



## *Artocarpus altilis* (breadfruit)

Moraceae (mulberry family)

*beta* (Vanuatu); *bia, bulo, nimbalu* (Solomon Islands); breadfruit (English); *kapiak* (Papua New Guinea); *kuru* (Cook Islands); *meduu* (Palau); *mei (mai)* (Federated States of Micronesia, Kiribati, Marshalls, Marquesas, Tonga, Tuvalu); *mos* (Kosrae); *'ulu* (Hawai'i, Samoa, Rotuma, Tuvalu); *'uru* (Society Islands); *uto, buco* (Fiji)

Diane Ragone

### IN BRIEF

**Distribution** Pantropical, very widely distributed.

**Size** Commonly found at 12–15 m (40–50 ft).

**Habitat** Grows best in tropical lowlands below 650 m (2160 ft) with rainfall of 1500–3000 mm (60–120 in).

**Vegetation** Associated with a wide variety of cultivated plants.

**Soils** Deep, fertile, well drained soils are preferred; some varieties are adapted to coral atolls.

**Growth rate** Fast growing in favorable conditions, growing 0.5–1.5 m (1.5–5 ft) per year.

**Main agroforestry uses** Soil stabilization, overstory, homegardens.

**Main products** Staple food, medicinal, lightweight wood.

**Yields** 160–500 kg (350–1100 lb) fruit per tree per year in intensive cultivation.

**Intercropping** Interplanted with small fruit trees or short-term fruit and vegetable crops.

**Invasive potential** Very little potential for invasiveness.



PHOTO: D. RAGONE

A young breadfruit tree.

## INTRODUCTION

Breadfruit has long been an important staple crop and a primary component of traditional agroforestry systems in Oceania, where numerous varieties are grown. The fruit can be cooked and eaten at all stages of maturity, is high in carbohydrates, and is a good source of minerals and vitamins. In addition to producing abundant, nutritious, tasty fruits, this multipurpose tree provides medicine, construction materials, and animal feed. The attractive, evergreen trees grow to heights of 15 to 21 m (48 to 70 ft) or more and the trunks may be as large as 2 m (6.6 ft) in diameter at the base. The trees begin bearing in 3–5 years and are productive for many decades. They are easy to propagate, require little attention and input of labor or materials, and can be grown under a wide range of ecological conditions. Most breadfruit is produced for subsistence purposes and small quantities are available for sale in town markets as fresh fruit or chips. There is interest in establishing small-scale orchards to provide fresh fruits and chips for export from Pacific islands to New Zealand, the United States, and Canada.

## DISTRIBUTION

### Native range

The wild, seeded, ancestral form of breadfruit, *Artocarpus camansi* Blanco, or breadnut, is native to New Guinea, and possibly the Moluccas (Indonesia) and Philippines. Breadfruit, both seeded and seedless forms, does not naturally occur in the Pacific islands, although long-abandoned plantings are sometimes mistaken for wild trees. It was first domesticated in the western Pacific and spread by humans throughout the region beginning 3000 years ago.

### Current distribution

Breadfruit is cultivated on most Pacific islands, with the exception of New Zealand and Easter Island. It is now pantropical in distribution. In the late 1700s several seedless varieties were introduced to Jamaica and St. Vincent from Tahiti, and a Tongan variety was introduced to Martinique and Cayenne via Mauritius. These Polynesian varieties were then spread throughout the Caribbean and to Central and South America, Africa, India, Southeast Asia, Madagascar, the Maldives, the Seychelles, Indonesia, Sri Lanka, and northern Australia. Breadfruit is also found in south Florida.



**Breadfruit is a beautiful and prolific tree, and an essential component of traditional Pacific island agriculture.** PHOTO: J. WISEMAN

## BOTANICAL DESCRIPTION

### Preferred scientific name

*Artocarpus altilis* (Parkinson) Fosberg

### Family

Moraceae

### Non-preferred scientific names

*Artocarpus camansi*

*A. mariannensis*

*A. communis*

*A. incisa*

### Common names

Pacific islands

*beta* (Vanuatu)

*bia, bulo, nimbalu* (Solomon Islands)

breadfruit (English)

*kapiak* (Papua New Guinea)

*kuru* (Cook Islands)

*meduu* (Palau)

*mei (mai)* (Federated States of Micronesia, Kiribati, Marshalls, Marquesas, Tonga, Tuvalu)

*mos* (Kosrae)  
*'ulu* (Hawai'i, Samoa, Rotuma, Tuvalu)  
*'uru* (Society Islands)  
*uto, buco* (Fiji)

### Other regions

*árbol a pan* (Spanish)  
*l'arbre à pan* (French)  
*rimas* (Philippines)  
*sukun* (Indonesia)

### Size

Trees can reach heights of 21 m (70 ft) or more at maturity, more commonly around 12–15 m (40–50 ft). The trunk may be large as 2 m (6.6 ft) in diameter, occasionally growing to a height of 4 m or more (13 ft) before branching. A white milky latex is present in all parts of the tree.

### Form

Single-trunked tree with spreading, evergreen canopy.

### Flowers

Monoecious with male and female flowers on the same tree and the male inflorescence appearing first. Male flowers are club-shaped, up to 5 cm (2 in) in diameter and 45 cm (18 in) long. Thousands of tiny flowers with two anthers are attached to a central, spongy core. Female inflorescences consist of 1500–2000 reduced flowers attached to a spongy core. The flowers fuse together and develop into the fleshy, edible portion of the fruit. It is cross-pollinated, but pollination is not required for the fruit to form.

### Leaves

Leaves are alternate, broadly obovate to broadly ovate, almost entire, with only slight lobing to deeply pinnately lobed, with sinuses up to 2/3 or more of the distance from margin to midrib, with up to six pairs of lobes and a large apical tip. Blade is generally smooth, glossy, dark green with green or yellow-green veins, and few to many white to reddish-white hairs on the midrib and veins. Leaves on new shoots and root suckers are generally larger and more hirsute than leaves on mature branches. Size is variable depending on the variety, ranging from 15–60 cm (6–24 in) long.

### Fruit

Fruits are variable in shape, size, and surface texture. They are usually round, oval, or oblong ranging from 9 to 20 cm (3.6–8 in) wide and more than 30 cm (12 in) long, weighing 0.25–6 kg (0.5–13 lb). The tough skin is composed of five- to seven-sided disks, each the surface of an individual



**The leaves and fruit are found in an amazing diversity of shapes, sizes, and shades of color.** PHOTOS: D. RAGONE

flower. Two strap-shaped, reflexed stigmas protrude from center of the disk and often leave a small distinctive scar when they blacken and wither. The skin texture varies from smoothly to slightly bumpy or spiny. The color is light green, yellowish-green, or yellow when mature, although one unusual variety ('Afara' from the Society Islands) has pinkish or orange-brown skin. The skin is usually stained with dried latex exudations at maturity. The flesh is creamy white or pale yellow and contains none to many seeds, depending upon the variety. Fruits are typically mature and ready to harvest and eat as a starchy staple in 15–19 weeks. Ripe fruits have a yellow or yellow-brown skin and soft, sweet, creamy flesh that can be eaten raw but rarely is in the Pacific



Look-a-likes *A. camansi* (left) and *A. mariannensis* (right). PHOTOS: D. RAGONE

## Seeds

Throughout the Pacific, breadfruit exhibits great morphological variability, ranging from true seedless varieties to those with several small aborted seeds, or one to a few viable seeds, to varieties with numerous viable seeds. Seeded types are most common in the southwestern Pacific. Seedless varieties are most common in Micronesia and the eastern islands of Polynesia. All of the breadfruit varieties elsewhere in the tropics are seedless.

Seeds are thin-walled, subglobose or obovoid, irregularly compressed, 1–2 cm (0.4–0.8 in) thick, and embedded in the pulp. The outer seed coat is usually shiny dark brown with a light brown inner seed coat. Seeds have little or no endosperm and no period of dormancy; they germinate immediately and are unable to withstand desiccation. Seeds are distributed by flying foxes, where they occur. Seeds are rarely used for propagation.

## How to distinguish from similar species

*Artocarpus camansi* (breadnut, camansi) has oblong, very spiny fruits with little pulp and numerous large, light-brown seeds and large, shallowly dissected leaves with 4–6 pairs of lobes. *Artocarpus mariannensis* (dugdug, chebiei) has small, cylindrical or kidney-shaped, dark-green fruits with yellow flesh and dark-brown seeds, and small, entire to shallowly 1–3-lobed leaves.

## GENETICS

### Variability of species

Breadfruit is genetically diverse, especially the seeded forms in the western Pacific and hybrids (with *Artocarpus mariannensis*) in Micronesia. Numerous Polynesian triploid

varieties are genetically identical but morphologically distinct. These Polynesian triploids tend to not thrive under atoll conditions, while both seeded and seedless hybrid varieties are best adapted to these conditions.

### Known varieties

There are hundreds of named varieties in the Pacific islands that are perpetuated clonally by vegetative propagation. Some varieties have a wide distribution, such as ‘Maopo’ in Samoa and Tonga (known as ‘Rare autia’ in Society Islands, ‘Mei aukape’ in Marquesas, ‘Uto lolo’ in Fiji, ‘Morava’ in Cook Islands, and ‘Sra fon’ in Kosrae). Others are localized to specific islands.

‘Maopo’ has an almost entire leaf with shallow lobes at the tip. The seedless fruits are oval or broad ovoid with pale white or creamy flesh, 16–26 cm (6.4–10.4 in) long and 16–18 cm (6.4–7.2 in) wide, weighing 2–3.5 kg (4.4–7.7 lb), averaging 2.4 kg (5.2 lb). The trees reach heights of 15 m (50 ft) or taller, and the timber is used for house building in Samoa.

‘Ma’afala’ is common throughout Polynesia and has been introduced to Pohnpei, Kosrae, and Tuvalu. It is generally a smaller tree up to 10 m (33 ft) tall with a spreading canopy. The small leaves are moderately dissected with three to five pairs of lobes. The small fruits are oval or oblong with white flesh, 12–16 cm (4.8–5.4 in) long and 10–13 cm (4–5.4 in) wide, weighing 0.6–1 kg (1.3–2.2 lb), averaging 0.75 kg (1.6 lb), with none to few seeds.

‘Puou’ is common throughout Polynesia. It is generally a smaller tree up to 10 m (33 ft) tall with a dense, spreading canopy. The large leaves are dull, shallowly dissected with 4–6 pairs of lobes. The fruits are round, 12–20 cm (4.8–8 in) long and 11–17 cm (4.4–6.8 in) wide, weighing 1.2–2.4 kg (2.4–4.8 lb), averaging 1.5 kg (3.3 lb) with a long, stout stalk

up to 10 cm (4 in) and a distinctive raised “neck.” The pale white or creamy flesh has none to few seeds.

‘Mein iwe’ (‘Mos n wa’, ‘Motinwae’, ‘Mejenwe’) is an important variety in the the FSM, the Marshall Islands, and Kiribati. The deeply dissected leaves have 3–4 pairs of lobes. The round to oval fruits with white flesh are seedless, 12–21 cm (4.8–8.4 in) long and 12–16 cm (4.8–6.4 in) wide, and weigh 0.8–2.2 kg (1.7–4.8 lb), averaging 1.6 kg (3.5 lb).

## ASSOCIATED PLANT SPECIES

Breadfruit is an aboriginal introduction in the Pacific islands and occurs only in cultivation throughout the area. It is grown around homes in villages and towns and is an important component of agroforestry systems, especially on the high islands of the FSM. It is associated with other staple crops such as taro (*Colocasia esculenta*), yam (*Dioscorea* spp.), banana, as well as Tahitian chestnut (*Inocarpus fagifer*), noni (*Morinda citrifolia*, Indian mulberry), coconut, kava (*Piper methysticum*), cacao, coffee, and

various fruit trees such as citrus and papaya. Understory plants include Polynesian arrowroot (*Tacca leotopetaloides*) and *Curcuma australasiatica* (in Pohnpei).

## ENVIRONMENTAL PREFERENCES AND TOLERANCES

### Climate

Breadfruit has a wide range of adaptability to ecological conditions. It grows best in equatorial lowlands below 600–650 m (2000–2160 ft) but is found at elevations up to 1550 m (5100 ft). The latitudinal limits are approximately 17°N and S; but maritime climates extend that range to the Tropics of Cancer and Capricorn.

### Elevation range

0–1550 m (5100 ft)



Left: Young farmer Fa'aaliga in American Samoa with the large-fruited 'Avelolola tala'. PHOTO: C. ELEVITCH. Top and bottom right: Varieties 'Maopo' and 'Mein padahk'. PHOTOS: D. RAGONE.



**Breadfruit is compatible with many other cultivated crops such as banana and taro, as shown here. In the lower left corner are young *Flueggea flexuosa* and coconut seedlings, which will grow to overtop the breadfruit. American Samoa. PHOTO: C. ELEVITCH**

### **Mean annual rainfall**

1500–3000 mm (60–120 in), but trees can yield regularly on Pacific atolls that receive 1000 mm (40 in)

### **Rainfall pattern**

It prefers climates with summer rains.

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

0–3 months

### **Mean annual temperature**

15–40°C (59–104°F), does best at 21–32°C (70–90°F)

### **Mean maximum temperature of hottest month**

32–38°C (90–100°F)

### **Mean minimum temperature of coldest month**

16–18°C (61–64°F)

### **Minimum temperature tolerated**

5–10°C (41–50°F)

### **Soils**

Deep, fertile, well drained soils are preferred, although

some varieties are adapted to the shallow sandy soils of coral atolls.

### **Soil texture**

Breadfruit prefers light and medium soils (sands, sandy loams, loams, and sandy clay loams).

### **Soil drainage**

It requires freely draining soils.

### **Soil acidity**

Neutral to alkaline soils (pH 7.4–6.1)

### **Special soil tolerances**

Breadfruit tolerates saline soils, as well as coralline soils and atolls.

### **Tolerances**

#### **Drought**

Breadfruit can withstand drought for a few months but will prematurely drop its fruits.

### Full sun

The tree does best in full sun and forms the overstory canopy in traditional mixed agroforests.

### Shade

Young trees prefer 20–50% shade when young but can be grown in full sun.

### Fire

It can sprout back from the roots after a small fire, but the trunk and branches are not fire-tolerant.

### Frost

It is damaged by frost, which causes it to lose all fruits and leaves, and some branch die-back may occur.

### Waterlogging

It can tolerate waterlogged soils for only very brief periods.

### Salt spray

It can tolerate some salt spray for brief periods, but the leaves will turn yellow and fall.

### Wind

The branches break and shed in heavy winds, especially with a heavy fruit load, but new shoots and branches quickly regrow.

### Abilities

Breadfruit produces numerous root shoots when roots are cut or damaged. It quickly regrows new shoots and branches after wind damage or when topped to facilitate harvest. Even large trees 1 m (3.3 ft) or greater in diameter will regenerate and produce fruits again in as soon as 2 years after severe pruning.

## GROWTH AND DEVELOPMENT

### Growth rate

Breadfruit is fast growing in favorable conditions, growing 0.5–1.5 m (1.7–4.8 ft) per year and to a diameter of close to 1 m (3.3 ft) in the first 10–12 years. Small branches often die back at the tip after fruiting, but new shoots and branches continue to develop throughout the life of the tree.

### Flowering and fruiting

Breadfruit bears seasonally, with most varieties producing one or two crops per year. The main crop typically occurs during the hot, rainy, summer months, followed by

a smaller crop 3–4 months later. Trees grown from seed begin flowering and produce fruit in 6–10 years, or sooner. Vegetatively propagated trees start fruiting in 3–6 years.

### Yields

Yields are extremely variable, ranging from less than 100 to more than 700 fruits per tree, depending on the variety, age, and condition of the tree. Average yields are 150–200 fruits per tree. A study of Pohnpeian varieties recorded:

Variety	Number of fruits	Average yield
'Mein iwe'	30–268	141
'Mein padahk'	26–557	219
'Mei uhwp'	10–615	218

### Rooting habit

Roots are spreading and grow on or slightly below the surface of the ground. Some varieties, especially *A. altilis* × *A. mariannensis* hybrids, develop extensive buttress roots.

### Reaction to competition

Breadfruit does well interplanted with a wide array of plants, and more than 120 useful species have been documented in traditional breadfruit agroforests on Pohnpei. Vines such as *Merremia peltata*, if left unchecked, can smother and eventually kill the trees.



Root shoot growing from surface roots. Root shoots help breadfruit trees survive wind damage and are a primary source for propagation material. PHOTO: D. RAGONE

## Diseases and pests

It is relatively free of diseases and pests, although mealybugs can be a problem locally. *Phellinus noxius*, a root rot, and fruit rots caused by *Phytophthora*, *Colletotrichum* (anthracnose), and *Rhizopus* can be a problem. Fruit flies infest ripe fruits on the tree and ground. Tree decline and dieback have been a problem throughout the Pacific and Caribbean islands, especially on atolls. No pathological cause has been identified. It is considered to be the result of storm damage, drought, aging of the trees, and salinity. Proper husbandry practices, such as removing dead and dying branches and mulching, are essential to maintaining the health and vigor of the trees.

## PROPAGATION

Breadfruit is easy to propagate from root shoots or root cuttings, by air-layering branches, or from seeds. Breadfruit can also be grafted using various techniques. Stem cuttings are not used. Seeds are rarely grown because they do not develop true to type. Vegetative propagation is a must for seedless varieties, and root shoots or root cuttings are the preferred methods for both seeded and seedless varieties.

### Propagation by root shoots and root cuttings

It is best to collect root shoots and root cuttings after the fruiting season is over and when the tree is in an active vegetative stage, producing new leaves. This generally coincides with the end of the dry season, and root shoots/cuttings should be collected as the rainy season commences. This is the period when carbohydrate stores in the roots are at their highest levels.

### Collection and handling of propagating material

#### Root shoots

The use of root shoots to propagate breadfruit is the traditional method in the Pacific, and some varieties, such as 'Puou', produce numerous root shoots. Collect healthy shoots when they are at least 20–25 cm (8–10 in) tall and the stem has become woody and is producing lobed leaves. Shoots up to 1 m (3.3 ft) tall can be used. Remove by cutting the attached root 10–15 cm (4–6 in) on either side of the shoot and carefully lifting out the shoot and any attached root system. Use a sharp machete or clippers to sever the shoot from the parent tree and to facilitate wound healing. It is difficult to avoid damaging the shoot's root system when the shoot is removed, so root shoots need to be grown under nursery conditions before outplanting. The success rate of directly transplanting shoots to another

location is low, around 25%. Trim off the leaves and cut the tip at a 45 degree angle at a height of 15–30 cm (6–12 in; see photo). Trimming the tip makes the root shoot more manageable, and the apical shoot tends to die back anyway. Plant in organic, well drained media in a 1–2 gallon (10–20 cm) pot. Keep shaded (up to 60% shade) and moist, but not wet, and misting is recommended. It should never be allowed to dry out. Depending on the size of the shoot, it will need to be grown under nursery conditions for 3–6 months before outplanting. The percentage of successful rooting and shoot growth ranges from 50 to 90%.

#### Root cuttings

Root shoots are not always available from a desired variety, and root cuttings can be used to mass-propagate breadfruit. Collect roots from healthy, vigorous trees. Carefully excavate roots that are growing just beneath the surface of the soil. Do not use surface roots because these tend to dry out and have a lower success rate. Look for roots with small rounded bumps on the surface—these adventitious buds will develop into new shoots. Roots 1.5–6 cm (0.6–2.4 in) in diameter can be used, and 3–4 cm (1.4–1.8 in) is suggested for best results. Removing roots larger than 6 cm (2.4 in) can be detrimental to the tree, damaging the root system, and because the wounded area will heal more slowly. Use a sharp machete or clippers to sever the root and facilitate wound healing. The remaining attached root will often develop a root shoot at the cut end.

Cut roots into 15–25 cm (6–10 in) sections. It is best to wash and scrub the roots to remove soil. Discard any pieces that are damaged or misshapen. Treatment with fungicide is recommended to prevent growth of pathogens that cause root rots. Hormone treatment is not required but standard hormone mixes can be used according to the manufactur-



Root shoots and root cuttings, both pictured here in nursery containers, are the primary means of propagating breadfruit.

PHOTO: D. RAGONE



ers recommendation.

Place the roots in a propagating bed, flats, or individual pots. Space roots 10–15 cm (4–6 in) in a row and 15–20 cm (6–8 in) between rows in beds or flats. Use well drained potting media or clean, washed silica sand. Do not use beach sand because it is too saline and alkaline. Cuttings are placed either horizontal (covered with media) or at an angle, but not upright, with a small upper portion of the root exposed.

Root cuttings should be kept shaded (up to 60% shade) and moist, but not wet; misting is recommended. The roots should never be allowed to dry out. The percentage of rooting ranges from 75 to 85%. Shoots begin to develop from adventitious buds after 3–4 weeks. When shoots are 20–25 cm (8–10 in) tall with their own root system—usually in 4–6 months—carefully uproot and transplant into 2–3 gallon (20–30 cm) pots. Use a well drained medium. If adding fertilizer (such as balanced 8–8–8) use only sparingly, less than half the manufacturers' recommendations. Keep plants in partial shade and weed-free. Grow to a size of 0.6–1.6 m (24–64 in) in 6–9 months.

### Propagation by air-layering

It is best to air-layer branches at the beginning of the rainy season when the tree is in an active vegetative stage, producing new shoots and leaves, and before fruits appear. Select newly developed shoots, and do not use the ends of branches that have previously flowered or fruited. Branches 2–4 cm (0.8–1.6 in) are prepared for air-layering by removing a strip of bark 3–5 cm (1.4–2 in) wide around the circumference of the branch. Use a sharp knife and be careful not to cut into the wood. Rooting hormone is not required but if used, follow the manufacturer's recommendations. Wrap moistened sphagnum moss, or other organic media, around this area and hold it in place with a piece of plastic, aluminum foil, burlap, or copra bag tied around the branch. Up to 50% of air-layers will not root but instead form a ring of hardened callus along the end of the cut. Also, the branches are brittle and may snap off in high winds. They can be braced with bamboo splints placed over the wrapped air-layer. After 2–4 months, new roots will develop and grow through the medium. Remove the air-layer by cutting the branch directly below the roots. Place in a 1–2 gallon (10–20 cm) pot in a well drained medium until the plant has an established root system (about a year). The tip of the branch often dies and the air-layer will fail to take unless a new shoot develops from buds lower on the branch.



Although a less common means of propagation than root suckers and root cuttings, air-layering of breadfruit also works well. Air-layers are shown here wrapped in aluminum foil to reduce evaporation and keep them cool. PHOTO: C. ELEVITCH

### Establishment in the nursery

Young breadfruit plants grow best in partial shade, so full-sun hardening is often not necessary. However, if plants are to be planted in full sun, gradually move to full-sun conditions in the nursery to harden them to the site conditions, at about 2 months. Young plants should never be allowed to dry out or be exposed to strong wind.

### Outplanting

Outplant when the plants have reached the desired size. Because of their large surface area it is best to reduce the size of the leaves to reduce transpiration. Carefully remove 1/2 to 2/3 of the lower leaves. Do not remove or damage the growing point of the plant where new leaves develop. Protect from wind and excessive heat during transport. Dig a hole the same depth of the container and twice as wide as the container. Add a small amount of fertilizer, such as 8–8–8 slow-release fertilizer, to the bottom of the hole and cover with soil. To prevent injury to the delicate root system, carefully cut off the container rather than pulling the plant out. Place the breadfruit tree in the hole, add soil no higher than the level of the plant in the pot, top-dress with compost, and water well. Close to 100% success rate can be expected.

Young plants prefer partial shade. It is best to plant at the onset of the rainy season, but if the weather is dry, irrigate for the first 1–3 months of establishment. Once established, breadfruit trees can withstand a dry season of 3–4 months, although it prefers moist conditions. Mulching young plants is beneficial by helping keep the soil moist and adding a steady supply of nutrients. It also helps control weeds



**Breadfruit remains a common tree in homegardens in much of the Pacific, such as pictured above in Apia, Samoa.** PHOTO: C. ELEVITCH

around the root system. Use of herbicides to control weeds around the base of the tree can damage the tree if it comes in contact with the surface roots or young trunk. Young trees need to be protected from cattle, goats, horses, and pigs that will eat the bark and tender shoots.

## DISADVANTAGES

### Potential for invasiveness

Breadfruit has no potential for invasiveness. Most of the varieties are seedless and can only be propagated vegetatively, requiring humans to distribute and spread this species. Breadfruit does produce root shoots, so clonal offsprings spread a limited distance from the original tree. Since seeds lose viability quickly, the seeded varieties are not readily spread.

### Susceptibility to pests/pathogens

Breadfruit is a relatively trouble-free plant to grow, with its disease and pest problems localized. The major problem is fruit rots caused by *Phytophthora*, *Colletotrichum* (anthracnose), and *Rhizopus*. *Phellinus noxius* root rot can be a problem; it spreads through root contact, especially when the tree is planted in areas of native forest that have been recently cleared.

### Host to crop pests/pathogens

Fruit flies are attracted to ripe fruits on the tree and ground and infest many fruit crops.

### Other disadvantages or design considerations

The spreading surface roots can interfere with other plants and are easily hit and damaged by mowers or other equipment.

## AGROFORESTRY/ENVIRONMENTAL PRACTICES

### Mulch/organic matter

The large leaves of this evergreen species provide abundant mulch for the tree and other plants growing beneath the canopy.

### Soil stabilization

Breadfruit is often grown on steep hillsides, especially on the high islands of Micronesia, where it is the canopy species in traditional agroforestry systems.

### Crop shade/overstory

Breadfruit can be interplanted with a wide range of crops and plants such as yams, bananas, medicinal plants, aroids, gingers, Indian mulberry, kava, etc.

### **Homegardens**

Breadfruit is well suited for homegardens, providing beneficial shade and numerous nutritious fruits.

### **Animal fodder**

All parts—flesh, peel, core, and seeds—of both mature and ripe fruits are edible and are fed to pigs and other livestock. The leaves are also edible.

### **Native animal/bird food**

Breadfruit is an important food source for flying foxes, native doves, and other birds in the Pacific islands.

### **Host plant trellising**

Breadfruit is used as a trellis tree for yam (*Dioscorea* spp.), especially in Pohnpei.

### **Bee forage**

Honeybees visit male inflorescences and collect pollen, especially from fertile, seeded varieties. Bees also collect latex that oozes from the fruit surface.

### **Ornamental**

Breadfruit is an attractive, evergreen tree with large, striking leaves.

## **USES AND PRODUCTS**

### **Staple food**

Breadfruit produces abundant nutritious fruits that are typically consumed as a starchy staple when firm and mature. The fruits are high in carbohydrates and a good source of vitamins and minerals. Breadfruit is canned in brine and sold in the Caribbean and speciality markets in the United States, Europe, and Canada.

### **Nut/seed**

Seeds are high in protein and low in fat and a good source of vitamins and minerals. They are cooked in the fruits and eaten throughout the Pacific islands, but rarely in Polynesia.

### **Medicinal**

All parts are used medicinally in the Pacific and Caribbean, especially the latex, leaf tips, and inner bark. The latex is massaged into the skin to treat broken bones and sprains and is bandaged on the spine to relieve sciatica. It is commonly used to treat skin ailments and fungus diseases such as “thrush,” which is also treated with crushed leaves. Diluted latex is taken internally to treat diarrhea, stomachaches, and dysentery. The sap from the crushed stems of

leaves is used to treat ear infections or sore eyes. The root is astringent and used as a purgative; when macerated it is used as a poultice for skin ailments. The bark is also used to treat headaches in several islands. In the West Indies the yellowing leaf is brewed into tea and taken to reduce high blood pressure and relieve asthma. The tea is also thought to control diabetes.

### **Timber**

The wood is lightweight, flexible, and may resist termites. Taller varieties such as ‘Maopo’ and ‘Aveloloa’ are preferred for house building in Samoa.

### **Fuelwood**

Breadfruit is used as firewood throughout the Pacific, but generally older, less productive trees are utilized.

### **Craft wood/tools**

The wood is easy to work and carve into statues, bowls, and other objects.

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

The light-weight timber is used throughout the Pacific islands to make small one- or two-person canoes.

### **Fiber/weaving/clothing**

The inner bark is used to make bark cloth (tapa), but this formerly widespread custom is now only practiced in the Marquesas.

### **Rope/cordage/string**

The inner bast was traditionally used to make strong cordage used for fishing and animal harnesses in Samoa, Micronesia, and the Philippines.

### **Wrapping/parcelization**

The large, flexible leaves are used throughout the Pacific to wrap foods for cooking in earth ovens.

### **Resin/gum/glue/latex**

The sticky white latex is used as a chewing gum and as an adhesive. It was widely used to caulk canoes and as birdlime (to catch birds).

### **Toxin/insecticide/fish poison**

Dried male flowers can be burned to repel mosquitoes and other flying insects.

## **URBAN AND COMMERCIAL FORESTRY**

The stately and attractive breadfruit tree is a familiar land-

scape tree in the Pacific islands. Widely planted throughout the region, breadfruit provides comfortable shade, delicious and nutritious fruits, timber, and other useful products. A common element in home landscapes, breadfruit trees are typically grown around and near homes so the fruits can be easily and quickly harvested. A few magnificent specimen trees can be found in parks and other public places. Unfortunately, in large metropolitan areas such as Honolulu, many beautiful old trees have disappeared from the urban landscape in recent years—cut down to make room for larger homes and buildings, and to open view planes.



A large tree cut back to open a view plane. PHOTO: C. ELEVITCH

### Size in an urban environment

Trees can reach heights of 18 m (60 ft) or more but are typically 12–15 m (40–50 ft). Some varieties are relatively short-statured, reaching average heights of 9 m (30 ft). The canopy is generally about two-thirds of the height.

### Rate of growth in a landscape

It is moderately fast growing in favorable conditions, grow-

ing 0.5–1.5 m (1.5–5 ft) per year.

### Root system

Roots are spreading, grow on or slightly below the surface of the ground, and can form raised buttresses. Surface roots are easily hit and damaged by mowers or other equipment.

### Products commonly used in a Pacific island household

Primarily grown for food, the nutritious, starchy fruits are usually consumed when mature. The mature fruit must be cooked when still green and firm, but it can be eaten raw when soft and ripe. These multipurpose trees have a lightweight, easy-to-work timber well suited for carvings and handicrafts, canoes, and house construction. Leaves, buds, latex, and bark all have medicinal uses. The sticky sap is widely used for glue and as a traditional caulk.

### Light requirements

Young trees can be grown in 20–50% shade when young but develop a more compact, dense canopy when grown in full sun.

### Water/soil requirements

Newly planted trees may require daily watering during dry periods until established, but mature trees normally tolerate dry conditions and do not require irrigation. Breadfruit prefers light and medium soils (sands, sandy loams, loams, and sandy clay loams) and requires good drainage.

### Life span

Trees begin bearing in 3–5 years and are productive for many decades.

### Varieties favored for use in a homegardens

Shorter-statured, more compact varieties such as ‘Puou’ or ‘Ma’afala’ from Polynesia or the Micronesian variety ‘Mei uhwp’ are ideal for homegardens.

### Seasonality of leaf flush, flowering, fruiting

Male flowers and fruits develop at the tips of branches, with the male flowers occurring first. The fruiting season typically coincides with the wet, rainy summer months, but a smaller flush may occur about 5 months later for some varieties. New leaves are produced year-round, with a heavy flush after a period of rest that follows the end of the fruiting season.

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

Because of its stature and dense foliage when grown in the

open, breadfruit is well suited as a specimen or shade tree that can serve as a visual screen when sited correctly.

### **Birds/wildlife**

Birds and honeybees are attracted to the fruits and/or male flowers.

### **Maintenance requirements**

Mulching with fallen breadfruit leaves and other organic material is beneficial. This relatively low-maintenance species can be fertilized once a year with a balanced NPK fertilizer, but trees can produce abundantly and thrive for years without supplemental fertilizer. Small tip branches often die back after fruiting and should be pruned and removed to maintain the long-term health of the tree.

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

Some fruits may drop prematurely, but most fruits develop and should be harvested when mature. High, out-of-reach fruits will ripen and fall to the ground throughout the fruiting period. Heavily laden branches may break off the tree during strong winds.

### **Nuisance issues**

Soft, ripe fruits that remain on the ground after falling draw clouds of fruit flies and quickly begin to rot into a gooey, unsightly mass.

### **Hazards**

Since some breadfruit varieties have fruits that weigh up to 5.5 kg (12 lb), trees should not be planted close to sidewalks or other public areas where falling fruits could hit and injure a passing pedestrian or trip passers-by.

### **Common pest problems**

The tree is relatively pest free. The main problems with breadfruit are fruit flies and fruit rots from fungal diseases. Vigilance in harvesting and disposing of fruits affected by fungal disease is the easiest way to limit problems. Household or farm pigs readily “pig out” on damaged and ripe fruits, solving disposal problems for the homeowner while benefiting from a nutritious foodstuff.



**Author with breadfruit tree bearing nicely 28 months after planting.** PHOTO: J. WISEMAN

### **Other comments about this species in urban environments**

Breadfruit trees are an essential component of homegardens and should be more widely planted throughout the islands. They are not as well suited as street or park trees. Soft, ripe fruits can make a mess of sidewalks, streets, or parked cars, and the sticky latex could adhere to and damage the finish of vehicles.

## **COMMERCIAL PRODUCTS**

Breadfruit is grown primarily as a subsistence crop throughout the Pacific islands and other regions where it is cultivated. It is available in village and town markets for local consumption. Breadfruit is produced and sold locally as chips in Fiji, Samoa, Guam, Hawai'i, and other islands. Fresh mature fruits, treated for fruit flies by hot forced air, are being exported to New Zealand from Fiji and Samoa. The fruits are harvested from small plantings and backyard

trees. There are no orchards in the Pacific islands with the exception of a farm in Hawai'i with more than 180 trees on approximately 2.5 ha (6 acres).

### Spacing

Trees should be planted 12–14 m (40–46 ft) apart under orchard conditions, although in the Caribbean trees are often spaced 8–12 m (27–40 ft).

### Management objectives and design considerations

Breadfruit is traditionally grown in integrated mixed agroforestry systems. Little information is available about managing breadfruit for commercial production. It is best to keep trees mulched. Provide a complete fertilizer at the beginning and end of the fruiting season to maintain the health and vigor of trees, especially trees that are 10 or more years old. Pruning should be limited to the removal of dead branches, but trees are often topped to make it easier to reach and harvest fruits. However, the new shoots and branches are brittle and readily break.

### Yields

Under orchard conditions, yield estimates range from 16 to 50 mt per ha (7–23 t/ac) of fruit based on 100 trees/ha (40 trees/ac). Approximately 5.5 mt per ha (2.4 t/ac) are produced in a traditional mixed agroforestry system on Pohnpei.

### Processing

Breadfruit is generally picked and consumed when mature but not yet ripe. Careful harvesting is essential for maintaining fruit quality. Fruits that fall to the ground may be bruised and soften sooner than those that are gently handled. Fruits quickly ripen in just 1–3 days after harvest. Shelf life can be extended by careful harvesting and pre-cooling fruits with chipped ice in the field and during transport. Covering fruits with water can also delay ripening for a few days.

### Markets

Breadfruit is usually available for sale in markets throughout the Pacific and Caribbean islands. An estimated 100–300 tons of breadfruit is sold in Samoa annually, with 60–130 tons sold in the Fugalei Market in Apia.

## INTERPLANTING/FARM APPLICATIONS

Breadfruit trees provide shade, mulch, and a beneficial microclimate. They are generally planted as part of a ho-



One of the great staples of Pacific island cultures, breadfruit is shown here for sale together with two other staples, sweet-potato and cooking banana. PHOTO: C. ELEVITCH

megarden or mixed agroforestry system with a wide array of useful plants. Widely spaced trees in an orchard can be interplanted with small fruit trees, such as citrus, and a leguminous cover crop. Short-term fruit crops, such as pineapple, banana, and papaya, or field and vegetable crops including taro, tomato, and eggplant, can also be grown between breadfruit trees. A leguminous cover crop should replace these intercrops when they begin to interfere with orchard operations. Some interplanting systems include:

### Example 1

#### Location

Federated States of Micronesia (Pohnpei).

#### Description

Breadfruit is typically grown with yam (*Dioscorea* spp.). The vines climb trellises of *Hibiscus tiliaceus* and grow into the canopy of the tree during the non-fruiting period and are dormant when the fruits are harvested. This allows the fruits to be picked without damaging the yam vines.

### Example 2

#### Location

American Samoa.

#### Description

Breadfruit is grown in a mixed planting with taro, cassava, bananas, citrus, and cacao.

## PUBLIC ASSISTANCE AND AGROFORESTRY EXTENSION

Extension offices for agroforestry and forestry in the Pa-

cific: <http://www.traditionaltree.org/extension.html>

The Cooperative Extension Service (CES) of the University of Hawai'i can assist landowners with questions relating to tree crops.

University of Hawai'i at Mānoa  
College of Tropical Agriculture and Human Resources  
Cooperative Extension Service  
Komohana Agricultural Complex  
875 Komohana St., Hilo, HI 96720  
Tel: 808-959-9155; Fax: 808-959-3101  
Web: <http://www2.ctahr.hawaii.edu/>

## GERMPLASM RESOURCES

The National Tropical Botanical Garden can provide selected varieties from an extensive breadfruit germplasm collection.

The USDA Clonal Germplasm Repository, Waiakea, Hawai'i, can provide selected breadfruit varieties.



**The National Tropical Botanical Garden's Kahanu Garden, Maui, Hawai'i, has the largest collection of breadfruit varieties in the world.** PHOTO: D. RAGONE

## INTERNET

The Breadfruit Institute: <http://www.breadfruit.org>.

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

## *Artocarpus altilis* (breadfruit)

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