



## *Artocarpus heterophyllus* (jackfruit)

Moraceae (mulberry family)

jack, jack tree, jackfruit, jak, jakfruit (English); *jacquier* (French); *kapiak* (Papua New Guinea); *uto ni India* (Fiji); *'ulu initia* (Samoa)

Craig R. Elevitch and Harley I. Manner

### IN BRIEF

**Distribution** Common in southeast Asia and found occasionally in Pacific island homegardens.

**Size** Trees typically reach a height of 8–25 m (26–82 ft) and a canopy diameter of 3.5–6.7 m (11–22 ft) at 5 years of age.

**Habitat** The tree grows well in equatorial to subtropical maritime climates at elevations of 1–1600 m (3.3–5250 ft) and average rainfall of 1000–2400 mm (40–95 in).

**Vegetation** A common component in polycultures together with numerous other cultivated species.

**Soils** Grows in freely draining, acid to neutral soils (pH 5.0–7.5).

**Growth rate** Grows moderately rapidly in early years, up to 1.5 m/yr (5 ft/yr) in height, slowing to about 0.5 m/yr (20 in/yr) as trees reach maturity.

**Main agroforestry uses** Shade, windbreak, homegarden.

**Main products** Fruit, timber, fodder, latex.

**Yields** 70–100 kg/tree/yr (150–220 lb/tree/yr) is typical, although much larger yields have been reported.

**Intercropping** It is interplanted with many other tree crops.

**Invasive potential** Not considered invasive; naturalization in new environments is unusual.



PHOTO: C. ELEVITCH

Row of trees with fruit.

## INTRODUCTION

Jackfruit (*Artocarpus heterophyllus*) is one of the most significant trees in tropical homegardens and perhaps the most widespread and useful tree in the important genus *Artocarpus*. It is a medium-size evergreen tree typically reaching 8–25 m (26–82 ft) in height that is easily recognized by its fruit, the largest among cultivated plants. The succulent, aromatic, and flavorful fruit is eaten fresh or preserved in myriad ways. The nutritious seeds are boiled or roasted and eaten like chestnuts, added to flour for baking, or cooked in dishes. It is also known for its remarkable, durable timber, which ages to an orange or red-brown color. The leaves and fruit waste provide valuable fodder for cattle, pigs, and goats. Many parts of the plant including the bark, roots, leaves, and fruit are attributed with medicinal properties. Wood chips yield a dye used to give the famous orange-red color to the robes of Buddhist priests.

The tree can provide many environmental services. It is highly wind tolerant and therefore makes a good component in a windbreak or border planting. Growing in pastures, it can provide fallen fruit for livestock, shade, and long-term timber. In homegardens, the dense jackfruit canopy can provide a visual screen and is very ornamental.

Introduced to most Pacific islands after European contact, the tree can be found throughout the Pacific, mainly in homegardens, where it finds a place among other favorite multipurpose plants. It is easy to grow and more adaptable than some of the other common *Artocarpus* species such as breadfruit (*A. altilis*). It is not considered to be an invasive species.

## DISTRIBUTION

### Native range

The tree is reportedly native to the rainforests of Malaysia and the Western Ghats of India.

### Current distribution

Jackfruit has been cultivated since prehistoric times and has naturalized in many parts of the tropics, particularly in Southeast Asia, where it is today an important crop of India, Burma, China, Sri Lanka, Malaysia, Indonesia, Thailand, and the Philippines. It is also grown in parts of Africa, Brazil, Suriname, the Caribbean, Florida, and Australia. It has been introduced to many Pacific islands since post-European contact and is of particular importance in Fiji, where there is a large population of Indian descent. In a 1985 survey, jackfruit was present on 10–24% of Indo-Fijian sugarcane farms in western Viti Levu, Fiji (Thaman

and Ali 1993). In comparison, mango (*Mangifera indica*), papaya (*Carica papaya*), drumstick tree (*Moringa oleifera*), *Murraya koenigii*, and tamarind (*Tamarindus indica*) were found on 75–100% of the farms. In Hawai'i, it is occasionally found in homegardens, and it is sold in farmer's markets, although commercial production is minor. Jackfruit is occasionally planted in backyard gardens in Guam. The species is also reported to have been introduced to Palau, Yap, Pohnpei, Nauru, Tabiteuea in Kiribati, Samoa, and other islands (Fosberg et al. 1979).

## BOTANICAL DESCRIPTION

### Preferred scientific name

*Artocarpus heterophyllus* Lam.

### Family

Moraceae (mulberry family)

### Non-preferred scientific names

*Artocarpus brasiliensis* Gomez

*Artocarpus heterophylla* Lam.

*Artocarpus maxima* Blanco

*Artocarpus philippinensis* Lam.

*Polyphema jaca* Lour.

*Soccus arboreus major* Rumph.

*Artocarpus integer* (Thunb.) Merr and its synonym *A. integrifolia* L. f. are a different species (champedak), and these names have often mistakenly been used as synonyms for *A. heterophyllus*.

### Common names

#### Pacific islands

*dapanapan*(?) (Yap)

jack, jack tree, jackfruit, jak, jakfruit (English)

*jacquier* (French)

*kapiak* (Papua New Guinea)

*uto ni India* (Fiji)

*'ulu initia* (Samoa)

#### Other regions

*banun, khanun, makmi* (Thai)

*buen pan, jaca, pan de fruta, rima* (Spanish)

*chakki, kanthal, kathal, kathar, panos* (Hindi)

*Jackfruttbbaum* (German)

*langka, nancas* (Filipino)

*nangka, nongko* (Javanese)

## Size and form

Jackfruit is a medium-size, evergreen tree that typically attains a height of 8–25 m (26–82 ft) and a stem diameter of 30–80 cm (12–32 in). The canopy shape is usually conical or pyramidal in young trees and becomes spreading and domed in older trees. The canopy diameter at 5 years old ranges from 3.5–6.7 m (11–22 ft) and can reach 10 m or more in older trees. The tree casts a very dense shade. Heavy side branching usually begins near the ground. All parts of the tree exude a sticky white latex when injured.

## Flowers

This species is monoecious, having male and female inflorescences (or “spikes”) on the same tree. Male and female spikes are borne separately on short, stout stems that sprout from older branches and the trunk. Male spikes are found on younger branches above female spikes. Male spikes are dense, fleshy, cylindrical to club-shaped, and up to 10 cm (4 in) in length. Flowers are tiny, pale green when young,

turning darker with age. Female flowers are larger, elliptic or rounded, with a tubular calyx. The flowers are reportedly pollinated by insects and wind, with a high percentage of cross-pollination.

## Leaves

Leaves are dark green, alternate, entire, simple, glossy, leathery, stiff, large (up to 16 cm [6 in] in length), and elliptic to oval in form. Leaves are often deeply lobed when juvenile and on young shoots.

## Fruit

Jackfruit has a compound or multiple fruit (syncarp) with a green to yellow-brown exterior rind that is composed of hexagonal, bluntly conical carpel apices that cover a thick, rubbery, whitish to yellowish wall. The acid to sweetish (when ripe) banana-flavored flesh (aril) surrounds each seed. The heavy fruit is held together by a central fibrous core. Fruits are oblong-cylindrical in shape, typically 30–40



Left: Female (top) and male (bottom) flower spikes. Right: Seedlings have lobed leaves compared to the entire leaves on mature trees. PHOTOS: C. ELEVITCH

cm (12–16 in) in length but sometimes up to 90 cm (35 in). They usually weigh 4.5–30 kg (10–66 lb), although a weight of 50 kg (110 lb) has been reported (Morton 1987). The heavy fruit is borne primarily on the trunk and interior part of main branches.

Fruits take 90–180 days to reach maturity. In the Northern Hemisphere, the main bearing season is late spring to early fall (between March and September). A few fruits mature in winter or early spring.

### Seeds

Seeds are light brown to brown, rounded, 2–3 cm (0.8–1.2 in) in length by 1–1.5 cm (0.4–0.6 in) in diameter, and enclosed in a thin, whitish membrane. Up to 500 seeds can be found in each fruit. Seeds are recalcitrant and can be stored up to a month in cool, humid conditions.

### Rooting habit

Jackfruit has a strong taproot.

### Similar species

Champedak (*Artocarpus integer* [Thunb.] Merr.) is easily mistaken for jackfruit. There are several indicators differentiating the two species; perhaps the easiest to see is that champedak has smaller, rounder fruits, with less latex and thicker rind. However, champedak is rarely found in the Pacific.

## GENETICS

### Variability of species

Because the flowers are open-pollinated, there is usually great variation in seedlings. Variation is exhibited in a wide range of characteristics such as tree size and structure, leaf and fruit form, age to bearing, and fruit quality. Fruit size, shape, and color of the fruit and texture, odor, and taste of the edible pulp vary tremendously. An exception is the ‘Singapore’ (or ‘Ceylon’) cultivar, which bears comparatively quickly from seed—usually in 18–30 months—and



Fruit on 7-year-old tree. PHOTOS: C. ELEVITCH



is relatively true to type. It has medium-size fruits (6–12 kg [13–26 lb]) with soft, fibrous, and very sweet flesh.

### Known varieties

Commercially, grafted cultivars are normally planted. The fruit of most cultivars weighs 10–30 kg (22–66 lb), although the full range of known cultivars is 2–36 kg (4.4–79 lb) and even heavier. The fruit is generally grouped into two major types by fruit quality: 1) thin, fibrous, and mushy edible pulp, usually very sweet and emitting a strong odor, and 2) thick, firm, often crisp, less fragrant pulp. There are numerous cultivars of each type in regions where jackfruit is a significant food crop, including South India, Thailand, Malaysia, the Philippines, and Ceylon. In Hawai'i, grafted cultivars include 'Black Gold', 'Dang Rasimi', 'Golden Nugget', 'Honey Gold', and 'NS1'. Jackfruit usually has two main seasons; in Hawai'i it bears in May–August and November–January. Details on these and other cultivars are available from several excellent references (e.g., Crane et al. 2002, Campbell and Lesdesma 2003, and Morton 1987) and in Tables 1 and 2 below.

### Culturally important related species in the genus

Jackfruit belongs to the genus *Artocarpus*, a genus rich in culturally important species including breadfruit (*A. altilis*), dugdug (*A. mariannensis*), and breadnut (*A. camansi*). These three species represent some of the most important traditional subsistence trees of Pacific islands. Elsewhere in Southeast Asia and India, champedak (*A. integer*), lakoocha (*A. lakoocha*), marang (*A. odoratissima*), kwai muk (*A. lingnanensis*), and others are important fruit trees, all with culturally important uses, and many with other valuable products, such as timber.

## ASSOCIATED PLANT SPECIES

### Associated native species commonly found

Jackfruit is reported as a locally common endemic tree species of the evergreen and semi-evergreen forests of the Western Ghats of India. These mountains are a center of biodiversity where more than 800 species of trees have been recorded. Ramesh (no date) classifies the vegetation of the Western Ghats into the following: Wet evergreen forests (with three subtypes based on elevation, with the highest located above 1400 m [4600 ft]); dry evergreen forests; moist deciduous forests; dry deciduous forests; and grasslands. In these forests, jackfruit is one of 352 endemic tree species.



There is great variation in fruit size, shape, color, etc., as shown here at a jackfruit competition in Rayong, Thailand.

PHOTO: C. ELEVITCH

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

Jackfruit is a post-European-contact introduction to Pacific islands. The tree is commonly planted in smallholder cane farms in Fiji held by farmers of Indian ancestry. It is occasionally found in small farms and homegardens throughout the Pacific. Associated tree species include breadfruit (*Artocarpus altilis*), dugdug (*A. mariannensis*), betel nut palm (*Areca catechu*), coconut (*Cocos nucifera*), *Musa textilis*, *M. paradisiaca*, *M. sapendium*, mango (*Mangifera indica*), *Annona* spp., *Pangium edule*, cocoa (*Theobroma cacao*), *Eugenia* spp., and guava (*Psidium guajava*). Jackfruit is found growing together with more than 50 tree species in Yapese homegardens (Falanruw 1990). It is found occasionally on farms and in homegardens throughout Hawai'i.

### Species commonly associated in modern times or as recent Pacific island introduction

The tree is often found as a component of homegardens

in many tropical regions, albeit few in number at each site. One example from Java shows but one jackfruit tree among a listing of 39 homegarden plants (Abdoellah 1990). The species is also a common associate of village tree gardens. Other tree species include durian (*Durio zibethinus*), *Gnetum gnemon*, *Eugenia polycephala*, *Mangifera caesia*, coffee (*Coffea robusta*), *Pangium edule*, and bilimbi (*Averrhoa bilimbi*), to name a few (Michon and Mary 1990).

## ENVIRONMENTAL PREFERENCES AND TOLERANCES

Jackfruit grows in a wide range of tropical to subtropical environments. It is most common in lowland forests up to 250 m (820 ft), decreasing in abundance up to 1000 m above sea level; it thrives best in moist tropical environments below 1000 m (3300 ft). Although tolerant of cooler environments up to 1600 m (5250 ft), jackfruit may suffer dieback in light frosts and does not tolerate freezing temperatures. It bears fruit at latitudes of up to 30° from the equator, with good crops at latitudes within ±24°.

### Climate

The tree grows well in the equatorial to subtropical maritime climates of the Indian and Pacific oceans. It is a component of the tropical moist (rainforest) to semi-dry forest.

### Elevation range

1–1600 m (3.3–5250 ft)

### Mean annual rainfall

1000–2400 mm (40–94 in)

### Rainfall pattern

It favors environments with a uniform rainfall pattern, although it will grow in seasonally dry climates.

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

2–4 months

### Mean annual temperature

24–28°C (75–82°F)

### Mean maximum temperature of hottest month

32–35°C (90–95°F)

### Mean minimum temperature of coldest month

16–20°C (61–68°F)

### Minimum temperature tolerated

–3–0°C (27–32°F)

### Soils

Jackfruit grows best in well drained, deep soils of moderate fertility but tolerates a wide range of soils including shallow limestone, sand, and rocky substrates. The tree does not tolerate water stagnation or poor drainage. If the roots touch stagnant water, the tree fails to bear fruit, or it may die.

### Soil texture

The tree can grow in light- and medium-texture soils (sands, sandy loams, loams, and sandy clay loams).

### Soil drainage

It requires free drainage.

### Soil acidity

The tree tolerates moderately acid to neutral soils (pH 5.0–7.5).

### Special soil tolerances

Jackfruit tolerates shallow, slightly saline, and infertile soils. It also tolerates high pH limestone soils, rocky, and laterite soils.

## Tolerances

### Drought

Jackfruit tolerates 3–4 months of drought. However, it does best with even and continuous soil moisture.

### Full sun

The tree prefers full sun at maturity.

### Shade

Seedlings are best grown in 30–50% sunlight, with sun exposure increasing to 100% as the tree matures.

### Frost

Jackfruit is more cold-tolerant than other species in the genus and can even tolerate light frost. At 0°C (32°F) the leaves may be damaged, and at –2°C (28°F), branches or the whole tree may die.

### Waterlogging

The tree does not tolerate waterlogging or poor drainage and will decline and die if roots become waterlogged for more than a day or two.

### **Salt spray**

Jackfruit has moderate tolerance for salt spray.

### **Wind**

The tree tolerates moderate wind quite well and has been known to survive hurricane-force winds, recovering from loss of leaves and small limbs.

### **Abilities**

#### **Self-prune**

Jackfruit tends not to self-prune, instead retaining side branches along the main trunk. Even when side branches are pruned off, fruiting branchlets continue to sprout on the lower trunk.

#### **Coppice**

The tree regrows well even after heavy pruning.

## **GROWTH AND DEVELOPMENT**

Jackfruit is a rapid grower, reaching a height of 3 m (10 ft) and canopy diameter of 2 m (6.6 ft) in 2 years. Height growth for the first few years is about 1.5 m/yr (5 ft/yr), slowing to 36–60 cm/yr (14–18 in/yr) (Acedo 1992). A 20-year-old tree can reach 17.5 m (57 ft) in height and 20 cm (8 in) in trunk diameter (Morton 1987). While trees can live to 100 years of age, their removal and replacement in Thailand plantations after 20 years of growth suggests a significant decrease in productivity with age.

### **Flowering and fruiting**

Seedlings usually take 4–14 years before bearing fruit, although the ‘Singapore’ (or ‘Ceylon’) cultivar begins bearing fruit 18–30 months after transplanting (Morton 1987). Fruits of most cultivars reach maturity in middle to late summer. Morton (1987) reports that in Asia, depending on the climatic region, fruits ripen mainly from March to June, April to September, or June to August, with some off-season crops from September to December.

### **Reaction to competition**

Jackfruit seedlings grow slowly in heavy shade. Weeding is recommended to lessen competition for light, water, and nutrients.

## **PROPAGATION**

(after Wilkinson and Elevitch 2003)

Jackfruit seedlings are very easy to grow. Seedlings devel-

op very quickly, reaching 25 cm (10 in) in height within 3–4 months. Seeds are cross-pollinated and therefore not true-to-type, so grafting known varieties onto rootstocks is often done, especially for commercial production where a uniform product with the best market qualities is important. Because the seeds are large and grow quickly and their root systems are sensitive to damage during transplanting, direct-seeding in the field can give the best results. Field-sown seedlings can be top-worked (grafted) with select varieties once they are established. Propagation by vegetative means such as cuttings and air-layering is also possible, although uncommon.

## **Seedlings**

### **Seed collection**

Trees usually bear fruit in two main seasons, although off-season fruiting is common. Collect seeds from fruits of trees with outstanding growth and fruit qualities.

### **Seed processing**

After opening the fruit with a large knife, seeds are separated from the fleshy sheaths that enclose the seeds. Each fruit contains 100–500 seeds; there is no correlation between fruit size and the number of seeds it contains. There are about 50–90 seeds/kg (23–41 seeds/lb). The thin, slimy coating around the seed (perianth lobe) should be removed and the seeds thoroughly rinsed in water to remove any remaining pulp juice or sugary residue. Only the largest seeds should be used, as these will give the earliest and highest germination and produce the strongest seedlings. Seeds may be air-dried in the shade for about an hour for ease of handling, but they should not be allowed to dry out, as this will kill them. Germination for seed sown within a few days of harvesting is usually high, around 90%.

### **Seed storage**

Seeds are recalcitrant, i.e., they do not retain viability when dried or stored for extended periods. They should be planted immediately for best germination and seedling vigor. Seeds can be stored moist in a plastic container in the refrigerator for up to a few weeks. Stored seeds germinate more slowly than fresh seeds.

### **Seed pretreatment**

No pretreatment is required. However, soaking in water or a dilute gibberellic acid solution for 24 hours prior to sowing hastens germination and is recommended. Hot water treatment has been used successfully to stimulate germination (Oyen and Dung 1999).

## Growing area

Seeds are sown at a depth of 2 cm (0.8 in), and can be laid flat or planted with the hilum pointing down.

## Germination

Germination begins in 1–3 weeks, or longer (up to 6 weeks) if seeds were stored more than a few days after collection. Daily watering is often necessary once seeds germinate.

## Media

A well drained medium is recommended, such as 50% peat moss, 25% perlite, 25% vermiculite amended with a little compost, dolomite lime, gypsum, and a 14-14-14 slow-release or an organic fertilizer. In the nursery, 2–4 l (2–4 qt) root-training containers work well. The seedlings should not be allowed to root through the container into the underlying substrate, as the roots would have to be cut or broken for transplanting.

## Approximate size at outplanting

Seedlings have reached target size when approximately 20 cm in height and have a stem diameter of 9 mm (0.35 in). This takes about 3–4 months in good growing conditions.

## Guidelines for outplanting

If seedlings are grown in the nursery, it is crucial to outplant them before they become root-bound. Transplanting seedlings when they have just filled out their growing container will ensure minimal trauma to the root system. In ideal conditions, field survival of about 90% can be expected.

## Direct-seeding

Direct-seeding in the field is the best propagation method if the planting locations are well prepared, weed free, and frequently tended for the first 6–12 months of growth. It eliminates any transplant trauma. In direct-seeding, an area is prepared for each planting spot, cleared of weeds, and cultivated to a depth of 50 cm (20 in) if the soil is compacted. Seeds are planted at a depth of 2–3 cm (0.8–1.2 in). Sowing several seeds at each site allows for selecting the most vigorous seedling and can prevent the necessity of reseedling. The drawbacks of direct-seeding include risk of predator damage (e.g., rats, pigs, cattle, etc.), lack of rains to sustain the newly germinated seeds, and the mandatory frequent maintenance that must be done to ensure weeds do not overcome the seedlings.

## DISADVANTAGES

Jackfruit is susceptible to damage by a wide number of boring insects and plant diseases. Although the tree is long-

lived, the recommended practice in some regions is to remove 20-year-old trees because of declining productivity. Some people find the aroma of the fruit to be objectionable, particularly in confined spaces.

## Potential for invasiveness

Jackfruit does not spread readily and is not considered invasive. In most areas of the world where jackfruit is grown, its presence is indicative of human cultivation.

## Pests and diseases

In southwestern and southern Asia, boring insects seem to be the major pests of jackfruit. These include *Indarbela tetraonis*, *Batocera rufomaculata*, *Margaronia caecalis*, and *Ochyromera artocarpio* (Morton 1987). In India the main insect pests are the shoot-boring caterpillar (*Diaphania caesalis*), mealybugs (*Nipaecoccus viridis*, *Pseudococcus corymbatus*, and *Ferrisia virgata*), spittle bug (*Cosmoscarta relata*), and jack scale (*Ceroplastes rubina*).

In southern China, the fruit stem is susceptible to damage from the larvae of the longicorn beetles *Aprona germarri*, *Pterolophia discalis*, *Xenolea tomenlosa asiatica*, and *Olenecamptus bilobus*. The caterpillars of leaf webbers (*Perina nuda* and *Diaphania bivitalis*), aphids (*Greenidea artocarpis* and *Toxoptera aurantii*), and thrips (*Pseudodendrothrips dwivarna*) are minor problems (Morton 1987).

Important diseases of jackfruit are pink disease (*Pelliculana* [syn. *Corticium*] *salmonicolor*); stem, fruit, and male inflorescence rot caused by *Rhizopus artocarpis*; and leafspot due to *Phomopsis artocarpina*, *Colletotrichum lagenarium*, *Sep-toria artocarpis*, and other fungi. Gray blight (*Pestalotia elastica*), charcoal rot (*Ustilana zonata*), collar rot (*Rosellinia arcuata*), and rust (*Uredo artocarpis*) occur on jackfruit in some regions (Morton 1987).

According to Crane et al. (2002), wood boring insects in Florida include *Elaphidion mucronatum*, *Nyssodrysin hal-demani*, and *Leptostylopsis terraecolor*. Various scales and mealybugs may attack stems and fruit.

Diseases include *Rhizopus* fruit rot (*Rhizopus artocarpis*), gray mold (*Botrytis cinerea*), root rot (*Pythium splendens*, *Phytophthora* spp., *Fusarium* spp., and *Rhizoctonia* spp.), and leaf spotting by fungi (*Gloeosporium* sp. and *Phyllosticta artocarpis*).

## Other disadvantages

The fruit is relatively uncommon in many parts of the Pacific including Hawai'i, and the large size and characteristic odor can be deterrents in the marketplace. Young plants

require protection from grazing animals and sun scald. In plantations, fairly wide spacing between trees is required in order to reduce competition for light, water, and nutrients.

## AGROFORESTRY/ENVIRONMENTAL PRACTICES

### Soil stabilization

The tree can be planted on farms to control soil erosion.

### Crop shade/overstory

Jackfruit is used as a shade tree for coffee, pepper, betel nut, and cardamom. Because the tree casts a deep shade, wide spacing such as 15 x 15 m (50 x 50 ft) is recommended unless the intercrop is considered short-term.

### Intercropping

In the Philippines, jackfruit has been used as an intercrop with coconuts. Other intercrops include durian, mango, and citrus. At an early age, short-term crops such as banana, sweet corn, and groundnut have been grown.

### Homegardens

Jackfruit makes an excellent tree for a homegarden for its beautiful foliage, many products, and bountiful production. One large tree in its prime can supply fruit for several families.

### Windbreaks

Jackfruit makes a very good component in a multi-species windbreak and has been known to withstand hurricane-force winds. Because the fruit is borne on the main trunk and interior of larger branches, fruit damage due to



Left: A heavily bearing mature jackfruit growing among other fruit trees including banana. Right: Trees grown for timber with side branches pruned and fruiting branchlets regularly removed from the lower trunk. PHOTOS: C. ELEVITCH

moderate wind is minimal.

### **Silvopasture**

Livestock readily eat jackfruit foliage, so young trees would not survive exposure to grazing animals. However, livestock can be pastured among mature trees. Fallen fruit are readily eaten by livestock and make an excellent contribution to their diet.

### **Host plant trellising**

Jackfruit has been used as a support for pepper vine and yam (*Dioscorea* spp.).

### **Ornamental**

Jackfruit has glossy, medium to deep green foliage and makes a wonderful ornamental. The highly fragrant fruit may be offensive to neighbors, which can be a drawback to growing jackfruit near houses, especially in urban areas.

## **USES AND PRODUCTS**

### **Staple food**

The pulp of the young fruit is cooked as a starchy food and has a consistency resembling meat. The young fruit is also pickled or canned in brine or curry.

### **Fruit**

The ripe fruit is eaten fresh or is processed into numerous delicacies including jam, jelly, and chutney. It also makes an excellent dried fruit or preserved candy when combined with sugar or honey. The pulp is also used as a flavoring in ice cream and drinks. Canned fruit is available in ethnic markets (e.g., Hawai'i).

### **Nut/seed**

The seeds must be cooked by boiling or roasting prior to eating. They are an excellent addition to curries, or can be eaten freshly cooked or dried with salt as a snack. The cooked and dried seeds are milled to a flour-like consistency and added to bread dough.

### **Leaf vegetable**

The tender young leaves are cooked and eaten as a vegetable.

### **Other vegetable**

Young male flower spikes can be grated or smashed and eaten with salt and vinegar as a vegetable, or pickled. They are also cooked and served as a vegetable.

### **Beverage/drink/tea**

Aside from flavoring for beverages, the fruit can be fermented and distilled to produce an alcoholic liquor.

### **Medicinal**

All parts of the tree are said to have medicinal properties. Morton (1987) reports, "The Chinese consider jackfruit

## **TIPS**

### **How to tell if a fruit is mature**

In order to achieve best fruit quality, the fruit must be allowed to develop to full maturity on the tree, then ripen after harvest. Harvested even a few days too early, the fruit will not ripen to its best quality. Fruits take 3–8 months from flower to mature fruit, depending on the individual tree, growing conditions, and weather; therefore, time from flowering alone is not a good indicator of maturity. It takes some experience to gauge maturity. There are four primary indicators. 1) The skin turns from light green to yellowish or brownish green; 2) the points of the spines grow further apart and flatten slightly, and the skin yields slightly to pressure; 3) The last leaf on the stalk turns yellow; 4) the fruit produces a dull, hollow sound when tapped. Usually two or more of these indicators are used to evaluate the maturity of fruit. After harvesting a mature fruit, it ripens in 3–7 days and begins to emit its strong, characteristic fragrance. For most people, the fragrance is too strong to bear indoors, and the fruit is kept outside or in an open shed until eaten.

### **Harvesting fruit**

Fruits are collected using an orchard ladder or by climbing the trees, cutting the stem of the fruit, and carefully lowering the fruit to the ground with a rope if necessary.

### **Reducing latex**

Harvesting ripe fruits between mid-morning and late afternoon can reduce latex flow (Acedo 1992).

### **How to avoid a sticky mess**

When cutting into a jackfruit, a very sticky latex is exuded from the rind and fibrous parts of the fruit. Coating the knife and hands with edible oil (such as coconut oil) will prevent the latex from sticking. If some latex becomes inadvertently stuck to the skin or hair, it can be removed by rubbing with edible oil.



**George and Margaret Schattauer show a 'Black Gold' fruit from their orchard weighing 34.7 kg (76.4 lb). Kealakekua, Hawai'i. PHOTO: K. LOVE**

pulp and seeds tonic, cooling and nutritious, and to be 'useful in overcoming the influence of alcohol on the system'. The seed starch is given to relieve biliousness and the roasted seeds are regarded as aphrodisiac. The ash of jackfruit leaves, burned with corn and coconut shells, is used alone or mixed with coconut oil to heal ulcers. The dried latex yields artostenone, convertible to artosterone, a compound with marked androgenic action (having male hormone activity). Mixed with vinegar, the latex promotes healing of abscesses, snakebite and glandular swellings. The root is a remedy for skin diseases and asthma. An extract of the root is taken in cases of fever and diarrhea. The bark is made into poultices. Heated leaves are placed on wounds. The wood has a sedative property; its pith is said to produce abortion."

#### **Animal fodder**

Cattle, goats, and other small ruminants relish the leaves. Cattle and pigs also readily eat fallen fruit. The waste after removing the pulp from fruits ("rags") is considered good

fodder for cattle and pigs.

#### **Flavoring/spice**

The ripe pulp, fresh, concentrated, or powdered, is made into flavoring for ice cream and beverages.

#### **Masticant/stimulant**

The latex can be used as chewing gum.

#### **Timber**

The wood is classified as a medium hardwood (specific gravity 0.6–0.7) and is highly valued for building material, furniture and cabinet making, and even for musical instruments. It is highly durable, resisting termites and decay, seasons easily, resembles mahogany in appearance, and takes a beautiful polish. As the wood ages, it turns from yellow or orange to red or brown. Although not as strong as teak (*Tectona grandis*), jackfruit wood is considered superior for many purposes including furniture, construction, turnery, masts, oars, implements, and musical instruments. The excavated roots of old trees are highly prized for carving and picture frames.

#### **Fuelwood**

Branches and trunk are burned for fuelwood.

#### **Craft wood/tools**

In the province of Cebu, Philippines, the wood is highly prized for making guitars, ukuleles, and other musical instruments.

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

The inner bark can be made into cordage or cloth.

#### **Wrapping/parcelization**

In India, leaves are used to wrap food for cooking and are woven together for plates.

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

The heated latex can be used as a glue for mending chinaware and pottery and as caulking for boats and buckets. The latex contains resins that may have use in varnishes. The latex also has bacteriolytic value comparable to that of papaya latex. Additionally, the sticky latex is used for trapping birds (birdlime) and for insect traps.

#### **Tannin/dye**

There is 3.3% tannin in the bark. When boiled with alum, wood chips, or sawdust, it yields a dye that is commonly used to give the characteristic color to the robes of Buddhist priests and in dyeing silk.



Cutting a large fruit, Rayong, Thailand. PHOTO: C. ELEVITCH

### Ceremonial/religious importance

In India and Nepal, flowers and fruit are offered to Lord Vishnu on the eleventh day of Shraavan. According to Morton (1987), dried branches are used to produce fire by friction in religious ceremonies in Malabar.

## COMMERCIAL CULTIVATION

The primary commercial products of jackfruit are fruit, timber, and to a lesser extent, fodder. In the Pacific the tree is most commonly grown in homegardens rather than for commercial purposes. Jackfruit is a popular tree for homegardens in India, the Philippines, Thailand, Sri Lanka, and other regions where jackfruit is grown commercially.

### Spacing

For fruit production, trees are planted 7.5–12 m (25–40 ft) apart. Closer in-row spacing can be used for slower growing or more compact clonally reproduced cultivars (usually

grafted clones) with in-row spacing of 4.6–7.6 m (15–25 ft) and between-row spacing of 6.1–7.6 m (20–25 ft) (Crane et al. 2002). For timber production, closer spacing should be used to inhibit side branching by shading and promote long, straight trunks. Spacing for timber of 2 x 3 m or 3 x 3 m (6.6 x 10 or 10 x 10 ft) is suitable.

### Management objectives and design considerations

During early establishment it is essential to control weeds, maintain soil moisture, and protect the area from all grazing animals. Weed-seed-free mulch such as leaves, chipped tree branches, or hay works very well to help suppress weeds and reduce soil evaporation. An alley cropping system to produce mulch for a jackfruit orchard gave promising results (Elevitch and Wilkinson 1999). At an age of 2–3 years, the trees can be topped at 3–5 m (10–16 ft) height to encourage lateral growth for fruit production at an accessible height. Once a tree is topped, however, new branches will not be as strong as the original frame of the tree, and top pruning will have to be done throughout the life of the tree to avoid branches breaking off due to wind or the weight of the fruit.

Pruning damaged branches, especially on the lower interior of the tree, is advised. Fertilizer needs are not well studied for jackfruit. The tree seems to perform well even on moderately fertile soils. A recommended commercial fertilizer regime is 100–150 g (3.5–5 oz) ammonium sulfate (20-0-0) per tree in the first year, increasing in pre-bearing years; then 0.5–1.0 kg (1.1–2.2 lb) of 14-14-14 fertilizer per tree increasing with age and size, with a full-grown tree 15–20 years old receiving 2–3 kg (4.4–6.6 lb) complete fertilizer (Coronel 1983). The use of nutrient-rich organic mulches such as prunings from fast-growing nitrogen-fixing trees can reduce or eliminate the use of industrial fertilizer.

For timber production, it is important to keep the lower portion of the trunk clear of branches and fruit-bearing lateral spikes in order to produce clear, knot-free wood. Because jackfruit has a tendency to produce fruit-bearing spikes low on the trunk, annual pruning of these spikes is often necessary.

### Advantages of polycultures

During the early years, jackfruit can be successfully intercropped with a number of short-term crops such as legumes, vegetables, and banana. The intercrop makes use of the unproductive space available in the early years and gives an income before the jackfruit trees come into production. As the trees grow closer, the crops grown among the trees can be replaced by a permanent ground cover.

**Table 1. Tree characteristics of cultivars found in Hawai‘i (after Crane et al. 2002).**

Cultivar and origin	Growth habit and rate	Fruit weight	Fruit shape	Yield per tree	Season and months	Comments
‘Black Gold’ Australia	Open, spreading, fast	10 kg (22 lb)	Long, tapered	55–90 kg (120–200 lb)	Late, Sept.– Oct.	Tree easily pruned to maintain small tree (~2.5 m [8 ft])
‘Dang Rasimi’ Thailand	Open, spreading, fast	8–9 kg (18–20 lb)	Uniform oblong	(75–125 kg (165–275 lb)	Mid, July– Aug.	Vigorous tree; annual pruning needed to maintain moderate size (~3.3 m [11 ft])
‘Gold Nugget’ Australia	Dense, spreading, fast	3–5.5 kg (7–12 lb)	Round	60–80 kg (132–176 lb)	Early, May– June	Thinning number of fruit recommended; tree easily pruned to maintain small tree (~2.5 m [8 ft])
‘Honey Gold’ Australia	Sparse, spreading, slow-moderate	4.5–5.5 kg (10–12 lb)	Blocky	35–50 kg (77–110 lb)	Mid, July– Aug.	Thinning number of fruit recommended; tree easily pruned to maintain small tree (~2.5 m [8 ft])
‘Lemon Gold’ Australia	Moderately dense, spreading, moderate	6 kg (13 lb)	Blocky	30–45 kg (66–100 lb)	Mid, July– Aug.	Vigorous tree; annual pruning needed to maintain moderate size (~3.5 m [12 ft])
‘NS1’ Malaysia	Dense, upright, moderate	4–5.5 kg (9–12 lb)	Blocky	90 kg (200 lb)	Early, May– June	Thinning number of fruit recommended for young trees; moderately vigorous tree; annual pruning to maintain moderate size (~3 m [10 ft])

**Table 2. Characteristics of edible portion, cultivars found in Hawai‘i (after Crane et al. 2002).**

Cultivar	Color	Texture	Flat spines at ripening	% edible flesh	# seeds per fruit; seed %	Flavor	Comments
‘Black Gold’	Deep orange	Medium-firm to melting, soft	No	35%	192; 17%	Good, sweet, aromatic	Flesh easily removed
‘Dang Rasimi’	Deep orange	Firm to soft	No	32%	187; 12%	Mild, sweet flavor, pleasant aroma	Flesh thin walled
‘Golden Nugget’	Deep orange	Soft to medium firm	Yes	41%	79; 13%	Very pleasant flavor	Fruit may split after heavy rains
‘Honey Gold’	Dark yellow to orange	Firm	Yes	36%	42; 5%	Sweet, rich flavor and aroma	Flesh thick walled, excellent texture
‘Lemon Gold’	Lemon yellow	Firm	Yes	37%	104; 14%	Sweet and aromatic flavor	Flesh thick walled
‘NS1’	Dark orange	Firm	Yes	34%	63; 5%	Sweet rich flavor	Excellent texture



Once topped, trees require continual pruning or the new growth of stems often breaks under the weight of the fruit.

PHOTO: C. ELEVITCH

Perennial crops such as durian, coffee, and citrus can be grown together with jackfruit, given wider spacing between jackfruit trees to allow sufficient space for the other crop trees.

### Yields

Potential yields of 100–200 fruits per tree per year have been estimated. For example, in India a good annual yield is considered to be 150 large fruits per tree (Morton 1987). Actual yields of mature trees are 70–100 kg (150–220 lb) of fruit/tree/yr depending on variety, cultural practice, and environmental factors (Soepadmo 1992).

### On-farm processing methods

The fruit can be processed in several ways such as drying, candying, and pickling. These are relatively simple methods to preserve the fruit that can be done on-farm.

### Markets

Jackfruit is heavy and cumbersome to transport and should be harvested when mature only 3–5 days from ripening, so it is best to have a market close by if selling fresh fruit. For more remote areas, where the local market is small, processing the fruit into a more stable product such as dried or processed fruit may be necessary.

## INTERPLANTING/FARM APPLICATIONS

Jackfruit has been planted as an intercrop in coconut groves, in durian, mango, and citrus orchards, and for dispersed shade in coffee plantations. In young jackfruit orchards, where there is ample space between trees, annual crops can be grown. One or two trees growing in mixed homegardens together with numerous other tree crops is also very common.

### Example system

(after Elevitch and Wilkinson 1999a)

#### Location

Holualoa, Hawai'i.

#### Description

This project studied alley cropping for mulch production in a jackfruit orchard. In alley cropping, fast growing nitrogen-fixing trees (NFTs) are grown in contour hedgerows alternated with crops to provide an abundant source of nutrient-rich organic matter that is applied to the soil as mulch. By cycling nutrients in the agricultural system, alley cropping in an orchard setting holds promise for greatly reducing, and possibly eliminating, the need for manufactured or imported fertilizer inputs, replacing them with an on-site organic source of fertility. Research focused primarily on the ability of the alley cropping technique to provide sufficient nutrients to tree crops, as well as the economic feasibility of the practice for orchards. The two NFT species were *Acacia angustissima* and *Calliandra calothyrsus*.

#### Crop/tree interactions

The hedgerows were pruned for mulch four times during the project. Hedgerow prunings fresh weight and nutrient concentrations for the two NFT species were measured at each cutting to ascertain fertilizer replacement values. Data show that the hedgerows produced about 136 kg (300 lb) of mulch per fruit tree per year. Nutrients from this mulch source provided the nutrient equivalent of over 561 kg chemical fertilizer per hectare per year (500 lb/ac/yr), potentially replacing 180 kg (400 lb) urea, 11 kg (25 lb) treble



**Hedgerows of fast-growing nitrogen-fixing trees grown between rows of jackfruit.** PHOTO: C. ELEVITCH

superphosphate, and 55 kg (120 lb) muriate of potash. Soil analysis showed significant increases in total nitrogen and potassium as a result of the practice. Soil pH also improved, becoming less acidic. The mulch also reduced the need for weed control around the crop trees and conserved soil moisture. The health and vigor of the mulched crop trees visibly surpassed that of the control trees without mulch, and analysis of the data shows a trend of faster growth and larger stem diameter in the mulched trees over unmulched. The costs of this practice are roughly equivalent to using purchased mulch materials. This practice may be particularly of benefit to cash-poor Pacific island farmers, who have better access to labor than cash.

### Spacing/density of species

The jackfruit trees were planted in contour rows 8–12 apart with 4 m (13 ft) spacing between trees in-row. The contour hedgerows were planted midway between jackfruit rows.

## PUBLIC ASSISTANCE AND AGROFORESTRY EXTENSION

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

## GENETIC RESOURCES

Germplasm collections are located in the United States (U.S. Department of Agriculture, Subtropical Horticultural Research Unit, Miami, Florida), Indonesia (Centre for Research & Development in Biology, Bogor), the Philippines (Institute of Plant Breeding, Los Baños), and Thailand (Plew Horticultural Research Centre).

## BIBLIOGRAPHY

(☛ indicates recommended reading)

- Abdoellah, O.S. 1990. Home gardens in Java and their future development. pp. 69–79. In: Landauer, K., and M. Brazil (eds.). *Tropical Home Gardens*. United Nations University Press, Tokyo.
- ☛ Acedo Jr., A.L. 1992. *Jackfruit Biology, Production, Use, and Philippine Research*. Monograph Number 1. Forestry/Fuelwood Research and Development (F/FRED) Project, Arlington, Virginia.
- Anonymous. 1998. Comoro Islands. *Worldmark Encyclopedia of Nations. Africa*. Gale, Detroit.
- ☛ Campbell, R.J., and N. Ledesma. 2003. *The Exotic Jackfruit: Growing the World's Largest Fruit*. Fairchild Tropical Garden, Coral Gables, Florida.
- Clarke, W.C., and R.R. Thaman. 1993. *Agroforestry in the Pacific Islands: Systems for Sustainability*. United Nations University Press, Tokyo.
- Coronel, R.E. 1986. *Promising Fruits of the Philippines*. University of the Philippines at Los Baños, College of Agriculture, Laguna.
- ☛ Crane, J.H., C.F. Balerdi, and R.J. Campbell. 2002. The Jackfruit (*Artocarpus heterophyllus* Lam.) in Florida. Fact Sheet HS-882. Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville. <[http://edis.ifas.ufl.edu/BODY\\_MG370](http://edis.ifas.ufl.edu/BODY_MG370)>.
- Elevitch, C.R., K.M. Wilkinson, and B. Mathews. 1998. Mulch from hedgerows of nitrogen fixing trees affects soil nutrient levels in a jackfruit orchard. *Forest Farm and Community Tree Research Reports* 3: 21–25.
- Elevitch, C.R., and K.M. Wilkinson. 1999. Orchard Alley Cropping in the Subhumid Tropics. *Permanent Agriculture Resources, Holualoa, Hawai'i*. <[http://wsare.usu.edu/pubs/98\\_99ar/pdf/sarefinal/aw95-103.pdf](http://wsare.usu.edu/pubs/98_99ar/pdf/sarefinal/aw95-103.pdf)>.
- Elevitch, C.R., and K.M. Wilkinson. 1999. A Guide to Orchard Alley Cropping for Fertility, Mulch and Soil Conservation. *Permanent Agriculture Resources, Holualoa, Hawai'i*. <<http://agroforestry.net/pubs/oachbk.pdf>>.
- Elevitch, C.R., and K.M. Wilkinson (eds.). 2000. *Agroforestry Guides for Pacific Islands*. Permanent Agriculture Resources, Holualoa, Hawai'i.
- Falanruw, M.V.C. 1990. The food production system of the Yap Islands. pp. 94–104. In: Landauer, K., and M. Brazil (eds.). *Tropical Home Gardens*, United Nations University Press, Tokyo.
- Fosberg, F. R., M. Sachet, and R. Oliver. 1979. A Geographical Checklist of the Micronesian Dicotyledonae. *Micronesia Volume 15*: 1–295.
- Food and Agriculture Organization of the United Nations (FAO). 1985. *Fruit Bearing Forest Trees*. FAO, Rome.

- ☛ Gunasena, H.P.M. 1993. Documentary Survey on *Artocarpus heterophyllus* (Jackfruit) in Sri Lanka. Monograph Number 2. Forestry/Fuelwood Research and Development (F/FRED) Project, Winrock International, Arlington, Virginia.
- Hossain, M.K., and T.K. Nath. 2002. *Artocarpus heterophyllus* Lam. In: Vozzo, J.A. (eds.). Tropical Tree Seed Manual. Agriculture Handbook 721. U.S. Department of Agriculture Forest Service, Washington, DC.
- ☛ Morton, J. 1987. Fruits of Warm Climates. Julia F. Morton, Miami, Florida. <[http://www.hort.purdue.edu/newcrop/morton/jackfruit\\_ars.html](http://www.hort.purdue.edu/newcrop/morton/jackfruit_ars.html)>.
- Neal, M. 1965. In Gardens of Hawaii. Bishop Museum, Honolulu.
- Ramesh, B.R. No Date. Vegetation types in the Western Ghats. <<http://sdnp.delhi.nic.in/nbsap/themes/terrestrial/vegetationtypes.html>>.
- ☛ Salim, A.S., A.J. Simons, C. Orwas, J. Chege, B. Owuor, and A. Mutua. 2002. Agroforestry database. World Agroforestry Centre, Nairobi, Kenya. <<http://www.worldagroforestrycentre.org/Sites/TreeDBS/AFT/AFT.htm>>.
- Smith, S.C. 1981. Flora Vitiensis Nova: A New Flora of Fiji, Vol. 2. National Tropical Botanical Garden, Lāwā‘i, Hawai‘i.
- Soepadmo, E. 1992. *Artocarpus heterophyllus* Lam. In: Verheij, E.W.M., and R.E. Coronel (eds.). Plant Resources of South East Asia 2. Edible Fruits and Nuts. PROSEA, Bogor, Indonesia.
- Thaman, R.R., and I. Ali. 1993. Agroforestry on smallholder sugar-cane farms in Fiji. In: Clarke, W.C., and R.R. Thaman (eds.). Agroforestry in the Pacific Islands: Systems for Sustainability. United Nations University Press, Tokyo.
- Whistler, W.A. 2000. Plants in Samoan Culture: The Ethnobotany of Samoa. Isle Botanica, Honolulu.
- Wilkinson, K.M., and C.R. Elevitch. 2003. Propagation protocol for production of container *Artocarpus heterophyllus* Lam. plants; Permanent Agriculture Resources, Holualoa, Hawai‘i. In: Native Plant Network. Forest Research Nursery, College of Natural Resources, University of Idaho, Moscow, Idaho. <<http://www.nativeplantnetwork.org>>.



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

## *Artocarpus heterophyllus* (jackfruit)

**Authors:** Craig R. Elevitch<sup>1</sup> and Harley I. Manner<sup>2</sup>

1. Permanent Agriculture Resources, PO Box 428, Hōlualoa, HI 96725 USA; Tel: 808-324-4427; Fax: 808-324-4129; E-mail: [par@agroforestry.net](mailto:par@agroforestry.net); Web: <http://www.agroforestry.net>
2. University of Guam, College of Arts and Sciences, UOG Station, Mangilao, GU 96923 USA; Tel: 671-735-2874; Fax: 671-734-5255; E-mail: [hmanner@uog.edu](mailto:hmanner@uog.edu)

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