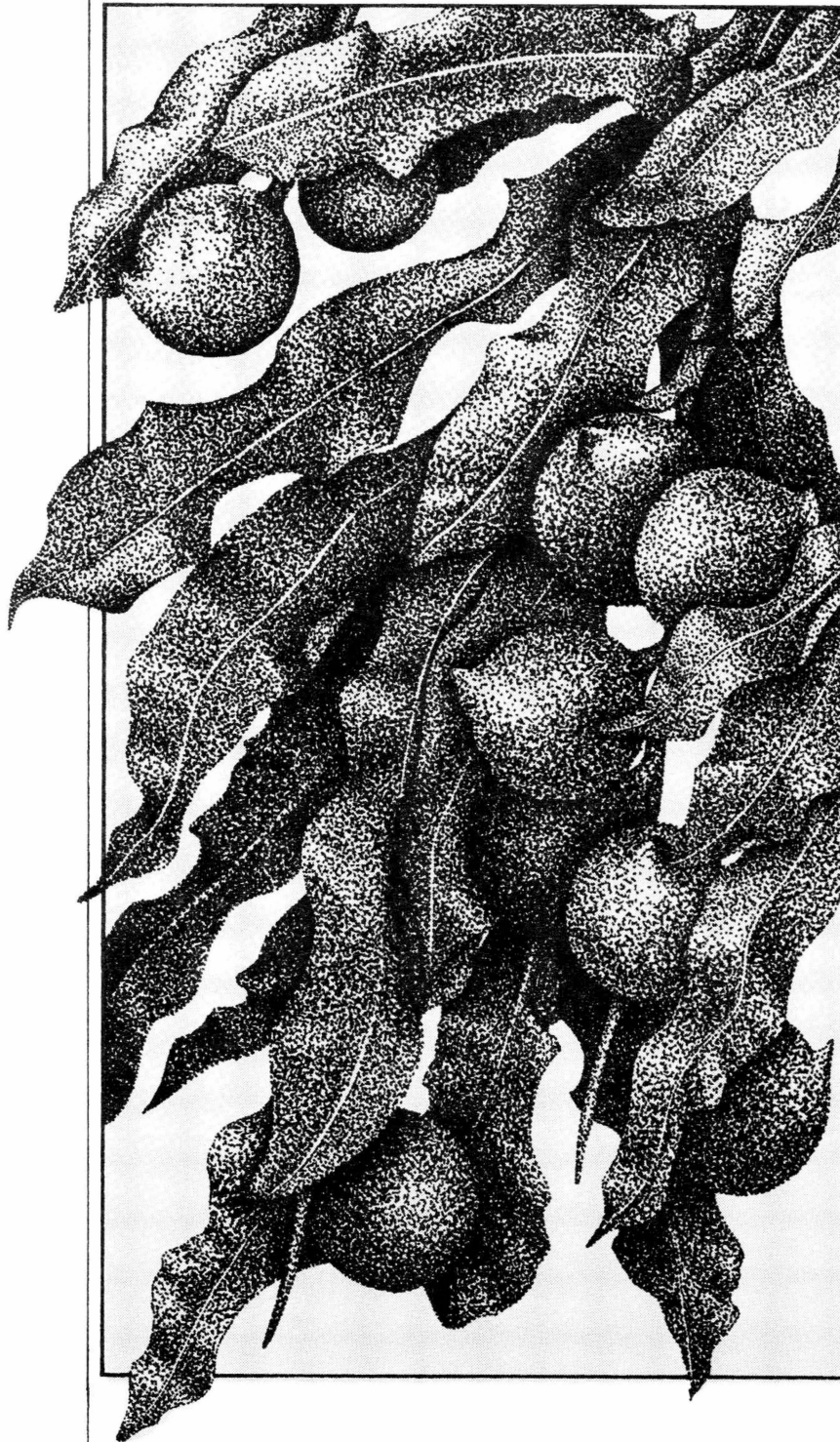


MACADAMIA NUT CULTIVARS RECOMMENDED FOR HAWAII

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THE AUTHORS

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

Philip J. Ito is Professor of Horticulture, College of Tropical Agriculture and Human Resources, University of Hawaii.

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MACADAMIA NUT CULTIVARS RECOMMENDED FOR HAWAII

Richard A. Hamilton and Philip J. Ito

Macadamia nut, *Macadamia integrifolia*, is a relatively new crop plant and the only native food plant of Australia to achieve world status as a commercial crop. Commercial development of this crop has taken place during the past 40 years in Hawaii, where more than 90 percent of the world's production of this fine dessert nut presently occurs. Production from several other countries including South Africa, Australia, Malawi, and Costa Rica is gradually increasing from plantings made during the past 15 years. These countries are expected to become more of a factor in future world production, although production from new orchards in Hawaii is also increasing. Macadamia nuts are now the most important tree crop of Hawaii in acreage, production, and value.

BREEDING AND SELECTION AT HAES

Macadamia breeding and selection work was initiated in 1934 by Hawaii Agricultural Experiment Station (HAES) horticulturists. Since then, 13 cultivars have been selected and named from more than 120,000 seedlings examined. Named cultivars are 'Keauhou', 'Nuuanu', 'Kohala', 'Pahau', and 'Kakea' (Storey, 1948); 'Ikaika' and 'Wailua' (Hamilton et al., 1952); 'Keaau' (Hamilton and Ooka, 1966); 'Kau' (Hamilton and Nakamura, 1971); 'Mauka' and 'Makai' (Hamilton and Ito, 1977); 'Purvis' (Hamilton et al., 1981a); and 'Pahala' (Hamilton et al., 1981b). Two other cultivars, 'Chong 6' and 'Honokaa Special', although not officially named, have become known by these names, and a few acres of these cultivars are still grown in the Kohala and Honokaa areas, respectively.

The 13 HAES cultivars were named and introduced after extensive yield trials, quality testing, and objective evaluation of tree, nut, and kernel characteristics. These cultivars presently make up practically all of the commercial acreage in the state. This situation is unique among fruit and nut cultivars, most of which have originated as chance seedlings selected by nurserymen, growers, and amateur horticulturists. Macadamia cultivars, on the other hand, have originated almost entirely as a result of breeding and selection efforts and rigorous testing carried on by University of Hawaii horticulturists and plant breeders.

TREE AND NUT STANDARDS FOR NEW SELECTIONS

Vigorous trees are selected with dark green foliage, strong crotches, and ascending rather than spreading branch structure. 'Keaau', 'Kau', 'Mauka', and 'Pahala' have more upright growth habits than 'Keauhou', 'Ikaika', 'Makai', 'Kakea', and 'Purvis', which have somewhat more spreading growth habits. Upright growth habits permit closer planting within the row and allow the planting of more trees per acre. The minimum annual production standards established for selection programs are 100 pounds of in-shell nuts from eight-year-old trees in favorable locations, and 75 pounds from 10-year-old trees in less favorable locations. Freedom from excessive numbers of stick-tight nuts, which remain on the tree after maturity, is also essential.

Trees are selected that bear medium-sized nuts, averaging 10 to 20 nuts per raceme, 60 to 70 uniformly sized nuts per pound, and 38 to 48 percent

kernel. The types of kernels preferred are uniform in size, round, white or cream colored, and without dark circles or off-color tops. There should be few or no stick-tight nuts, and at least 95 percent of grade 1 kernels with a specific gravity less than 1.0, determined as the percentage of kernels that float in water. Nut, shell, and kernel characteristics of seven currently recommended cultivars are compared with those of two older cultivars present in most orchard plantings (Figure 1). Table 1 lists average nut and kernel characteristics of these cultivars.

CURRENT HAWAIIAN CULTIVARS

Of the 13 cultivars developed and named in Hawaii, five are presently being grown commercially (Table 1). No one cultivar is superior to all others in every respect. Choice of cultivars to plant is made largely on the basis of adaptation to location, availability of scionwood, and preference of the grower. Detailed descriptions of cultivars listed in Table 1 have been published by the authors and others.

Approximately 120,000 seedlings have been examined and analyzed since 1934 to obtain the seven recommended cultivars. With the germplasm that was available in Hawaii, these were probably the best selections obtainable. These cultivars are certainly largely responsible for the success of the macadamia nut industry in the state.

Some improvement may be anticipated in the areas of yield, vigor, tree form, and stronger, wind-resistant rootstocks. Cultivars with more compact, upright tree forms may allow the planting of more trees per acre.

Immediate considerations, such as availability of scionwood, often influence choice of cultivars to plant. An example of this is 'Kau', presently being planted in much larger numbers than 'Purvis', 'Pahala', 'Mauka', and 'Makai'. The reason for this is because scionwood of 'Kau' is more readily available and the variety better known, although more recently introduced varieties have performed as well or better than 'Kau' in field tests at Kona, Waiakea,

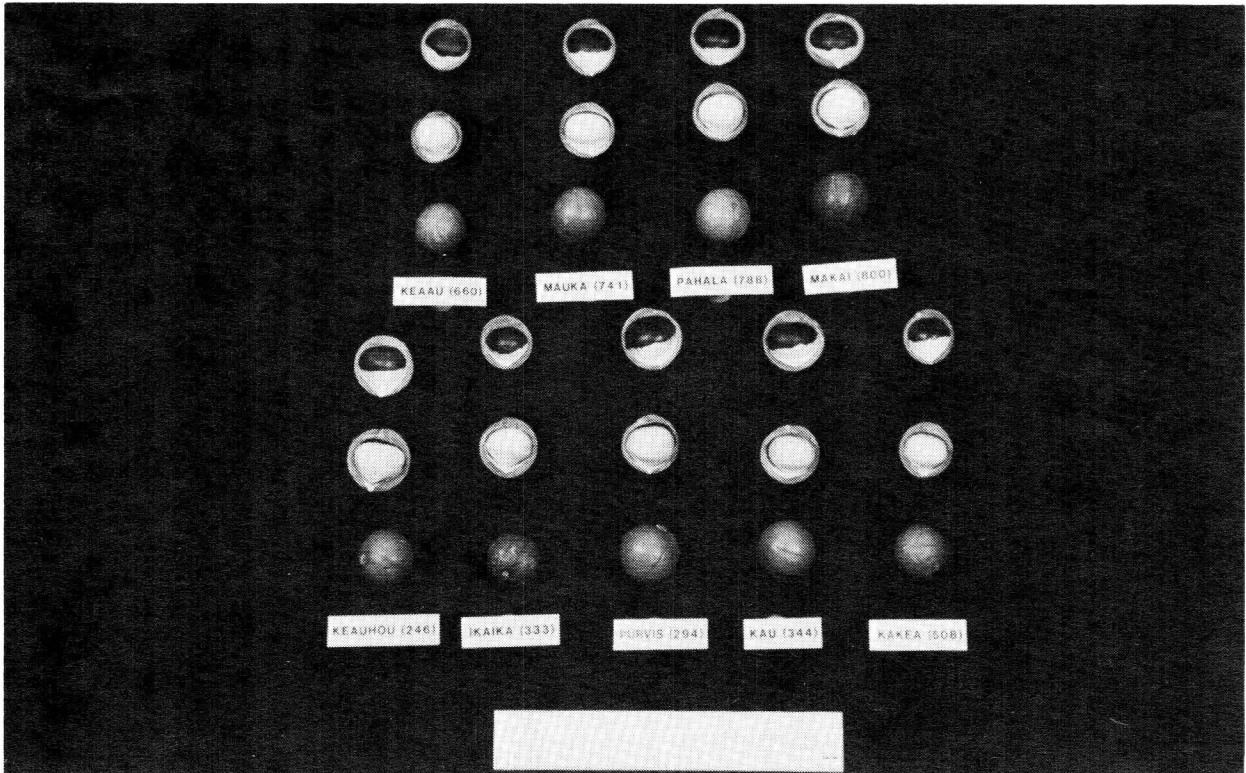


Figure 1. Nut kernel and shell characteristics of seven recommended macadamia cultivars: top row, left to right, 'Keaau', 'Mauka', 'Pahala', and 'Makai'; bottom row, center to right, 'Purvis', 'Kau', and 'Kakea'. Two older cultivars, no longer recommended, are 'Keauhou' and 'Ikaika', bottom row, left.

Table 1. Average nut and kernel characteristics of nine named macadamia cultivars developed and grown in Hawaii

| Cultivar | HAES Nos. | Percent kernel | Nut weight | Kernel weight | Nuts per pound | Hawaii grade No. 1 kernels | Cooked kernel appearance |
|-----------------------|-----------|----------------|------------|---------------|----------------|----------------------------|--------------------------|
| | | % | g | g | | % | |
| Keauhou ¹ | 246 | 39 | 7.2 | 2.8 | 63 | 85 | good |
| Ikaika ¹ | 333 | 34 | 6.5 | 2.2 | 70 | 89 | fair |
| Purvis ² | 294 | 39 | 7.9 | 3.0 | 58 | 95 | very good |
| Kau ^{1,2} | 344 | 38 | 7.6 | 2.9 | 60 | 98 | very good |
| Makea ^{1,2} | 508 | 36 | 7.0 | 2.5 | 65 | 90 | excellent |
| Keaau ^{1,2} | 660 | 44 | 5.7 | 2.5 | 80 | 97 | excellent |
| Mauka ² | 741 | 43 | 6.5 | 2.8 | 70 | 98 | excellent |
| Pahala ^{1,2} | 788 | 43 | 6.5 | 2.8 | 71 | 96 | excellent |
| Makai ² | 800 | 40 | 8.0 | 3.2 | 57 | 97 | excellent |
| Mean | | 39.5 | 6.77 | 2.73 | 66 | 94 | |

¹Cultivars presently grown commercially in Hawaii.

²Cultivars presently recommended for commercial orchards in Hawaii.

Poamoho, and Makawao experiment stations. In other words, growers usually have to see bearing trees and learn about cultivars from their own experience. It is hoped that the following brief varietal descriptions may assist growers in deciding which cultivars to plant.

Descriptions of cultivars presently recommended for planting are given here to correct misconceptions and unfounded rumors that frequently influence growers in their choice of cultivars. The following seven cultivars are presently recommended for commercial planting in Hawaii: 'Purvis' (294), 'Kau' (344), 'Makea' (508), 'Keaau' (660), 'Mauka' (741), 'Pahala' (788), and 'Makai' (800). Descriptions of 'Keauhou' (246) and 'Ikaika' (333) are included for comparison because they are present in orchards planted before 1970. They are no longer recommended because cultivars now recommended are superior to 'Keauhou' and 'Ikaika' in yield of grade 1 kernels.

'Keauhou' (246)

'Keauhou', the oldest Hawaiian cultivar, was selected in 1935 and named in 1948 (Storey, 1948). The tree is broadly spreading and somewhat susceptible to wind damage. 'Keauhou' requires wider spacing in the orchard than narrower, more upright cultivars. It is a productive cultivar with attractive nut characteristics but is not as hardy or wind resistant as other cultivars such as 'Kau' or 'Ikaika'. 'Keauhou' is a satisfactory cultivar in favorable areas, particularly Kona, where it has performed well, producing good crops of satisfactory quality nuts. It is no longer recommended for general planting in the state, however, because its kernel quality is marginal in many locations (Hamilton et al., 1975).

'Ikaika' (333)

'Ikaika' was selected in 1936 and named in 1952, largely because of its vigorous tree characteristics,

early bearing tendencies, and dark green foliage (Hamilton et al., 1952). It has been widely planted in areas where wind is a limiting factor in growth and production. The nuts are relatively thick shelled, and recovery of grade 1 kernels is less than 30 percent. Although 'Ikaika' is hardy and precocious, it is not presently recommended for planting because yields of older trees are generally lower and nut and kernel characteristics are not as desirable as those of the seven recommended Hawaiian cultivars.

RECOMMENDED CULTIVARS

'Purvis' (294)

'Purvis' was first selected in 1936. It was named, in 1981 (Hamilton et al., 1981a), after the late William Purvis, who introduced and planted the first seed nuts of *M. integrifolia* in Hawaii in 1882. It is interesting that one of the seedling trees from the original introduction has survived and still produces nuts at Kukuihaele on the island of Hawaii. 'Purvis' trees have consistently produced good crops with higher average percentages of grade 1 kernels than the first five cultivars named in 1948, with the exception of 'Kakea'. 'Purvis' kernels are of exceptionally good quality and flavor.

'Kau' (344)

'Kau', formerly HAES 344, was first selected in 1935 but not officially named until 1971 (Hamilton and Nakamura, 1971). 'Kau' resembles 'Keauhou' in nut characteristics and productivity, but develops appreciably better kernel quality in most locations. The tree form is more upright and shapely than 'Keauhou'. 'Kau' is also hardier and more wind resistant than 'Keauhou'. 'Kau' has been a relatively productive variety and appears adapted to elevations from 300 up to about 2000 feet. It is considered a good commercial cultivar.

'Kakea' (508)

'Kakea', an excellent commercial cultivar, was selected in 1936 and named in 1948 (Storey, 1948). It has performed exceptionally well in yield trials at the Poamoho, Waiakea, Haleakala, and Kona experiment stations. It is reasonably hardy, producing kernels of excellent quality, and has been consistently productive and long-lived in all test locations. 'Kakea' is considered harder to graft than most other varieties and also has a tendency to retain more stick-tight nuts than other recommended cultivars. Because of this, other cultivars may be preferred in high rainfall areas where stick-tight nuts become a problem. 'Kakea' remains one of the

best and most productive varieties for commercial planting in Hawaii, although it has a prolonged harvest season, making it less desirable for shake harvesting.

'Keaau' (660)

Formerly HAES 660, 'Keaau' was selected in 1948 and named in 1966 (Hamilton and Ooka, 1966). It has an upright growth habit, permitting somewhat closer planting than most other cultivars, without undue crowding. 'Keaau' has outstanding nut and kernel characteristics, with 42 to 46 percent kernel and more than 95 percent of grade 1 kernels. 'Keaau' nuts tend to germinate when left on the ground for more than a month during rainy weather. This is not considered a problem except when harvesting is neglected or unavoidably delayed for long periods of time during rainy weather. 'Keaau' is considered particularly well suited to shake harvesting because it has a shorter harvest period than other recommended cultivars, ripening most of its crop by the last week in November. This excellent cultivar has performed well over a wide range of elevations where it has been tested, including favorable locations up to 2000 feet.

'Mauka' (741)

'Mauka' is a relatively new cultivar selected in 1957 and named in 1977 (Hamilton and Ito, 1977). It was named 'Mauka' because it has performed better than other named cultivars at elevations up to 2200 feet, where most other cultivars are marginal. It is a hardy, upright-growing tree permitting closer spacing in the orchard than more spreading cultivars. Nuts are similar in size and percentage of grade 1 kernels to those of 'Kau' but average about 43 percent kernel, compared with 38 percent for 'Kau'. 'Mauka' has about 13 percent greater recovery of grade 1 kernels from a given weight of in-shell nuts than does 'Kau'.

'Pahala' (788)

'Pahala', one of the newest macadamia cultivars, was first selected in 1963 and named in 1981 (Hamilton et al., 1981b). The growth habit of the tree is somewhat narrow and upright so that 'Pahala' trees require less space in the orchard than varieties with larger, wider trees. Up to twice as many 'Pahala' trees per acre can be planted as cultivars with wide, spreading trees. The rate of recovery of grade 1 kernels from oven-dried nuts of 'Pahala' was 41.2 percent, approximately 50 percent higher than from 'Keauhou'. While overall yield capacity of 'Pahala' has not yet been fully evaluated, nut characteristics

and kernel quality have been thoroughly tested and found to be as good as or better than those of other commercial cultivars.

'Makai' (800)

This promising, high-quality cultivar was first selected in 1967 and named in 1977 (Hamilton and Ito, 1977). It was given the name 'Makai', a Hawaiian word signifying "toward the sea," because it appears better adapted to lower elevation sites than other recent selections or any of the older cultivars. 'Makai' is a seedling of 'Keaouhou', which it most resembles in tree form, nut characteristics, and yield potential. The kernel quality and percentage of grade 1 kernels from 'Makai' nuts are outstanding and significantly better than those of 'Keaouhou'.

DISCUSSION

These nine cultivars presently make up practically all of the commercial acreage and production of macadamia nuts grown in Hawaii. 'Mauka', 'Kau', and 'Keaou' have generally performed well from about 1700 to 2000 feet in elevation. They appear better adapted to planting at higher elevations than most other cultivars. For lower elevation plantings from 300 to 1000 feet, 'Purvis', 'Makai', and 'Keaou' have performed well in commercial and experimental plantings and are recommended for planting in areas below 1000 feet where there is adequate rainfall or irrigation. Most of the highest producing macadamia acreage in Hawaii is at elevations of 1000 to 1700 feet. All seven of the recommended cultivars have performed well in this elevation range and deserve consideration for new commercial plantings in the state.

The highest recorded yield from seedling orchards is about 1 ton of in-shell nuts per acre. Yields up to 4.5 tons per acre have been obtained from the best grafted orchards in Kona. The best kernel recovery obtainable from seedling orchards is about 25 percent, compared to more than 35 percent from good grafted cultivars. This translates into 500 pounds of kernels per acre from seedlings, compared with 3500 pounds of kernels from grafted orchards, and means that our current cultivars are capable of producing a yield of kernels per acre about seven times higher than the best seedling orchards.

Present cultivars in Hawaii were developed as a direct result of a selection and testing program carried out by Hawaii Agricultural Experiment

Station personnel and University of Hawaii horticulturists with valuable assistance from cooperators in the private sector. Breeding and selection of macadamia nut cultivars has been an interesting and rewarding experience. Further improvements and refinements can be expected in future cultivars. As acreage and value of macadamias in Hawaii continue to increase, it is interesting and thought provoking to speculate whether a macadamia industry of any consequence could have developed in Hawaii without the selection and introduction of these superior cultivars.

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