



# Macadamia:

## Hawaii's Dessert Nut

Richard A. Hamilton  
Warren Yee  
Philip Ito

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## THE AUTHORS

**Richard A. Hamilton** is Professor of Horticulture, College of Tropical Agriculture and Human Resources, University of Hawaii.

**Warren Yee** is Emeritus Specialist in Horticulture, Cooperative Extension Service, College of Tropical Agriculture and Human Resources, University of Hawaii.

**Philip Ito** is Associate Horticulturist, Hawaii Agricultural Experiment Station, College of Tropical Agriculture and Human Resources, University of Hawaii.

## MACADAMIA: Hawaii's Dessert Nut

Richard A. Hamilton  
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The macadamia nut, considered to be the world's finest dessert nut, belongs to the Proteaceae family. It is native to the coastal rain forest areas of southern Queensland and northern New South Wales in Australia. Macadamia is unique in that it is the only native Australian plant to attain the status of a commercial food crop.

Macadamia seeds were first imported into Hawaii in 1882 by William Purvis and macadamias have since become the most important tree crop in this State. More than 90 percent of the world's production of macadamia nuts is grown on Hawaii, the southernmost island of the State. Smaller quantities are produced on Maui and Kauai. Orchard plantings have been made in Australia and California and more recently in Rhodesia, Malawi, Kenya, South Africa, Guatemala, Costa Rica and Brasil. Many of these orchards are still in the developmental or experimental stage. It is only in Hawaii, where improved clonal varieties have been selected and grown for about 30 years, that macadamia nuts have achieved major success as a commercial crop. Macadamias are presently in great demand in Hawaii, the U. S., and the world market. Prices of in-shell nuts and processed kernels remain relatively high because the demand greatly exceeds the present supply.

### **Description and Botany**

There are two species which produce edible kernels: *Macadamia integrifolia* and *M. tetraphylla*. Both species are attractive, medium-sized, evergreen trees, which with age can attain a height of 60 feet and a spread of 40 feet. They have shiny, green, holly-like foliage, and grafted trees of selected varieties make attractive, shapely specimens well worth growing as combination ornamental shade and nut trees.

*M. integrifolia*, the only commercially important species, commonly known as "smooth-shell" macadamia, has proven suitable for large-scale processing as a high-quality dessert nut. The fruit is a follicle with a



Figure 1. Mature 30-year-old 'Kakea' trees at the Kona Research Station with annual yields of 250 lbs. of in-shell nuts per tree.

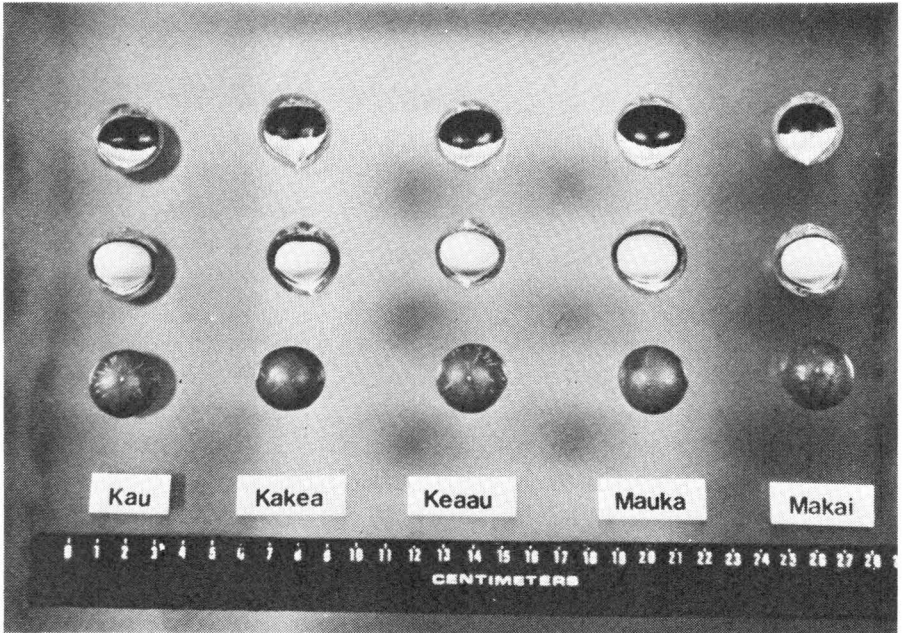


Figure 2. Shell kernel and nut characteristics of five commercial macadamia nut varieties. Left to right: 'Kau' (344), 'Kakea' (508), 'Keaau' (660), 'Mauka' (741) and 'Makai' (800).

husk which opens along one suture enclosing a single seed, rarely double, with a hard, round seed coat. The seed coat is commonly known as the shell. The edible part, or kernel, is the creamy white embryo containing about 80 percent oil and 4 percent sugar when dry. It is enclosed by a hard, round shell ranging from about 0.8 inch to 1.1 inches in diameter, which is, in turn, enclosed within a dull-green pericarp usually referred to as the husk. The shiny, oblong leaves are 5 to 10 inches long, characteristically borne in whorls of 3 at a node. Margins of leaves of older trees are usually smooth, but those of young trees are frequently spiny. New growth is light-green to bronze in color. The small, perfect, cream-colored flowers are borne in axillary racemes 6 to 12 inches long consisting of several hundred flowers. Although there are a large number of flowers in each raceme, usually not more than about 10 nuts set and mature.

The "rough-shell" species, *M. tetraphylla*, produces spindle shaped nuts which have characteristically rough, pebbled surfaces. The coarse, leathery leaves borne in whorls of 4, are sessile and up to 20 inches long with very thorny, toothed leaf margins. New growth may be either reddish, purple or pale green. The flowers are usually pink (rarely cream colored), borne in racemes 8 to 15 inches long. The kernels are usually darker colored than the other species and often have a grayish upper half. They are much more variable in quality than smooth-shell kernels, ranging from about 67 to 75 percent oil and from 6 to 8 percent sugar. This high sugar content makes the kernels palatable and pleasant to eat raw, but their high sugar content and marginal oil content makes them characteristically more variable in color, texture and flavor when cooked. Varieties suitable for commercial processing have not been found. Rough-shell macadamia trees are sometimes planted as ornamental or shade trees and for their edible kernels. The major value of *M. tetraphylla*, seems to be as a rootstock for smooth-shell varieties although scion overgrowth, which is considered undesirable, sometimes occurs.

Many trees which are hybrids of the two species have been found but they possess no particular merit or value. Kernel quality of these hybrids most resembles the rough-shell species, which, as noted, is inferior for processing.

## Culture

About 50 macadamia cultivars have been described from Australia, California, South Africa, and Hawaii. The first 5 varieties named in



Figure 3. An example of scion overgrowth: smooth-shell variety grafted on rough-shell rootstock.

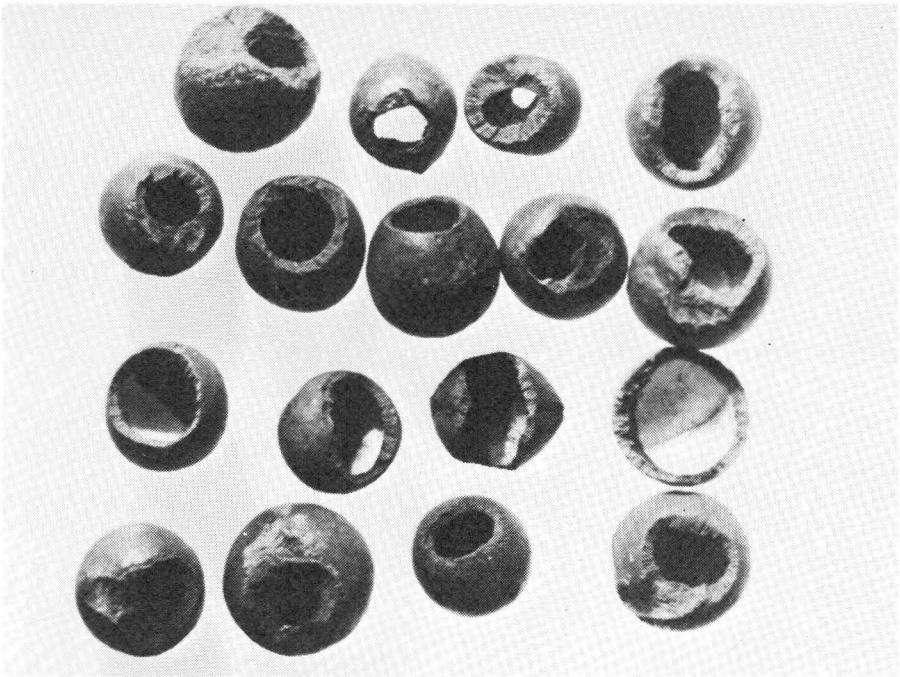


Figure 4. Macadamia nuts with kernels eaten by rats.

Hawaii were released in 1948 and a total of 11 clones have now been selected, tested and named by University of Hawaii horticulturists. Of these 11 varieties, 5 are presently being used for orchard planting in the state. These are: 'Kau' (No. 344), 'Kakea' (No. 508), 'Keaau' (No. 660), 'Mauka' (No. 741), and 'Makai' (No. 800). The original selection numbers of these varieties are listed in parenthesis because many growers and nurserymen still prefer to use the numbers instead of names. The last 2 varieties named are 'Mauka' and 'Makai'. 'Mauka' has produced satisfactory yields of good quality kernels at between 1800 and 2200 ft. elevation where most other varieties tested have proven marginal, while 'Makai' produced good crops of large nuts with exceptionally high quality kernels at elevations between 300 and 1500 ft. Several other named cultivars, notably 'Ikaika' and 'Keauhou', also occur in older orchards but are no longer recommended because they usually have lower percent recovery of No. 1 kernels than the other varieties mentioned.

Most macadamia plantings in other countries have been made with Hawaiian cultivars. With good care, in suitable areas of Hawaii, these improved cultivars may begin producing appreciable crops 6 to 7 years after planting and usually attain full production in 10 to 12 years.

Yields from well-managed, mature, clonal orchards in Hawaii range from 1 to 4.5 tons of in-shell nuts per acre depending on location and variety. The trees do not respond favorably to close planting, and the heaviest producing orchard on record was spaced 34 by 34 feet. In the past most orchards in the State were spaced from 20 to 30 feet between adjacent trees, but unfortunately these spacings resulted in excessive crowding which usually occurs by the ninth or tenth year. This adversely affects yields so that thinning or heavy pruning becomes necessary. With standard sized trees, spacings of about 30 to 35 ft. between rows and 16 to 20 ft. between trees in the row are reasonable, depending on tree form and growth rate of the trees. Spacing of up to 20 ft. between trees in the row can be advantageous because it permits removal of alternate trees in the row when this becomes necessary due to crowding as the trees increase in size with age.

### **Propagation**

Vigorous, well-grown seedlings of both species have been used successfully as rootstocks in commercial plantings. Rough-shell seedlings are preferred by some nurserymen because they germinate uniformly, grow faster and more uniformly in the nursery, and are considered

easier to graft and transplant. Most of the trees in producing orchards in Hawaii are, however, grafted on smooth-shell rootstocks because there is no adequate reliable source of proven rough-shell seed in the state. Macadamias are not considered difficult to graft although some actual experience with macadamias is usually essential for success because the wood is exceptionally hard and brittle. Scion-wood girdled at least 5 weeks in advance is usually necessary for successful grafting. Vigorous seedling rootstocks  $\frac{1}{4}$  to  $\frac{3}{4}$  inch in diameter, which are usually about a year old, are grafted by various methods, the side-wedge graft and the top-splice graft being preferred. Bark or veneer grafts are used in top-working, larger trees.

### **Climatic Adaptation**

Important factors to be considered in deciding on suitable locations for new macadamia orchards are soil, natural wind protection, elevation, rainfall, and accessibility for harvesting and cultural operations.

Macadamias have proven best adapted to mild, frost-free, subtropical climates with at least 50 inches of annual rainfall fairly well distributed throughout the year. Although macadamia trees tolerate and survive mild frosts and drought conditions, yield and quality are adversely affected. In Hawaii, the best conditions for growing macadamias are found between 700 and 1800 foot elevations, although some successful plantings have been made higher and lower than this. Macadamia trees are considered susceptible to wind damage and do best where there is good, natural wind protection or adequate planted windbreaks. When there is less than 50 inches of well-distributed annual rainfall, supplementary irrigation is beneficial since moisture stress can cause reduction in yield and quality of nuts. There have been some indications that temperatures over 90° F. reduce production and growth, but these temperatures seldom occur where macadamias are grown in Hawaii.

### **Soil and Fertilization**

Macadamias can be grown successfully on a variety of Hawaiian soils ranging from loose volcanic lava soils to well-drained, lateritic clays. Fertilization is necessary for good production and growth. Slow-release, pelleted fertilizer with a 2-4-1 or 1-1-1 ratio of nitrogen/phosphorus/potassium has given good results. Fertilizer applications should be made at least 3 times per year, with the amount of fertilizer increasing with size and productivity of the tree. Supplementary nitrogen fertilizer at



flowering time is considered beneficial to fruit setting. The most common minor element deficiencies that occur are iron, magnesium, and zinc. These deficiencies can be corrected by soil applications of appropriate materials. Liming is considered beneficial to tree growth and yields on soils with pH values less than 5.0.

### Diseases and Pests

Macadamias in Hawaii are comparatively free from serious diseases and pests. Several problems sometimes occur, however, so that control measures should be instituted as necessary. Stick-tight nuts (anthracnose) are said to be caused by *Colletotrichum* spp., which darkens and kills the husks of developing nuts, causing them to hang on the tree after the crop has matured. Stick-tight nuts are a serious problem because they are generally of inferior quality and difficult and costly to separate from good nuts. Anthracnose damage most commonly occurs in wet, humid areas but is readily controlled by planting resistant varieties. The 'Keauhou' variety is immune to anthracnose, and most other commercial varieties have fairly good resistance. Flower racemes are sometimes subject to fungus attack, which is thought to reduce the crop. Fungi involved are *Botrytis* spp. and *Phytophthora* spp. This type of damage usually occurs during periods of high humidity. Some reduction in fruit set may occur but no spray program or other control measure is in general use.

*Phytophthora cinnamomi*, which also causes avocado root-rot, occasionally attacks the trunk and main branches of macadamia trees but does not seem to affect the roots. Affected trees are weakened and sometimes girdled and killed, but the disease is much more frequent on seedling trees than in grafted orchards. This disease is so infrequent in commercial orchards that to date, control methods have not seemed warranted.

Rats, wild pigs, and nut borers feed on macadamia nuts and sometimes cause considerable loss to the crop. Rats feed on the kernels of both mature and immature nuts. They can be controlled with a well-planned poison bait program. Wild pigs often invade macadamia orchards to feed on mature nuts which have fallen to the ground. When numerous enough to be a problem, wild pigs have been successfully controlled by hunting and trapping them in and around the orchard. Two nut borers, *Cryptophlebia illepeda* and *C. ombrodelta* cause some damage by boring through the shell into the kernels of both immature

and mature nuts. Considerable damage from nut borers may occur to the first harvest of early maturing nuts, but losses to the main crop are seldom serious. Up to now, macadamia growers have not found it necessary to use control measures against nut borers.

Leaves and husks of developing nuts are often heavily infested with thrips and mites. Effects on quality and production of nuts have not been established however, and control programs are not generally necessary in commercial orchards. Young leaves on new growth flushes, flower buds and flowers may become infested with the black citrus aphid, *Toxoptera aurantii*, and the broad mite, *Polyphagotarsonemus latus*. These pests can be controlled by spray applications of insecticides and miticides cleared for use on macadamia. The southern green stink bug, *Nezara viridula*, feeds on developing nuts, causing unsightly spots on the kernels of affected nuts. Introduced parasites have reduced stink bug populations and macadamias are not a preferred host plant of stink bug, so the amount of damage that occurs is generally not a cause of great concern.

### **Harvesting and Processing**

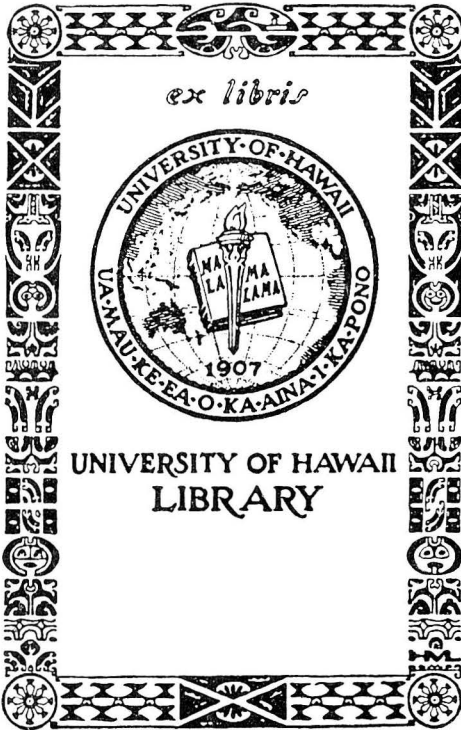
The main harvest period for macadamia nuts in Hawaii extends from about August through January. October and November are peak months, but it is common for some nuts to mature every month of the year. 'Keaau', 'Kau' and 'Mauka' have relatively short harvest periods, maturing most of their crop in September, October, November and the first part of December. Macadamia nuts fall to the ground when mature and should always be gathered before they begin to mold, germinate, or become rancid. During rainy weather this should be every 2 to 3 weeks, but if the weather is dry, picking intervals can be extended to once a month. Husking should be done within 24 hours after picking to prevent development of off-flavors. The husked nuts should be dried in wire-bottomed trays under shade for 2 weeks or in a forced-air dryer for 3 days at 100° F. The process is completed by drying the nuts an additional 3 days in the drying oven at 125° F. to bring them down to approximately 1½ percent moisture. The dried kernels are processed by roasting them in refined cooking oil for 12 to 15 minutes at 275° F., or by roasting in a rotary oven at approximately 350° F. for 20 to 30 minutes.

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