

Macadamia:

HAWAII'S DESSERT NUT

Richard A. Hamilton
Warren Yee

AUG 28 1974

Contents

	Page
Description and Botany	3
Culture	5
Propagation	7
Climatic Adaptation	7
Soils and Fertilization	8
Diseases and Pests	9
Harvesting and Processing	10

The Authors

Richard A. Hamilton is Professor of Horticulture, University of Hawaii

Warren Yee is Specialist in Horticulture, University of Hawaii

Cover photograph of the 'Keaau' variety courtesy of Masao Miyamoto.

MACADAMIA: Hawaii's Dessert Nut

Richard A. Hamilton and Warren Yee

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

Macadamia nut seeds were first imported into Hawaii in 1882 by William Purvis and have since become the most important tree crop in the State. More than 90 percent of the world's production of macadamia nuts is grown on Hawaii, the southernmost island in the State, with smaller quantities produced on Maui and Kauai. Exploratory orchard plantings have been made in California and Australia and more recently in Rhodesia, Malawi, Kenya, South Africa, Guatemala, and Costa Rica, but these are largely in the experimental or developmental stage. Only in Hawaii, where improved clonal varieties have been selected and grown for about 25 years, have macadamia nuts achieved the status of a commercial crop. Macadamias are presently in great demand. Prices of in-shell nuts and processed kernels remain strong since the demand greatly exceeds the present supply.

Description and Botany

Two different species, *Macadamia integrifolia* and *M. tetraphylla*, produce edible kernels. Both species are attractive, medium-sized, evergreen trees, which may 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 ornamentals and shade 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 which opens along one suture when mature, and consists of a husk containing a



Fig. 1. Two of the oldest, heaviest-producing macadamia trees in the world, 25-year-old 'Keauhou' trees at the Kona Research Station on Hawaii.



Fig. 2. Flower racemes and fruit cluster of smooth-shell macadamia, *M. integrifolia*.

single (rarely double) seed with a very hard, brittle 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 and 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 no more than 3 to 7 nuts set and mature.

M. tetraphylla, the "rough shell" species, produces nuts that are usually spindle shaped and have a characteristically rough, pebbled surface. 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 purple or pale green. The flowers are pink and borne in racemes 8 to 15 inches long. Kernels are usually darker colored than the other species and often have a grayish upper half. They are more variable in quality than smooth-shell kernels, averaging about 70 percent oil and 6 to 8 percent sugar. High sugar content makes the kernels palatable and pleasant to eat raw, but their high sugar content and marginal oil content makes the nuts characteristically more variable in color, flavor, and texture. Varieties suitable for commercial processing have not been found. Rough-shell macadamia trees are sometimes planted as ornamental or shade trees and for their kernels, which are sweet and palatable to eat raw. The major value of *M. tetraphylla*, however, seems to be as a rootstock for smooth-shell varieties.

Many trees have been found which are hybrids between the two species, 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 commercial processing.

Culture

About 45 macadamia cultivars have been described from Australia, California, South Africa, and Hawaii. Only 5 of these—'Kakea,' 'Keauhou,' 'Keaau,' 'Kau,' and 'Ikaika'—are planted commercially in Hawaii. All are *M. integrifolia* clones selected in the State. Most macadamia

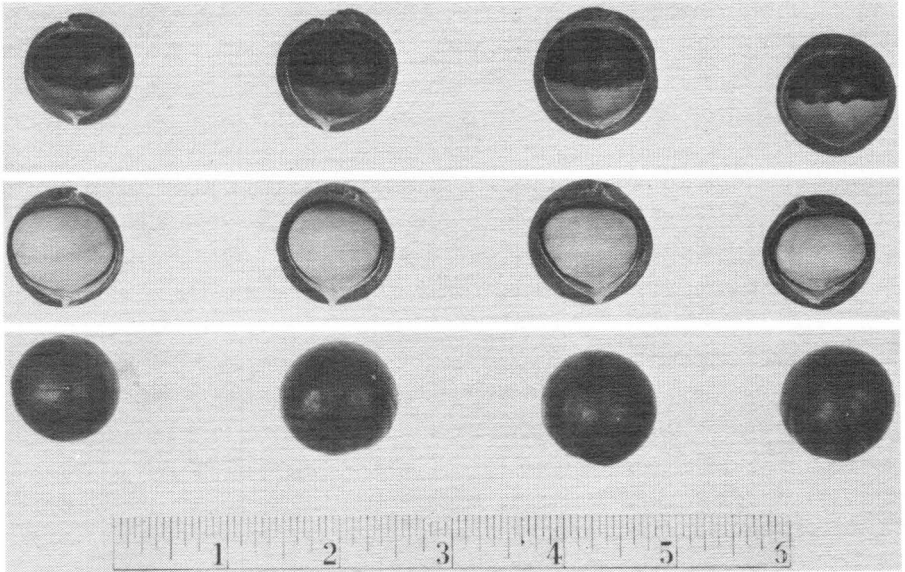


Fig. 3. Shell, kernel, and nut characteristics of four macadamia varieties. Left to right: 'Keaau,' 'Keauhou,' 'Ikaika,' and 'Kakea.'



Fig. 4. Five-year-old macadamia orchard near Honokaa, Hawaii, with the tree spaced 30 feet by 30 feet.

plantings attempted elsewhere are also of these varieties. With good care, in suitable areas of Hawaii, these cultivars begin producing appreciable crops 6 to 7 years after planting and usually attain full production in 10 to 12 years.

Yields from mature orchards in Hawaii range from 1 to 4 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 is spaced 35 by 35 feet. Most orchards in the State are spaced from 20 to 30 feet between adjacent trees, but at these spacings, excessive crowding commonly occurs at about the ninth or tenth year, adversely affecting yields so that thinning or heavy pruning becomes necessary.

Propagation

Vigorous, well-grown seedlings of both species have been used successfully as rootstocks for commercial plantings. When available, rough-shell seedlings are preferred as rootstocks by many nurserymen because they germinate uniformly, grow faster and more uniformly in the nursery, and are considered easier to graft and transplant. Macadamias are not considered difficult to graft although some actual experience with macadamias is usually essential for success, primarily 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 also used in top-working, larger trees.

Climatic Adaptation

Important factors to be considered in deciding on a suitable location for a new macadamia orchard 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 drouth 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



Fig. 5. Ten-year-old macadamia orchard, 'Kau' variety at the Waiakea Research Station, Hilo, Hawaii.

considered susceptible to wind damage and do best where there is good, natural wind protection or where adequate planted windbreaks are provided. When there is less than 50 inches of well-distributed, annual rainfall, supplementary irrigation is beneficial since moisture stress results in reduction in yield and quality of nuts. There have been some indications that temperatures over 95° F reduce production and growth, but these temperatures do not occur where macadamias are grown in Hawaii.

Soils 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, and such deficiencies can be corrected by soil applications of appropriate materials.

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 although they are not usable, it is almost impossible to separate them from good nuts. Anthracnose most commonly occurs in wet, humid areas but is readily controlled by planting the most resistant varieties. 'Keauhou', for instance, is immune to anthracnose. 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 is possible, 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. Affected trees are weakened and sometimes girdled and killed, but the disease is more frequent on seedling trees than in grafted orchards. This disease is so infrequent in commercial orchards that control methods have not seemed warranted to date.

Rats, wild pigs, and nut borers sometimes cause considerable loss to the macadamia crop. Rats feed on the kernels of both mature and developing nuts. They can be controlled with a well-planned poison bait program. Wild pigs often invade macadamia orchards to feed on mature nuts on the ground under the trees. When numerous enough to be a problem, wild pigs have been successfully controlled by hunting and trapping them in 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 may occur to the first harvest of early maturing nuts, but it is seldom serious in the main crop. Up to now, macadamia growers have not found it necessary to use control measures against these 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. Control programs have not been found necessary in commercial orchards. 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 serious.

Harvesting and Processing

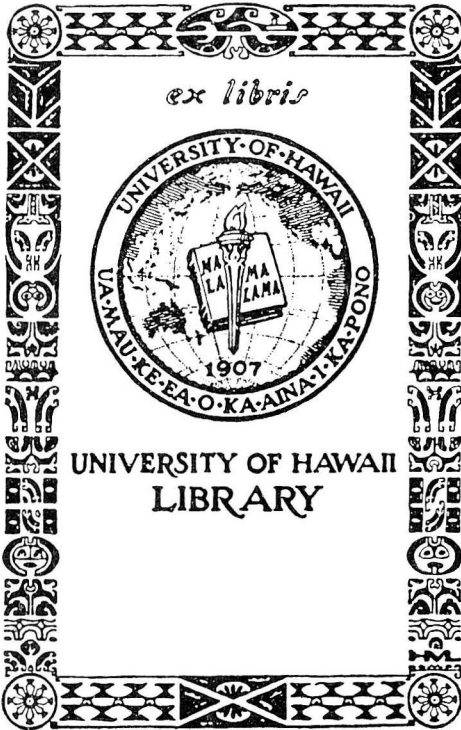
The main harvest period for macadamia nuts in Hawaii extends from August through January. October and November are peak harvest months, but it is common for some nuts to mature every month of the year. 'Ikaika,' 'Keauhou,' and 'Keaau' have short harvest periods, maturing most of their crop in September, October, and November. The nuts fall to the ground when mature and must be gathered before they begin to mold, germinate, or turn 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. Dehusking 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 72 hours at temperatures below 100° F. After cracking the nuts, kernels should be dried an additional 72 hours at about 125° F down to approximately 1½ percent moisture. The dried kernels are roasted in refined cooking oil for 12 to 15 minutes at 275° F or dry roasted in a rotary oven at 315° F for 25 to 30 minutes.

The Hawaii Cooperative Extension Service provides equal opportunities in its programs and employment.

Hawaii residents may order single copies of publications free of charge from county offices. Quantities of any one publication are sold at cost. Quotations will be furnished on written request to Agricultural Publications and Information Office, College of Tropical Agriculture, 2500 Dole Street, Krauss Hall Room 107, Honolulu, Hawaii 96822. Price per copy to bulk users, 15¢ per copy.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U. S. Department of Agriculture. C. Peairs Wilson, Dean, College of Tropical Agriculture, and Director, Cooperative Extension Service. Dale N. Goodell, Associate Director, Cooperative Extension Service, University of Hawaii, Honolulu, Hawaii 96822.

CIRCULAR 485-AUGUST 1974-2.5M



ex libris



UNIVERSITY OF HAWAII
LIBRARY