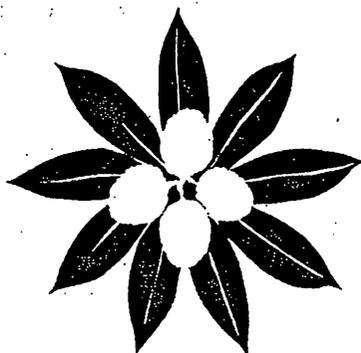




Growing Lychee in Hawaii

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Lychee is a popular tree in Hawaii, valued for its delicious fruit. As its botanical name implies, *Litchi chinensis* originated in China. Lychee (also written litchi, li-chi) is a large, long-lived, subtropical, evergreen tree that bears fruit from May to August in Hawaii. The first lychee plant brought to Hawaii was imported from China in 1873 by Mr. Ching Chock and planted on the property of Mr. Chun Afong at the corner of Nuuanu and School Streets on Oahu. It was known as the "Afong" tree and was initially considered to be the Chinese variety 'Kwai Mi' (or 'Kwai Mei'), but it was later identified as 'Tai Tso' (or 'Tai So').



Many locations in Hawaii are therefore less than ideal for reliable and consistent lychee yields. For commercial production, site selection can strongly influence profitability. Winter temperature cannot be controlled except by site selection for the general climate of the region or a suitable microclimate. Some degree of climate control affecting lychee flowering can be obtained by selecting a dry site with irrigation that can be withheld to create a dry period.

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Environment

In Hawaii, lychee can be grown in almost any type of soil from sea level to 2000 ft (600 m) elevation where annual rainfall is 50–80 inches (1300–2000 mm) or more, or where irrigation is available. Lychee trees require well drained soil and grow best in acidic soil (pH 5.0–5.5).

Hawaii has many microclimates that vary considerably over relatively short distances. Careful site selection can make a great contribution to the growth of lychee trees. Wind protection is critical for good growth and fruit production. An ideal orchard site has long, hot days in summer (82°F, 28°C), adequate rainfall (around 63 inches, 1600 mm), and a cool, dry winter with day/night temperatures of 59/50°F (15/10°C). A dry period between October and February with lower temperatures (<59°F, <15°C) is necessary for prolific flower initiation on mature lychee trees and helps ensure a good crop.

In Hawaii, the cool winter season, generally lasting from October through April, is also the wet season in most places. Winter temperatures vary from year to year.

Varieties

Many lychee varieties are known in various parts of the world, including 26 major and 40 minor varieties identified in Guangdong, China, 33 varieties in India, and numerous local selections in Australia, Florida, Taiwan, Thailand, and Hawaii. Because lychee is one of the most environmentally sensitive fruit trees, improper selection of varieties can result in erratic or no fruit production. Good growth in one location is not a guarantee of similar growth in another. For example, the Chinese variety 'No Mai Tsz' is one of the most recognized and preferred lychees in the world, but it is not suitable for production in Hawaii. Two mature 'No Mai Tsz' trees at CTAHR's Waiakea Research Station arboretum (Hilo) produced only two crops during the period 1986–1998.

In Hawaii, good performance is obtained with the varieties 'Kaimana' and 'Groff', which were selected from 'Hak Ip' seedlings by CTAHR horticulturists. They require less chilling for flower initiation than traditional

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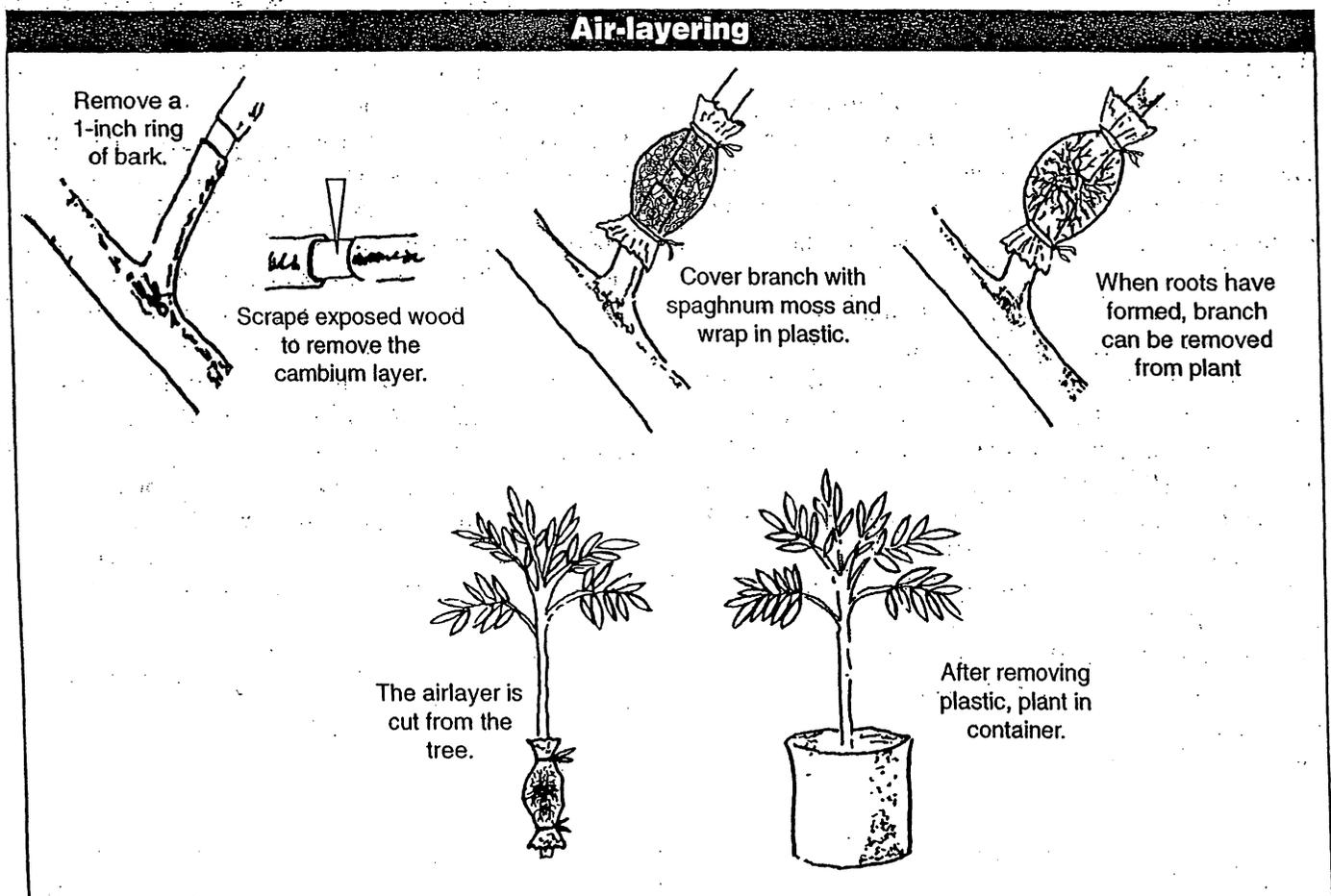
Chinese lychee cultivars. 'Kaimana' has proven to be a desirable cultivar because of its early harvest season (May–June), good fruit qualities, and large fruit size. Other lychee varieties that are being grown in Hawaii are 'Souey Tung', 'Hak Ip', 'Tai So', 'Brewster', and 'Bosworth 3' (see the table on p. 7).

Propagation

Air-layering

Lychee is most commonly propagated by air-layering. The procedure is as follows:

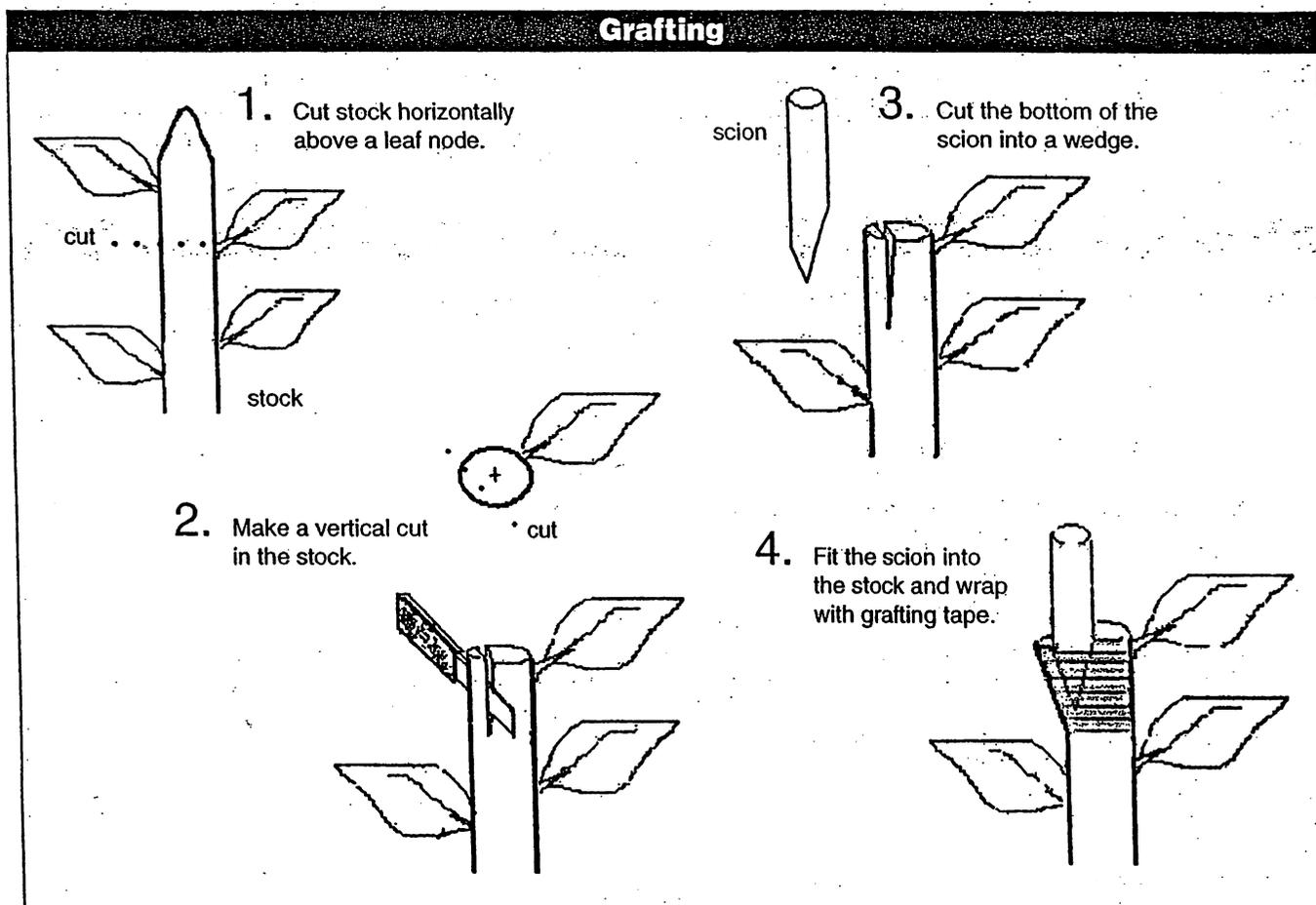
- Remove a ring of bark 1–1½ inch (2.5–3.75 cm) from an upright shoot ½–¾ inch (1.25–1.88 cm) in diameter.
- Scrape the exposed wood to remove the thin, white cambium layer beneath the bark.
- Mold a handful (2½ x 4 inch, 6.25 x 10 cm) of dampened but not wet sphagnum moss around the cut area.
- Wrap and secure the moss with a plastic sheet. In high-rainfall areas, secure the ends to ensure that water cannot enter the wrapped area, because rooting does not occur in water-saturated media.
- Harvest rooted air-layers in 2–3 months, when roots are visible and plentiful, by cutting the branch just below the root ball.
- Remove about three-fourths of the foliage from the air-layer, partially unwrap the plastic wrap, and place the root ball in water for 10–15 minutes before completely unwrapping it. The young lychee roots are very brittle, and careful handling is critical during planting.
- The planting medium should be high in organic matter with good drainage. A potting medium of equal parts soil, compost, and black cinder is good for lychee.
- Place plants under 50–70 percent shade and cover stems and leaves with a slightly perforated, clear plastic bag to maintain high humidity. Protect transplants from wind and extreme temperatures.
- Do not overwater.
- Fertilize with a ½ teaspoon of a complete fertilizer 6 weeks after planting.
- Reduce shade gradually when new shoots mature.



Grafting

Lychee can also be propagated by grafting. For the introduction of new lychee varieties to Hawaii, scion wood is easier to collect and transport than rooted air-layers and carries a lower quarantine risk of harboring pests and diseases. Lychee can be grafted using the following modified top-wedge method developed at the USDA/ARS National Clonal Germplasm Repository in Hilo:

- Use a 1–2-year-old 'Hak Ip' or 'Tai So' seedling root-stock $\frac{1}{2}$ – $\frac{3}{4}$ inch (1.25–1.88 cm) in diameter.
- Cut the stock at a node about 1 ft (30 cm) above soil level (retain one healthy set of leaflets below the cut).
- On the side opposite the leaflets, place the knife vertically at $\frac{1}{3}$ to $\frac{1}{4}$ of the stem's diameter and make a 1-inch (2.5-cm) cut into the stem (see Figure 1). Press the blade into the stem with a see-saw motion for a smooth cut.
- Use a recently matured scion $\frac{1}{4}$ – $\frac{1}{2}$ inch (6–8 mm) in diameter with smooth bark and smooth petiole scars.
- Form a wedge at the base of the scion by making a slanted cut $\frac{3}{4}$ –1 inch (2–2.5 cm) long, then another cut $\frac{1}{4}$ inch (6 mm) long on the opposite side.
- Fit the scion wedge into the cut made in the stock, with the long side of the wedge toward the stem. Line up the cambium and bark on one edge of the scion's inner wedge with the cambium and bark of the stock.
- Bind scion and stock tightly with grafting rubber bands.
- Wrap the entire scion surface and the scion-stock union with laboratory wax film (such as Parafilm®).
- Place grafted plants in a greenhouse with 30+ percent shade and fertilize with $\frac{1}{4}$ teaspoon of complete fertilizer. Water immediately, but avoid wetting the graft union.
- If the graft is successful, new growth will push through the wax film in 3–4 weeks.
- Allow only two of the scion's new shoots to grow.
- Reduce shade gradually after the new growth matures.



Field planting

Field preparation varies with local conditions. Measures to improve water movement into and through the soil may include breaking up compacted soil and hardpan by cultivation. Contouring the site can manage runoff and reduce ponding. Soil erosion can be controlled by contouring and establishing protective ground covers. Organic soil amendments (compost, manure) can improve the soil's capacity to hold water and nutrients. Applications of other soil amendments (such as lime and phosphorus) should be based on soil analysis recommendations. Windbreaks of trees suited to the site should be established well in advance of planting.

A planting distance of 18 x 18 feet (6 x 6 m) is recommended for upright varieties such as 'Bosworth 3'. For 'Kaimana', a spacing of 24 x 24 ft (8 x 8 m) is recommended if annual pruning is practiced to control tree size. For more vigorous varieties such as 'Tai So' and 'Brewster', a 24 x 36 ft (8 x 12 m) spacing is recommended.

Air-layered plants 6-12 months old that have been sun-hardened can be transplanted to the field when there is adequate soil moisture. Handle the young lychee plants carefully to avoid breaking their extremely brittle roots. The transplanted tree will require about a year to become well established in the field, and adequate wind protection during this period is important. A single-tree

wind shelter can be made by covering the sides of a cylinder of 52-inch hog-wire fencing 36 inches in diameter (130 x 90 cm) with 40-50 percent shade cloth. These netted cylinders also shield the plant from rose beetle damage.

Fertilizer

During the first four years after planting, fertilizers should be applied generously to promote canopy development. A schedule developed in Australia is given below.

Fertilizer should be spread beneath the leaf canopy from the leaf drip line to no closer than 8 inches (20 cm) from the trunk. Micronutrients may be applied as foliar sprays in summer and fall. Boron and iron should be applied to mature summer and fall growth. Zinc, copper, and manganese should be applied to expanding summer and fall flushes.

Tree training

Under ideal growing conditions, young trees produce five or more vegetative flushes each year. Training and shaping trees should be done during the first 3-4 years based on the growth habits of the cultivar and the environmental conditions.

For cultivars with a spreading canopy, such as 'Kaimana', open-center pruning is recommended. Three to four evenly spaced laterals with sufficiently wide

Fertilizer program for lychee

Fertilizer application amounts for establishing lychee trees

Tree age (years)	ounces	grams
1	1.1	30
2	1.4	40
3	2.1	60
4	2.8	80

Apply the amounts of fertilizer listed above in the months indicated

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		U	U	U	U	U	U				
		C+			C+						

U = urea; C+ = complete (12-5-14) formulation plus micronutrients; the formulation used in Australia contains the following nutrients (in percent): 11.4 N, 4.8 P, 14.6 K, 7.6 S, 4.3 Ca, 1.3 Mg, 0.1 B, 1 Mn, 0.04 Cu, 0.02 Zn, 0.0006 Co.

Annual application amounts for bearing trees

Age (years)	pounds	kilograms
4-5	4.4	2
6-7	6.6	3

Subsequently, increase the application by 2.2 lb (1 kg) for each 2-year advance in age.

(>30°) branching angles are retained about 20 inches (50 cm) above ground to form the main branches of the canopy. Very light thinning is done thereafter to remove low-hanging, tangled, weak, diseased, or dead branches. In Sichuan, China, the point of branching for the main frame can be as low as 4 inches (10 cm) above ground. This training system is reported to encourage early fruiting and low canopy height.

In Chiang Rai, Thailand, a lychee variety with vigorous vegetative growth, similar to 'Tai So', is trained with a central-leader system. A main stem is retained, with lateral branches evenly spaced on the main trunk at different heights to form an upright canopy. These trees are topped and maintained at about 15–21 ft (5–7 m), and the inner canopy is heavily thinned to ensure good light and air penetration. Only two or three new shoots per branch from the summer-fall flushes are retained for fruit production. Despite the upright style of pruning, harvesting is relatively simple, because the long-limbed branches are bent downward by the weight of the fruit clusters. Pruning at harvest is important: 6–8 inches (15–20 cm) of each branch is removed along with the fruit. The harvest pruning and a biannual topping allows management of tree height and shape at the desired level.

Production management

Once an orchard is established, management practices such as pruning, girdling, root pruning, and regulating the supply of irrigation and nutrients are means to synchronize and/or suppress vegetative growth and facilitate fruit production. Lychee flowering and fruit set can be managed easier in light soils, which facilitate drought stress when withholding irrigation.

Pruning at harvest

Traditional harvesting practice has been to remove no more than two pairs of leaves with a fruit cluster. The zone of compacted nodes located above the fruit clusters, known as the "dragon head" in Chinese literature, was believed to contain fruiting branches for the following season.

Observations of 'Kaimana' in Hawaii revealed that the "dragon head" node produced new shoots about 6–8 weeks after harvest. These multiple branches were short, slender, and had poor vigor. If the "dragon head" node was removed during harvest along with 6–12 inches (15–

30 cm) of stem above the cluster, the new growth emerged approximately four weeks later and the number of shoots produced per node was less, but these shoots were longer and more vigorous.

In Taiwan, up to 24 inches (60 cm) of the branch is removed from 'Yu Ho Pau' at harvest to ensure vigorous vegetative flushes. Similar treatment of 'Hwai Lai' in China resulted in increased production over the traditional pruning method. The effect of pruning on production varies among cultivars. 'Yok Ho Pau' was reported to have a good yield with harvest pruning, while 'Hak Ip', 'Sam Yu Hung', and 'Sah Keng' had reduced yield after the same treatment.

Restricting fertilizer

In Australia, the most effective method to prevent untimely vegetative growth is to maintain leaf N content at 1.75–1.85 percent during the critical 4–6-week period before flower initiation. Maintaining low leaf N levels can be achieved by applying N fertilizer only after panicle emergence and fruit set and at no other time during the growing season. This method has proven effective even in areas with heavy rainfall.

For bearing trees of early-season varieties (May–June harvest) such as 'Kaimana', it is desirable to induce two vegetative flushes after harvest, one in June–July and a second in August–September. To promote these two flushes, one-half of the fertilizer allocated for the year should be applied with irrigation immediately after harvest. The balance of the year's fertilizer should be applied in two equal parts, one in spring during flower panicle elongation and the second in early summer when fruits reach pea size.

For bearing trees of late-season varieties (July–August harvest) such as 'Bosworth-3' and 'Groff', a single vegetative flush is promoted after harvest. One-third of the fertilizer allocated for the year should be applied two weeks before harvest. The remaining two-thirds of the fertilizer should be applied in two equal parts, one in spring during flower panicle elongation and the second when fruits reach pea size. The first application, before harvest, ensures sufficient time for the vegetative growth to mature before winter; the second, smaller application avoids high residual leaf N levels, which may inhibit flower induction.

For bearing trees in areas with deep soil and high rainfall, the allocation of fertilizer should be applied in two equal parts, one during spring flower panicle elongation and the other when fruits reach pea size. N-containing fertilizer should not be applied after harvest.

Suggested management procedure for 'Kaimana' lychee in Hawaii

The following practices to ensure fruit production worked reasonably well with 'Kaimana' in the Hilo area, which has high rainfall and highly weathered lava soils. Results may vary in locations with different soil types and microclimates. Use this as a general guide for bearing trees with May–June harvest, and customize your own management plan for lychee at your location.

- Prune back 12 inches (30 cm) from all branches during or immediately after harvest.
- Apply one-half of the year's allocated fertilizer with 3 lb (1.4 kg) of dolomite; mulch lightly and irrigate to synchronize and promote shoot growth. The first round of growth should mature around early July.
- Irrigate in August–September to promote vegetative growth. This second vegetative growth flush matures around late October to early November.
- Do not fertilize or irrigate after the second flush matures in late October.
- Girdling is not recommended for 'Kaimana'. While girdling may hold back untimely vegetative growth for 6–7 weeks, young 'Kaimana' trees responded to girdling by producing a large overgrowth above the girdle, with reduced growth and production the following year.
- In some years, cold temperature does not occur until December or January, and a new flush of vegetative growth may emerge in late November. If this occurs, pinch off each new shoot at 1–2 inches (2.5–5 cm) above the base as the first leaf begins to expand. The complete removal of a shoot without leaving a stub generally results in immediate vegetative growth from axillary buds. By using the recommended pinching method, the growth of the axillaries can be delayed for approximately 6 weeks to allow buds to be exposed to the cool temperatures necessary for flower initiation.
- In January, when flower panicles reach 4–5 inches (10–13 cm), apply one-fourth of the year's fertilizer and irrigate. Apply fertilizer only to plants with well

formed and fully elongated flower panicles; otherwise, emerging shoots may revert to vegetative growth.

- Apply the remaining one-fourth of the year's fertilizer and irrigate when fruits reach pea size.
- 'Kaimana' lychee matures about 4–5 months after fruit set. Irrigation should be stopped 2–3 weeks before harvest.
- Repeat the management cycle for the next crop.

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Characteristics of lychee cultivars grown in Hawaii

Variety	Hak Ip	Souey Tung	Tai Tso	Brewster	Bosworth 3	Groff	Kaimana
Other names	Woo Yip, Baidum, Oh Hai	Souey Tung, (<i>Hak Ip</i>)*	Mauritius Hong Huey (<i>Kwai Mi</i>)*	Chen's Purple Chen Zi	Kwai May Pink		
Origin	China	China	China	China	Australia	Hawaii	Hawaii
Season	Mid	Mid	Early-Mid	Mid	Late	Late	Early-Mid
Fruit characteristics	Egg-round, dull red, smooth thin skin, suture obvious, large seed, shriveled seeds rare	Slanted heart, dark dull red, thin smooth skin, suture not obvious, 10% shriveled seeds	Ellipse to long heart, bright red-dull red (mature), sharp-pointed spikes, suture not obvious, 20% shriveled seeds	Ellipse, bright purplish red, short sharp spikes, inner membrane distinctly pink, 30-50% shriveled seeds	Near spherical, yellow to yellow pink to orange-red, sharp spikes, suture not obvious, 15-40% shriveled seeds	Small broad heart-shaped fruit, dark rose red, short blunt spikes, 97% shriveled seeds	Slanted heart, smooth dark maroon skin, a spike ridge band across fruit base, medium seed, 33% shriveled seeds
Fruit ht. [width] (cm)	3.2 [3.3 x 3.2]	3.2 [3.7 x 3.1]	3.7 [3.5 x 3.3]	3.5 [3.2 x 2.8]	3.4 [3.5 x 3.4]	[2.2-2.5]	[3-4]
Fruit wt. (g) [range]	17 [12-22]	22 [19-27]	24 [15-35]	19 [14-25]	22 [15-28]	11 [11-12.5]	24 [16-36]
Flesh % [range]	72 [68-77]	68	[71-76]	74 [58-87]	72 [65-82]	80	71 [71-75]
TSS (%)	20	18	18	17.4	21.3	20.3	19
TA (%)	0.46	0.41	0.24	0.35	0.29		0.47
Vit. C (mg/100 g)	24.8	57.0	37.3	46.6			

TSS = Total soluble solids, TA = Total titratable acids, * (*italic*) = incorrect name.

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