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

May survive 2–4 months of drought.

### Mean annual temperature

15–31°C (60–90°F)

### Minimum temperature tolerated

It is intolerant of frost.

### Soils

It grows on a wide variety of soils, from calcareous to lava (as on Savai'i, Samoa), weathered clay (as on Rarotonga), and even as an epiphyte without soil.

### Soil texture

It tolerates medium to heavy texture soils (loams, sandy clay loams, clays, clay loams, and sandy clays).

### Soil drainage

The tree grows in soils with free drainage.

### Soil acidity

pH 5.5–6.5

### Special soil tolerances

Can grow in shallow and infertile soils and on lava flows.

## Tolerances

The plant is adapted to sunny places with sufficient rainfall, and too much shade or too little water will deter its growth.

### Drought

Seems to tolerate drought well. Too little water deters growth. However, water stress stimulates flowering.

### Full sun

It prefers, and flowers best in, full sun.

### Shade

It tolerates partial shade, although it will not grow as well as in full sun.

### Frost

The plant does not tolerate frost.

### Waterlogging

Probably does not tolerate waterlogging very well, because it is adapted to dry places such as lowland lava flows and epiphytic situations

### Salt spray

It is moderately tolerant of salt spray.

### Wind

Pua kenikeni is moderately tolerant of wind, although it can suffer leaf and flower damage.

## Abilities

### Coppice

Regrows well from pruning, which is a common method of keeping the tree low enough to pick the flowers.

## GROWTH AND DEVELOPMENT

The plant is slow to start from seed, often taking several years to reach a height of 1 m (3.3 ft). Plants started from air-layers or cuttings are relatively fast growing.

### Growth rate

It is common that a 0.5 m (1.5 ft) rooted cutting reaches 2 m (6.6 ft) in 3–5 years in optimal conditions.

### Flowering and fruiting

Both occur throughout the year, but often with peaks (e.g., flowering in Samoa is reported to peak in May to Septem-

ber). Flowering for a vegetatively propagated plant usually begins within months of outplanting.

## Yields

The tree is fairly easy to grow and produces many flowers, but flowering is sometimes sporadic.

## PROPAGATION

The plant readily reproduces by seed, but seedlings usually take 5–7 years or longer to begin flowering. Air-layering is a common propagation method that yields plants capable of flowering within 9 months under optimum conditions. Cuttings are used commercially. Probably the best sources of seed for propagation are trees growing in a habitat that matches where they will be cultivated. Seedlings found in the forest in its native range are sometimes transplanted, typically into the trunk of a tree fern (*Cyathea* spp.).

### Air-layering

Air-layering is best carried out on young branches 1–2 years old. Branches 1–2 cm (0.4–0.8 in) in diameter and 30–45 cm (12–18 in) long are ideal. Pick branches that are easy to access, and preferably with stems that are shaded by other branches. Air-layering works well any time of year, but the mother plant should be in good health and have adequate water and nutrition available.

### Preparation

With a sharp knife, remove a ring of outer bark about 2–4 cm (0.8–1.6 in). This step is called girdling or wounding. Position this bark removal with at least 15 cm (6 in) below it to where it attaches to the main stem.

### Treatments

A hormone treatment of the bark immediately above the wound can accelerate root formation. The rooting hormone IBA (indole butyric acid) is commonly used at 5000–10,000 ppm. Apply the rooting hormone to 2.5 cm (1 in) of the bark. It doesn't matter if some rooting hormone drips below this.

### Rooting media

Once the girdle is made, the area is packed with a moist rooting medium and then wrapped with an impermeable moisture barrier. Many types of rooting media work well, including sphagnum moss, coir fiber, and wood shavings. The rooting medium should be light and hold together when placed in position. Use enough medium to allow for growth of sufficient amount of roots to sustain the new plant after separating the branch from the mother plant.

Too much medium will make the wrapping ungainly. Usually one or two handfuls are enough. Moisten the rooting medium with water and squeeze it until no more water drips out. Place the rooting medium around the girdle and wrap it with clear polyethylene plastic (the same as in typical sandwich bags). Using a clear wrapper allows easy inspection of root growth. The wrapping should be taped snugly around the branch, sealing in the moisture and sealing out rainwater. Nursery grafting tape, twist ties, or vinyl flagging can be used. Be sure to tape well around the top edge of the plastic so that rainwater does not get funneled down the branch and inside the plastic.

If the rooting medium is not fully shaded by leaves and thus gets exposure to sun, an outer wrapping with aluminum foil can help reduce overheating.

### Separation from mother plant

Begin inspecting the rooting medium 6–8 weeks after starting the air-layer. When a sufficient amount of roots to sustain the plant can be seen in the rooting medium, the air-layer is ready for separation. Remove the propagule by cutting the branch below the plastic wrap (on the side of the plastic closest to the main stem of the tree). The new roots are very fragile, and the severed branch should be transported very carefully to the potting area. Remove the wrapping around the rooting medium very carefully with minimal disturbance, and plant the air-layer in a pot large enough to establish it. A 4- or 8-liter (1- or 2-gal) container should work fine. The plant is then placed in semi-shade (approximately 50%) to acclimatize it during its beginning growth. After 2–3 months, the plant can be moved to a sunnier area, where it can become established in its container for about 6 months before being outplanted.

### Size at outplanting

The size at outplanting depends upon the size of the original air-layer. A common size is 45 cm (18 in) tall and about 1–2 cm (0.4–0.8 in) diameter at the base.

### Other comments on propagation

With good technique, a success rate of 80% or higher is possible. By first establishing air-layers in a container for up to a year, then transplanting into the field, survival is expected to be 100%. Pua kenikeni will grow as a container plant, with a minimum container size of 5 gallons or more recommended.

## DISADVANTAGES

### Potential for invasiveness

The plant seems to not be invasive. It has long been cultivated in Hawai'i but has not been reported to be naturalized there. It is unlikely to be an invasive pest outside its native range.

### Susceptibility to pests/pathogens

Common diseases reported are leaf spots, fungal root rots, and root-knot nematode. Mealybugs, scales and thrips are also common pests.

### Other disadvantages in agroforestry

For flower production, it is best to prune the trees to stimulate new growth for flowering and to keep the tree low enough for easy harvest. Since pua kenikeni requires full sun, other species planted together with it are limited to those that will not grow taller than the ideal height for picking the flowers.

## AGROFORESTRY/ENVIRONMENTAL PRACTICES

### Homegardens

It is planted in some places, such as Hawai'i and Tonga, as a garden ornamental.

### Native animal/bird food

The fruits are commonly eaten by birds and fruit bats over its native range.

### Wildlife habitat

It is an important component of some forests, particularly ridge forests (as on Rarotonga) and lava flows (Samoa).

### Ornamental

It is a highly desirable ornamental because of its showy, fragrant flowers.

## USES AND PRODUCTS

The tree is esteemed mostly for its showy flowers and its timber. The flowers are worn singly over the ear or strung



Here grown at a cemetery entrance on Tongatapu together with noni (*Morinda citrifolia*), screwpine (*Pandanus* sp.), and in the background, beach she-oak (*Casuarina* sp.). PHOTO: C. ELEVITCH

## LORE

In Mangaian legend “the pua tree was the tree that guarded the entrance to the land of the spirits in the underworld.” In Tahitian legend, “the first pua tree was brought from the tenth heaven by Tane, god of the forests. Hence the tree is sacred to him, and images of him were always made of pua wood.” (Neal 1965)

into fragrant leis throughout Polynesia, Melanesia, and Micronesia and are also favored for making scented coconut oil. Leis of the flowers are sold commercially in Hawai‘i, Tonga, and elsewhere. Young plants are sold as an ornamental plant in Hawai‘i. Pua kenikeni has a durable, light brown, fine-grained but usually twisted timber that can be worked to a high polish. It was much valued for making tool handles, tools (such as one used for splitting breadfruit in Samoa), house posts (in Samoa and Fiji), and in modern times, handicrafts, but it probably has little potential value as a timber tree that could be grown on plantations. It was esteemed for making furniture, drums, and canoe parts in Tahiti. The flower is so esteemed in the Marquesas that it may well be called the “national flower” of those islands.

### Medicinal

The inner bark is used to treat asthma and diabetes in Fiji (Smith 1998). An infusion of the bark is used to treat internal injuries in Tonga, usually in a potion comprising several species. The boiled leaves are reportedly used in New Caledonia for treating rashes and skin irritations.

### Beautiful/fragrant flowers

The flowers are used to make leis, and single flowers are worn over the ear. The flowers are soaked in coconut oil to make scented oil. The tree makes an excellent fragrance tree.

### Timber

The good quality wood is used for house posts.

### Fuelwood

It can be used for firewood, especially where common.

### Craft wood/tools

Used for tool handles, drums, handicrafts, and furniture.

### Body ornamentation/garlands

It is very popular for making leis throughout its range, because of its attractive and fragrant flowers.

### Ceremonial/religious importance

The tree was considered to be sacred in the Cook Islands, where its branches were regarded as paths for spirits of the dead descending to the underworld. In Tahiti, it was sacred to the god Tane, whose images were always made with its wood.

## URBAN AND COMMUNITY FORESTRY

Pua kenikeni’s relatively compact size makes it ideal for use in both public and private urban areas. The tree is well known throughout the Pacific islands for its fragrant flowers that are used for leis, decoration, and to scent oil.

### Size in an urban environment

Although the tree can grow up to 15 m (50 ft) in height, it typically reaches only half that height in landscape environments. When grown in the open, it usually has several co-dominant stems and a spreading canopy.

### Rate of growth in a landscape

Growth is slow to moderate, up to about 0.5 m (1.5 ft) per year under optimal conditions.

### Root system

It is unlikely that the root system is invasive or interferes with normal landscape operations.

### Products commonly used in a Pacific island household

Use of the fragrant flowers in leis and other decoration is the most widespread use in Pacific islands. The wood is used for crafts and general construction. Parts have medicinal uses. In the Solomon Islands, the skin of the fruit is removed exposing the sticky interior and serving as a fly trap.

### Light requirements

Pua kenikeni grows and produces flowers best in full sun. It will grow in partial shade (sometimes even as an epiphyte within the canopy of another plant), although not as vigorously as in full sun.

### Water/soil requirements

The tree requires at least 1500 mm (60 in) in annual rainfall to grow well but will thrive in drier environments when provided with irrigation water to keep the soil moist. It



The tree does well in open areas on farms and in homegardens. Here it grows together with coffee, bananas, coconuts, and many other species in North Kona, Hawai'i. PHOTO: C. ELEVITCH

requires free soil drainage. Withholding irrigation water during periods of low rainfall stimulates flowering.

### **Life span**

There is no data available; however, it is estimated to be many decades.

### **Varieties favored for use in homegardens or public areas**

Local varieties have been described for Micronesia. Plants that perform well locally can be propagated by air-layering or cuttings to preserve desirable qualities.

### **Seasonality of leaf flush, flowering, fruiting**

New vegetative growth and flowering take place year-round. Peaks in flowering occur at different times depending on the region (see "Flowering and fruiting" above).

### **Exceptional ornamental values**

The nearly constant profusion of fragrant flowers is the hallmark of this tree.

### **Use as living fence, hedge, or visual/noise barrier**

It is usually not used for these purposes. However, it is possible that if planted about 2 m (6.6 ft) apart, pua kenikeni trees could form a hedge. In this case, the trees could be pruned to size to encourage vegetative growth on lower branches.

### **Birds/wildlife**

The fruits are eaten by birds and bats.

### **Maintenance requirements**

In urban environments, regular pruning can be used to control the size of the tree, which also stimulates new growth, encourages flowering (which occurs on new growth), and keeps the flowers within picking height. Limited fertilizer use helps encourage new growth without suppressing flowering.

### **Special considerations regarding leaf, branch, and fruit drop**

Pua kenikeni is moderately tolerant of wind. Usually the tree is kept short by pruning for flower production, which



limits any damage from broken branches during high winds. Specimen trees that grow tall are more susceptible to wind damage.

### Nuisance issues or hazards

None known.

### Common pest problems

Several common landscape pests affect the tree (see “Susceptibility to pests/pathogens” above). Normally none of these are significant enough to require treatment.

## COMMERCIAL PRODUCTS

The tree is well known as a minor ornamental and lei flower tree. Therein lies its two biggest commercial products: lei flowers and ornamental nursery plants. The flowers were once sold in Hawai‘i for making leis. Each flower cost a dime, hence the Hawaiian name *pua kenikeni*, literally, “dime flower.” Coconut oil scented with the flowers is made on locally on some Polynesian islands. Pua kenikeni has a modest commercial potential as an attractive ornamental plant and one planted for its flowers used in leis.



The creamy white, very fragrant flowers make wonderful lei flowers. PHOTO: C. ELEVITCH

### Spacing for commercial production

The typical spread of a mature pua kenikeni is 4.6 m (15 ft). For flower production in monocultures, spacing of 4.6 x 4.6 m (15 x 15 ft) is recommended. In mixed plantings, spacing can be highly variable depending on the type of intercrops included.

### Management objectives

Flowers are produced on new growth, so pruning is the best

way to maintain flowering. Fertilizer use should be moderate, as overfertilizing will stimulate leaf growth rather than reproductive growth. Periodic water stress tends to increase flower production.

### Harvest

Flowers are best harvested 2–3 times per week in the early morning. They are harvested by breaking the stem below the flower, leaving the green leafy base attached. Open white flowers can be stored at room temperature for up to 3 days, while flowers that have turned yellow or orange store for lesser periods of time.

### Advantages and disadvantages of growing in polycultures

The plant grows very well in a mixed homegarden, but requires full sun in order to flower well.

### Estimated yields, including monocultures to mixed agroforestry systems

No data available.

### On-farm processing methods required to access market

Do not rinse the flowers in water. To remove thrips from flowers, wrap them in moist newspaper inside a sealed plastic container, and submerge in ice-cold water.

### On-farm processing methods

Pua kenikeni flowers cannot be preserved by drying and must be used fresh in leis.

### Markets

It has some value in the tourist market; tourists may buy leis of these flowers or coconut oil scented with their fragrance. Leis of the flowers were or are sold in Hawai‘i and Tonga and probably elsewhere.

## INTERPLANTING/FARM APPLICATIONS

Some interplanting systems include:

### Example 1

#### Location

Kona, Hawai‘i

#### Description

On a small family farm where the main crop is coffee, many

plants are grown among the coffee for family use, including several pua kenikeni, bananas, kava, mountain apple, and citrus. Pua kenikeni is grown next to other short plants, such as coffee and dwarf bananas, which ensures full sun most of the day.

### Spacing

Four pua kenikeni trees are growing with 2–3 m (6–10 ft) spacing.

### Example 2 (Johansen 2004)

#### Location

South Kona, Hawai'i, at 1550 m (1800 ft) elevation

#### Description

Six 1-year-old seedlings were planted into an established ti (*Cordyline fruticosa*) grove. Minimum care was given during the first 3 years of growth, with three trees thriving, two surviving, and one dying, and none flowering.

#### Crop/tree interactions

Ti seems to be a good nurse crop in drought-prone areas. They keep the ground cool and funnel rain down their trunks to the ground.

### Spacing

Six trees were planted with 2.5–3 m (8–10 ft) spacing.



Pua kenikeni growing well under ti (*Cordyline fruticosa*) plants in South Kona, Hawai'i. PHOTO: C. ELEVITCH

## 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))

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