

**Farm and Forestry
Production and Marketing profile for**

Mangosteen

(Garcinia mangostana)

By Yan Diczbalis

USES AND PRODUCTS

Mangosteen is primarily consumed as a fresh fruit. The fruit is common delicacy and often referred to as the “Queen of Fruit” in Southeast Asia.

The volume of production in Thailand is increasing and fruit is now being processed into value-added products such as jam, candy, and wine.

In traditional communities, the fruit pericarp (rind) was used as an antibacterial agent and for curing diarrhea. The use of the fruit rind and or whole fruit as a medicinal/nutritional beverage has been a recent trend in western societies. Mangosteen extracts and processed products have now entered the worldwide health food and nutritional supplement market.

The timber, dark red in colour, is used when available in cabinet making and where a heavy durable wood is required.

Scale of commercial production worldwide and in the Pacific

Thailand is the world’s largest producer of mangosteen, producing approximately 240,000 metric tons (MT) annually, with exports recorded at 15,000 MT in 2006. Malaysia, Vietnam, and Indonesia are also major producers. Most people enjoy mangosteen and the fruit has a ready market in western countries where it is considered a tropical delicacy. Recent production in Central America is being exported into Europe. A modest commercial production occurs in Hawai’i, primarily for local markets. The fruit has a good postharvest life which is beneficial for export, although it is regarded due to lack of contradictory evidence as a potential fruit fly host.

NOMENCLATURE

Preferred scientific name

Garcinia mangostana L

Family

Clusiaceae

Non-preferred scientific names

None.

Common names

English: mangosteen, purple mangosteen, queen of fruit

Indonesia, Philippines: *manggis*

Thailand: *mang khút*

Vietnamese: *cây măng cụt*

Japanese: *mangosuchin*

French: *mangostan, mangostanier, mangoustan, mangoustanier*

BRIEF BOTANICAL DESCRIPTION

Mangosteen is a slow growing, pyramidal shaped evergreen tree growing up to 30 m (100 ft). The single stemmed trunk has symmetrical and alternatively opposite branches. The trees flush from terminal shoots 3–4 times per year. Young emerging leaves are red/pink in colour, turning light green and dark green as they mature. The flower buds protrude from between the terminal leaf petioles as small bulbous protrusions usually as single floral bud but also occur as double or triple buds. The flowers, having four sepals and four petals, are borne on short thick stalk. Mangosteen produces only female flowers. The tree has large thick, elliptic shaped leathery leaves.



Left: Perfect fruit on display. Right: 100% mangosteen fruit drink sold as “super fruit” nutritional supplement in a health food store. Kahalui, Hawai’i.



Left: Symmetrical and alternatively opposite branching in mangosteen. Note that internal secondary branches have been removed to facilitate air movement through the tree. Top right: Mangosteen shoot enclosed by the terminal leaf pair petioles (leaf stalks). Bottom right: New leaf flush.

DISTRIBUTION

Native range

Mangosteen is believed to be a sterile hybrid between *G. hombronia* and *G. malaccensis* (Yaacob and Tindall 1995). It was originally distributed in the Malay Peninsula and the eastern Indonesian archipelago and the island of Borneo.

Current distribution worldwide

The tree is widely distributed throughout Southeast Asia where it is an important commercial fruit crop. The crop is grown extensively in Thailand, Cambodia, Vietnam, Philippines, Laos, and Burma. Mangosteen is also widely distributed into northern Australia, India, West Indies, Central and South America, Africa, and Hawai'i. There are also claims of flowering and fruit specimens grown in greenhouses in England. Viable commercial production generally occurs within 10° of the equator but extends to 18°S on the east coast of Australia and 22°N in Hawai'i. Specimen plants exist throughout the Pacific, however, it is not widely commercialized in this region.

Relatives of mangosteen such as *G. hombronia*, *G. warrenii*, *G. livingstonei* are widely distributed (Borneo, Australia, and Africa). Many of the former *Rheedea* species in South America have been taxonomically reclassified as *Garcinia* species (e.g., *G. intermedia*, *G. madrona*, *G. brazilliensis*, and *G. laterifolia*).

The Pacific is the home of a few important edible relatives, namely, *Garcinia pseudoguttifera*, *G. hollrungii*, *G. jaweri*, and *G. floribunda* (Walter and Sam 2002). *Garcinia dulcis* is commonly found in the Pacific following introduction as a fruit suited to village production. There are also native ornamental/forest species such as *heilala* (*Garcinia cessilis*), and *feto'omaka* (*Garcinia myrtifolia*) in Tonga (Chay et al. 2007).

ENVIRONMENTAL PREFERENCES AND TOLERANCES

Mangosteen prefers a warm and humid environment with well distributed rainfall and a 3–5 week dry season. The plant is native to the equatorial tropics. Young seedlings

prefer a high level of shade and young trees prefer moderate shade. Mature trees provided with adequate moisture and nutrients will grow, flower, and fruit in full sun if humidity remains high. Weibel et al. (1993) report that maximum photosynthesis in mangosteen occurs at low light levels similar to that observed in understory rainforest trees. In severe environments with high irradiance, e.g., the monsoonal tropics of Northern Territory, Australia, mangosteen struggles in full sunlight during the dry season even with adequate irrigation.

Soils

Mangosteen prefers deep, well drained soils with good moisture retention. The tree grows well on deep river loams. Soils should be high in organic matter. It has been observed to perform poorly on sandy soils low in organic matter. In North Queensland, trees have been grown on soils with a pH range of 4.8–7.6 and 1.5–7.9% organic matter.

GROWTH AND DEVELOPMENT

The mangosteen is a slow growing tree taking 2–3 years for seedlings to reach a stage where they can be planted in the field. Under ideal conditions of temperature, soil moisture and light, young mangosteens may produce 4–5 vegetative flushes per year, however, only 2–3 flushes is common. The leaf petioles of the terminal flush hide the growing tip. Vegetative and reproductive buds emerge through the joint between the two terminal leaf stalks.

Young seedlings and nursery trees require at least 50% shade. Newly planted trees also prefer shade provided artificially

Elevation, rainfall, and temperature

	lower: sea level
Elevation range	upper: 1,000 m (3,300 ft) in the tropics. Mangosteen will grow above 300 m [1,000 ft] in Hawai'i but not produce fruit reliably.
Mean annual rainfall	lower: 1,500 mm (60 in) upper: 5,000 mm (200 in)
Rainfall pattern	Mangosteen can thrive in summer, bimodal, and uniform rainfall patterns. Irrigation may be required where mean rainfall is less than 100 mm/month
Dry season duration (consecutive months with <40 mm [1.6 in] rainfall)	1–2 months
Mean annual temperature	lower: 22°C (72°F) upper: 28°C (82°F)
Mean maximum temperature of hottest month	lower: 23°C (73°F) upper: 35°C (95°F)
Mean minimum temperature of coldest month	lower: 15°C (59°F) upper: 25°C (77°F)
Minimum temperature tolerated	8°C (46°F)

(shade cloth and stakes) or by companion plants such as banana or shade tree species. Mature trees provided with adequate moisture and nutrients will grow, flower, and fruit in full sun.

All parts of the mangosteen contain a thick yellow latex which oozes from wounds. The latex, commonly known as “gamboge,” can compromise fruit quality if the fruit are injured by insects or high soil moisture levels promote latex rupture within the fruit.

Flowering and fruiting

In North Queensland, the earliest recorded age at which mangosteens have been observed to flower and fruit is 6 years with 8–10 years of age being most common. Ten years or longer is typical in Hawai'i. Flowering occurs at the shoot tip, generally after a rain free period of 3–4 weeks. In North Queensland, the main flowering occurs in November/December following 2–3 dry months. A minor flowering occurs in August in some seasons. Two flowering periods are commonly experienced in growing areas which receive a bimodal rainfall pattern. Fruit is ready for harvesting in 100–120 days after flowering, with the development period varying depending on temperature.

AGROFORESTRY AND ENVIRONMENTAL SERVICES

Mangosteen is often interplanted with other species because of the beneficial effect of shade on tree growth and yield particularly where soil moisture and nutrient supply may be limited. Mixed fruit tree gardens are common in traditional Southeast Asian village life where mangosteen has an important role. The tree is attractive, a visual and productive asset to any garden where sufficient room is available. It's dense crown, extending nearly to the ground, could be an asset as a privacy barrier in urban areas.

PROPAGATION AND PLANTING

Mangosteen is commonly propagated from its recalcitrant seed whose viability is limited to several days if allowed to dry. Seed should be cleaned and kept moist in a neutral substrate such as perlite, clean sawdust, or charcoal if storage is required for up to 2 weeks. Genetic research has shown that there are a number of different types, which results in small but perceptible differences in fruit and tree shape. Before ordering seed, the grower should be aware of fruit characteristics of the mother trees. Seeds should be sown in tall pots (>30 cm [12 in]) to allow taproot development to occur.

Wood from a bearing tree can also be grafted onto seedling rootstock. Such grafted trees tend to flower earlier, but fruit are smaller and tree vigor and shape is difficult to maintain.



Left: Week-old mangosteen seedlings. Right: A small grafted tree that is already bearing fruit. Rayong, Thailand.

Hence there are few if any advantages to grafting and it is not commonly undertaken commercially.

Mangosteen seedlings are notoriously slow growing. A porous but moist mix is important for good growth. In Australia, a mix of equal parts of sand, peat, and composted pine-bark is recommended. Regular use of foliar fertilizers and small amounts of urea or sulphate of ammonia can assist rapid development. Shade, water and nutrient management, and warm conditions are critical to rapid seedling development.

Well developed nursery trees approximately 100 cm [40 in] tall are preferred for planting out. Mangosteen needs particular care at planting. The roots are sensitive to disturbance and moving plants from the shade house environment to the open field requires a hardening off process or the provision of shade in the field.

Companion plants such as banana or other fast growing food crops can provide useful shade and protection for young field-planted mangosteen trees.

CULTIVATION

Variability of species and known varieties

Until recently, all mangosteen trees were considered to be identical because fruit and seed develop without sexual fertilization taking place. Studies in Malaysia (Bin Osman and Rahman Milan 2006) indicated that 16 of 830 mangosteen accessions collected were identified as being distinctly different. Growers in non-traditional mangosteen growing areas have noted that fruit and tree shape may vary depending on the seed source. Genetic finger printing studies (Sando et al.

2005) carried out in Australia showed that there were three distinct varieties growing in Australia. Only two of the varieties have fruited and the major difference in “Borneo”-sourced seed material is that the fruit are elliptical in shape and the trees have noticeably sparser foliage with upright branches. The more usual spherical fruit variety is preferred as it is considered more vigorous and the fruit are easier to pack.

Basic crop management

There are no special horticulture techniques required to produce mangosteen except the skill and experience required to raise healthy trees. Well managed, healthy mangosteen trees, clearly evident by appearance, will flower and fruit earlier and produce more abundant and larger fruit. Patience and



Entries in a “largest fruit” competition in Chanthaburi, Thailand. The largest fruit weighed 230 gm (8 oz), far larger than the average size for mangosteen fruit of 70–125 gm (2.5–4.5 oz).



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Top: A young mangosteen seedling planted with pigeon pea (*Cajanus cajan*), a leguminous tree for temporary shade. San Marcos district, Guatemala. Middle: Juvenile mangosteen trees with companion banana and artificial shade in North Queensland. Bottom: Young mangosteen seedling growing in the shade of an old rambutan tree it will eventually replace. Chanthaburi, Thailand.



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Young mangosteen trees that were originally established in commercial bananas and grown with palms as permanent shade. Far North Queensland.

continued regular management is crucial to the success of mangosteen production. At flowering and early fruit development, control of red banded thrips and mites is important if well presented, unblemished fruit are required for the market. Recommended basic crop management includes

- Irrigate, particularly when the monthly rainfall is less than 150 mm (6 in)
- Fertilize (foliar, inorganic, and organic) in small amounts regularly
- Ensure the area under the canopy is well mulched and weed free
- Maintain control of pests and diseases
- Control competition from shade trees or companion plants if present.

The management routine remains much the same for 6–10 years before flowering begins. Commercial fertilizer recommendations vary but rates for mature fruiting trees of 3–6 kg (6.6–13.2 lb) per tree per year of $N:P_2O_5:K_2O$ (12:12:17) or similar are generally used.

Advantages and disadvantages of polycultures

Mangosteen is well adapted to being grown in a polyculture. The shade and other micro-environmental benefits (reduced wind, etc.) provided by companion species are of enormous benefit to early growth. Mangosteen can be an irregular producer in some environments, hence the addition of other species in the open space ensures that the plot of land remains productive with an added bonus when the mangosteen produces fruit. Fast growing banana and papaya are excellent companion plants that ensure early production as well as improving the microenvironment for young mangosteen trees.



Top: Mature mangosteen trees established and grown under permanent shade (*Albizia falcataria*) in Far North Queensland. Middle: A mixed orchard of mangosteen, rambutan, and durian. Rayong, Thailand. Bottom: Young tree interplanted with culinary herbs. Chanthaburi, Thailand.

PESTS AND DISEASES

Susceptibility to pests/pathogens

Mangosteen is moderately susceptible to a range of pests and diseases. Problems increase in suboptimal environments. Leaf eating pests (caterpillars, grasshoppers, beetles) can be a problem. Control is important, particularly for young trees where severe defoliation can slow development. Large mature trees are not as susceptible to this type of pest.

Fruit skin quality can be adversely affected by a mite and red-banded thrip. The rasping feeding action of these pests can cause scarring to the fruit surface, which, although cosmetic in nature, can greatly devalue the fruit for the fresh market.

A few diseases have been recorded in mangosteen. In North Queensland, *Pestalotia* sp. has been associated with canker development and shoot tip die back. This disease is seen more commonly where trees are growing poorly or have been severely sunburned following a rapid loss of shade. Applications of copper fungicides are recommended as well as improved water and nutrient management. Stem canker, algal leaf spot, and sooty mould can also present as problems.

Gamboge and translucent flesh, common imperfections that are not due to pests or diseases, tend to be a greater problem if fruit mature during very wet conditions.

Sustainable methods for preventing and treating problem pests and diseases

Ideal growing conditions and vigorous, healthy trees are the most sustainable method of preventing and treating pest and disease problems in mangosteen. Slow growing trees where growth is compromised are most susceptible to pest and disease problems.

Few pesticides are registered specifically for mangosteen. Commonly available insecticides and copper-based fungicides can handle most problems. Always read and follow pesticide labels.

DISADVANTAGES OF THIS CROP

The tree requires reasonably exacting conditions for it to grow and bear well. The long juvenile period is a constraint to commercial profitability. In North Queensland, gross margin analysis suggests that a mangosteen orchard does not have a positive return on investment within the first 20 years.

Potential for invasiveness

Mangosteen is not an invasive plant due to the special care required for seed germination and early seedling growth.



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Top left: Mangosteen fruit downgraded because of severe gamboge present on the fruit skin. Bottom left: Mangosteen fruit with internal gamboge most likely caused by rupture of cells following fruit fall. This damage is often not visually evident in whole, unopened fruit. Right: An internal gamboge rupture can usually be detected as a hard spot on the fruit skin.

COMMERCIAL PRODUCTION

Postharvest handling and processing

Mangosteen fruit are climacteric. Climacteric fruit can be picked from the tree when they are mature and will continue to ripen, whereas non-climacteric fruit must ripen fully on the tree prior to harvest. As mangosteen fruit ripen they change colour from yellow-green to pink, red, and then dark red to purple. The maturity stage of fruit is important when harvesting for commercial sale. Fruit has reached the ideal picking stage when it is pink to light red in colour. Fruit with more colour than this are ideal for local or immediate consumption.

Fruits are picked by hand using a specialized picking pole and bag. Dropped fruit should be avoided as they are more susceptible to internal damage.

Fruit should be washed, and the space under the calyx inspected for live insects, dirt, etc. This space is best cleaned using compressed air or a mild detergent solution. After cleaning, fruit can be sized and packed as appropriate for

the market and distance of travel. In Australia, plastic inserts with premoulded cups are used for shipping retail quality fruit. They are available in a range of packing densities to allow 24–42 fruits per 3 kg (6.6 lb) tray. Smaller retail-ready packs are also produced with 3–6 fruits on a plastic wrapped foam tray. Retail packs could also be made utilizing small cane or coconut weave baskets. Imperfect fruit due to external blemishes, but sound internally, can be sold in bulk.

Value-added processing

Mangosteen is primarily consumed as a fresh fruit, however it can be processed for the production of preserves, jam, and puree. The puree base has been successfully used in the production of sorbets and tropical fruit wines.

There is a new potential market for the whole fruit in the production of nutraceutical beverages. In Australia, the returns for this fruit have so far been below that achieved for sound whole fruit sent to the wholesale fresh fruit market.

Product quality standards

There are few quality standards available. In a market where there is little or no fruit available, quality is not as important for successful marketing. Where mangosteen is produced in relatively large volumes, quality standards have been formulated which take into account fruit maturity at picking,

fruit size, fruit colour, blemishes, and packing presentation. The Northern Territory Department of Primary Industry & Fisheries in Australia produced a quality standards chart with the assistance of other government agencies and tropical fruit growing associations (Lim et al. 1998). Suggested quality standards for 1st grade fruit include



Top left and right: Picking pole with special picking tool with bag to catch the fruit. Chanthaburi, Thailand. Bottom left: Newly picked fruit at ideal picking stage, mature but a few days from full ripeness. Bottom right: Fully ripened, washed and sorted fruit.

- Minimum weight of 70 g (2.5 oz)
- Fruit at the correct harvest colour to allow fruit to develop to full colour when ripe
- Fruit skin blemish free
- Area under the calyx free of dirt and insects
- Calyx undamaged and fresh green in colour
- Sized fruit packed individually

Product storage requirements

At ambient tropical temperatures fruit can easily be kept for 7–10 days before rind hardening or other quality deteriorations occur. Ripe mangosteen can be successfully stored at 5°C (41°F) at a relative humidity (RH) greater than 85% for 4 weeks from ripening. If storing at a lower relative humidity, the rind will rapidly harden making the fruit unusable.

Recommended labeling for products

Fruit packaging and labeling standards vary depending on country of production and market requirements. The minimum labeling requirements for a local domestic market may include fruit name, grower identification, and net weight of package. Labeling requirements become more strenuous for export markets.

SMALL-SCALE PRODUCTION

The tree is ideally suited for small-scale commercial or home garden production, if space allows for the relatively large amount of space an older tree can occupy. Mangosteen is present in the Pacific but it not extensively grown. It has a minimal contribution to the nutritional health of Pacific communities given its limited distribution and commercialization in the region. However, where it is produced, it offers an important healthy fruit alternative to the community. Where the crop can be successfully produced it will contribute to reducing imports and also to boosting local crop production and marketing opportunities.

Mangosteen is a promising tree crop for tropical Pacific islands, where soil and climatic condition exist which allow production and local high-end markets exist for fresh fruit, particularly in the visitor industry and restaurants. The tree fits well into a polyculture and the fruit is well liked by most people.

Nutrition

	Quantity per 100 g
Energy	76 kcal
Moisture	80 g
Protein	0.5 g
Fat	0.2 g
Carbohydrate	15 g
Fibre	5 g
Ash	0.2 g
Vitamin C	1 mg

Source: www.nal.usda.gov/fnic/foodcomp/

YIELDS

Individual tree yield varies widely with tree age and growing location. Average yields for 10–15 year old trees can vary from 40 to 70 kg (88–154 lb) per tree annually. High yields in excess of 150 kg (330 lb) per tree have been recorded. In a 2-year mangosteen production survey carried out in North Queensland the maximum yield recorded was 10 MT per hectare (4.4 T/ac) in a commercial orchard of 2,000 trees, which equated to 50 kg (110 lb) per tree (Diczbalis and Westerhuis 2005).

Recommended planting density

The recommended planting density is 6 m × 9 m or 7 m × 7 m spacing (20 ft × 30 ft or 23 ft × 23 ft). This allows about 50 m² (540 ft²) per tree.

In mixed orchards more room per tree is allowed with the space in between mangosteen trees filled with other crops.



Left: Mangosteen packed in a 28-fruit tray. North Queensland. Right: Example package labeling. Hāmākua, Hawai'i.



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Top: The calyx can harbor ants and other insects, and should be inspected and cleaned prior to sale. Middle: Typical method of cutting the fruit open for eating. Bottom: The scar pattern on the bottom of the fruit matches the number of sections inside the fruit.

In mixed plantings, tree spacing should take into account the size and shape of companion species.

MARKETS

Local markets

Mangosteen is appreciated by people from all cultures. As for any new fruit, customer knowledge is important if sales are to be successful.

Mangosteen would particularly lend itself to agritourism and island tourism as the fruit is relatively well known, attractive, and almost universally appreciated by those who taste it.

Export markets

Fresh mangosteen is a product with a relatively strong demand in North America and Europe. Supply and demand will strongly influence the price. Thai mangosteens have a strong presence in Europe from May to July and hence any new suppliers should consider supply times which do not clash with Thai production times.

Both North America and Europe have stringent import conditions covering food safety and pesticide residues. The U.S. also has stringent import regulations based on pest and disease quarantine issues and fruit may have to undergo costly quarantine treatments. The USDA has approved the importation of irradiated fruit from Thailand. This could impact both local and export markets from Pacific producers.

Specialty markets

Specialty market opportunities may exist depending on growing location and markets. In Australia and Hawai'i, organic market opportunities are being explored by some producers. However a recent comment from a grower in Australia suggested that the marketplace was reluctant to pay a price premium for tropical fruit and for organic fruit relative to cheaper supplies of alternatives. Insufficient information is available to comment on how these opportunities may be explored in the Pacific.

Branding possibilities

Branding opportunities vary with growing location, market and the skill of the marketing personnel involved. A geographic moniker, such as "Hawai'i grown," is an example branding strategy.

Potential for Internet sales

Internet sale potential exists, however, it must be firmly linked to regular, rapid, and inexpensive freight connections. Fruit sold via the Internet also must meet the conditions imposed by the quarantine authorities in the importing region.

EXAMPLE FARMS

Onomea Orchards (Jenny and Richard Johnson)

Onomea Orchards in Hāmākua, Hawai'i, has 39 producing mangosteen trees that were planted in 1990. It was the first in the U.S. to have commercial quantities of fruit in 2000. At 19 years old, the trees were 9 m (30 ft) tall. The fruit is hand-picked 2–3 times per week during the harvest season so that minimal numbers fall to the ground. After harvest, the fruit is soaked in a water bath with a little detergent to remove debris and any ants that may have taken residence under the fruit calyxes. Then the fruit is graded into first and second grade, with first grade being all hand picked from the tree, and free from blemishes. Most of their fruit is sold through the Hawai'i Tropical Fruit Cooperative, Inc., a farmer-owned coop that markets commercial quantities of tropical fruits including mangosteen, rambutan, longan, lychee, and starfruit. The fruit is pack in standards that have their own Onomea Orchards label, as well as the cooperative's name. In 2009, the retail price for first grade was \$16.50–17.60/kg (\$7.50–8.00/lb).



Richard Johnson standing under one of his 19-year-old mangosteen trees at Onomea Orchards.



Onomea Orchards mangosteen interplanted with starfruit.

Wailea Agricultural Group, Inc. (Michael Crowell and Lesley Hill)

The 110-acre Wailea Agricultural Group is located in Hāmākua, 14 miles north of Hilo at 75–180 m (250–600 ft) elevation. The farm currently has 2 ha (5 ac) planted in mangosteen. Many of the mangosteen trees were interspersed within existing productive orchards as replacements for trees that died or were not thriving, such as bananas and avocados. By planting them within an existing orchard, the seedlings had good wind protection and did not need to be established within an artificial wind shelter. The tree spacing is approximately 7.5 m × 10.5 m (25 ft × 35 ft). The owners believe in polycultures for biological and economic diversity. After harvest, the best grade of fruit is sorted and given a light cleaning with a cloth dampened with 10% bleach solution. All fruit is sold in Hawai'i to high-end restaurants, mostly through a large wholesaler.



A young mangosteen tree (on right) interplanted in an avocado field at Wailea Agricultural Group.

ECONOMIC ANALYSIS

Expenses of production

Production costs for mangosteen are not readily available. Malaysian data (Osman and Milan 2006) show that the major are associated with nursery material and planting costs and then the regular maintenance costs associated with irrigation, fertilizer, pesticide, and herbicide. Their economic analysis suggests that the payback period for an investment in a 10 ha (25 ac) mangosteen orchard of varies from 15 to 19 years depending on the sale price and other factors.

Mangosteen can be a profitable crop, but alternative income sources are required for the initial investment of land, trees, and irrigation infrastructure and for the long period of maintenance costs before fruit production begins. Income from companion-planted fast-growing species such as papaya and banana should be considered as part of the production model.

Expected income per tree

Mature trees yielding 50 kg (110 lb) per tree achieve a gross return of approximately \$500 per tree in Australia. In Thailand a similar yielding tree would give a producer a gross return of approximately \$50 per tree. The important difference, not immediately seen, is the cost of production. In countries where labour costs are low or where growers do not pay themselves a wage for their labour, returns may be sufficiently optimistic to justify production.

FURTHER RESEARCH

A shortened juvenile period is probably the single most important area for crop improvement. Grafting can result in an earlier crop but usually at the expense of tree shape and size. Also, fruit from grafted trees is generally smaller. Grafted trees may lend themselves to being grown at high density with trellising and artificial shade. Improvements and alternatives to grafting should be explored.

Genetic resources

There are no known formal collections, given the limited genetic variability in mangosteen. However, extensive plantings are maintained in research stations in Thailand (e.g., Chantaburi), Peninsula Malaysia, Sarawak, and Sabah. Prior to purchasing seed, a description of the fruit shape and tree productivity should be sought.

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OTHER RESOURCES

Internet

Australian Government Tropical Fruit Research Final Reports: <http://www.rirdc.gov.au>

Specialty Crops for Pacific Island Agroforestry (<http://agroforestry.net/scps>)

Farm and Forestry Production and Marketing profile for Mangosteen (*Garcinia mangostana*)

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Recommended citation: Diczbali, Y. 2011 (revised). Farm and Forestry Production and Marketing Profile for Mangosteen (*Garcinia mangostana*). In: Elevitch, C.R. (ed.). Specialty Crops for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Holualoa, Hawai'i. <http://agroforestry.net/scps>

Version history: November 2009, February 2011

Series editor: Craig R. Elevitch

Publisher: Permanent Agriculture Resources (PAR), PO Box 428, Hōlualoa, Hawai'i 96725, USA; Tel: 808-324-4427; Fax: 808-324-4129; Email: par@agroforestry.net; Web: <http://www.agroforestry.net>. This institution is an equal opportunity provider.

Acknowledgments: We thank growers in Australia, Hawai'i, Thailand, and Guatemala who have allowed the author access to their farms, shared information, and provided the settings for the photographs. Our thanks to Michael Crowell, Lesley Hill, Ken Love, Richard Johnson, and Robert Paull for advice and contributions to this publication.

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Sponsors: Publication was made possible by generous support of the United States Department of Agriculture Western Region Sustainable Agriculture Research and Education (USDA-WSARE) Program. This material is based upon work supported by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, and Agricultural Experiment Station, Utah State University, under Cooperative Agreement 2007-47001-03798.

