The mango varieties pictured on the cover are, from left to right, top row, Kalihi, Smith, and Hanson; middle row, Fairchild, Ewa, and Julie; bottom row, Haden, unnamed seedling, and Lott's Special.
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THE MANGO IN HAWAII

Warren Yee
Specialist in Horticulture

HISTORY

The mango (Mangifera indica) is a popular evergreen fruit tree native to southeastern Asia. It has been in cultivation for over 4,000 years, during which time it has spread from southeastern Asia to tropical and subtropical countries. Spanish and Portuguese explorers and traders carried the mango to various parts of the world. Mangos were first introduced into Hawaii from Mexico by Don Francisco de Paula y Marin, a Spanish horticulturist, between 1800 and 1820. Don Marin was known as "Manini" by the early Hawaiians; hence, the name "Manini" was given to the early type of mangos which he introduced. The Hawaiian mango, also called the "common" mango, is the descendent of one of these early types. In 1824, Captain John Meek brought the first mango trees from Manila to Hawaii. In 1885, Joseph Marsden introduced several mango seedlings from Jamaica, and of these, No. 9 or more popularly known as the "Chinese" mango became well established in the Islands. Later introductions were made by S. M. Damon, G. P. Wilder, the Hawaii Agricultural Experiment Station, and others who brought in improved varieties from India, the West Indies, the Philippines, and Saigon. Among them were Mulgoba, Jamshed, Sandersha, Brindibani, Cowasjee-Patel, Totapari, Ameeri, Pirie, Cambodian, Carabao, and Manila. The only variety of this group which has become popular in Hawaii is the Pirie mango, introduced in 1899.

The variety that has exerted the greatest influence on the development of the mango crop in Hawaii is Haden, which was imported from Coconut Grove, Florida, about 1930. Today, there are more Haden mango trees grown in Hawaii than any other variety (Fig. 1).

The mango has not developed into a major fruit crop in the Territory for several reasons. These include:

1) Erratic fruit production of the Haden mango—the principal commercial variety.
Figure 1. Haden mango tree, most widely-grown variety in Hawaii.

2) The quarantine of fresh fruit shipments to the Mainland due to the mango weevil.
3) A pocket market. Honolulu is the only sizeable market for the mangos.

With the solving of the above problems, an increase of commercial plantings can be anticipated.

SOIL AND CLIMATE

Although the mango is primarily grown in Hawaii at elevations below 1,000 feet, trees may be found growing from sea level up to about 2,800 feet. The tree itself is not difficult to grow and is relatively tolerant to drought and poor soil conditions, but not poor drainage. It is usually cultivated in areas with less than 60 inches of rainfall a year. It is also found as an escape from cultivation, growing to very large trees in the wet areas where there is more than 120 inches of rain per year. The trees seem tolerant to different soil types, for they can be seen doing well in sandy soils such as found at Kahului, Maui, as well as the red low humic latosol soils of Kaunakakai, Molokai.

The most desirable location for mangos, however, is in the hot and dry sections on sandy soils or dry, low humic latosol soil types. Low-rainfall areas are preferred
for mango growing because water supply can be controlled by irrigation, and there is less likelihood of anthracnose epidemics on inflorescence and fruit.

USES

Mangos are primarily used as fresh fruit. Usually, they are peeled and eaten out of hand or used in mixed fruit salads. They are also served much the same way as a half cantaloupe is served (Fig. 3). This is possible only with varieties with flesh that separates from the seed easily. Pirie, Smith, and Gouveia are varieties that can be served in this manner.

Recipes on various mango products such as mango chutney and butter are obtainable from the book, *Fruits of Hawaii*, by Carey D. Miller, Kathetine Bazore, and Mary Bartow (Honolulu: University of Hawaii Press, 1957).

VARIETIES

Most of Hawaii's backyard and commercially grown mango varieties are introduced varieties. Of these the most widely grown are Pirie and Haden. The former is used mostly for home plantings; whereas the latter is used for both home and commercial plantings. The number of Haden trees planted is probably greater than all other varieties combined.
During the past 10 years, Florida has been one of the chief sources of new mango varieties. The recent introductions from Florida are: Kent, Zill, Keitt, Sensation, Edwards, Carrie, Irwin, and Lippins. The merit of these varieties has yet to stand the test of time.

Very few Hawaiian seedling selections have gained the popularity of Pirie and Haden. A few have been named, but none have gained widespread recognition. These include White Pirie, Shibata (Syn. MacArthur), Kinney, Texeira, and Joe Welch. Of these, Joe Welch is probably the most popular. It has achieved a reputation for off-season and annual crops. The reputation of this variety for off-season bearing has led to its use for backyard plantings.

It was not until 3 years ago that a survey of outstanding Hawaiian seedlings was made. The stimulus was received when the Economic Planning and Coordination Authority, established by the Territorial Legislature, began a search for possible sources of income to broaden the economic base of the Territory. Tropical fruits were considered, and the mango was one of these. In order to locate the best available seedlings in the Territory, a mango contest was held by the University. It resulted in the discovery of several promising seedlings which are now under observation. Among these are Ah Ping and Gouveia.
DESCRIPTION

Established Varieties

Haden: A Mulgoba seedling planted in 1902 in Coconut Grove, Florida. Fruit, medium, 1-1 1/2 pounds; color, bright crimson blush with yellow ground color and many white lenticels; flesh, juicy, firm, subacid with some fibers; seed, small. Tree is spreading and open. Fruit production, good but inconsistent. Season, June-July. (Fig. 4.)

Pirie (Syn. Strawberry, Peter's No. 1, Paheri): An Indian mango variety imported by the late S. M. Damon in 1899. Fruit, small, 8-10 ounces, ovate, thick, and plump; color, greenish-yellow with crimson overcast; flesh, juicy, fiberless, melting, rich, and sweet; seed, medium. Tree is spreading, thick, and vigorous. Fruit production, poor to fair and inconsistent. Season, July. (Fig. 5.)

Varieties for Trial and Home Planting

Ah Ping: A selection from a seedling orchard planted by Mrs. Chun Ah Ping about 25 years ago at Mapulehu, Molokai. Fruit, medium, 1-1 1/2 pounds, exceptionally firm, produced in clusters; color, deep yellow-orange with crimson blush, numerous white lenticels; flesh, firm, fiberless, and subacid; seed, small. Tree is upright and open with exceptionally large and long leaves. Fruit production of the original seedling tree reported to be good. Season, July.

Gouveia: A Pirie seedling planted by Mrs. Ruth Gouveia about 16 years ago at 1445 Mahuna Street below St. Louis Heights, Honolulu. Fruit, medium, 1-1 1/2 pounds, ovate, oblong; color, maroon with greenish-yellow ground color; flesh, juicy, melting, fiberless, and very sweet; seed, small. Tree is upright and open. Fruit production of the original seedling tree reported to be good and consistent. Season, August. (Fig. 6.)

Joe Welch (Syn. Mapulehu): A seedling from fruit obtained from India and planted on Molokai by Joe Welch in 1929. Fruit, medium, 1-1 1/4 pounds, ovate, thick, and well filled; color, yellow; flesh, juicy, fiberless, melting, and subacid; quality, fair to good; seed, small. Tree is vigorous with spreading crown. Fruit production, very good; sporadic off-season fruiting common. Season, July. (Fig. 7.)

Kent: A Borsha seedling originated in Coconut Grove, Florida. Fruit, large, 1 1/2-2 1/2 pounds, ovate with somewhat flattened sides; color, dark crimson in full sun with numerous white lenticels, greenish-yellow ground color; flesh, juicy, very sweet, melting, and fiberless. Tree is upright and thick. Fruit production, good and fairly consistent. Season, August-September. (Fig. 8.)

Zill: A Haden seedling originated in Lake Worth, Florida. It was first introduced into the Islands by the Territorial Board of Agriculture and Forestry about 1944. Fruit, small, 5-6 ounces, ovate; color, crimson blush covering the fruit almost completely, yellow ground color; flesh, juicy, very sweet, and fiberless; seed, small. Tree
is dome-shaped and open. Fruit production, good and fairly consistent. Season, June-July. (Fig. 9.)

Julie: A variety introduced into the United States from Trinidad. Fruit, small to medium, 6-10 ounces, oblong with flattened sides; color, dark green tinted with red on side exposed to sun; flesh, orange, juicy, sweet, and moderately fibrous. Tree is slow growing, dwarf growth and spreading. Fruit production, good and consistent. Season, August-September. (Fig. 14.)

Ono: Said to be a Pirie seedling grown by R. W. Smith of Makiki Heights, Honolulu. Fruit, small, 5-8 ounces, ovate, oblong; color, yellow with tinge of pink on side exposed to sun; flesh, yellow, juicy, melting, rich, and spicy. Season, July. (Fig. 14.)

Edwards: A Haden and Carabao cross made by Edward Simmonds of Florida. Fruit, medium, 1-1½ pounds, oval-oblong; color, rich yellow with light red or pink blush with many green-colored lenticels; flesh, very firm, moderately juicy, fiberless, and sweet; seed, small. Tree is spreading in form. Fruit production, fair. Season, June-July. (Fig. 10.)

Fairchild: Graft wood of this variety was imported into the Territory from the Panama Canal Zone by Allan Bush, former Superintendent of Grounds at the University of Hawaii, in 1926. Fruit, small, 5-7 ounces, oval; color, attractive yellow; flesh, juicy, almost fiberless, sweet, and rich; seed, medium-large. Tree is spreading and open. Fruit production, fair. Season, July. (Fig. 11.)

Georgiana: A seedling tree planted in the yard of Mrs. Georgiana Akana at 477 L Road, Damon Tract, Honolulu, about 20 years ago. Fruit, small, 4-6 ounces; color, rich yellow with slight crimson blush; flesh, juicy, fiberless, and sweet; seed, large. Tree is upright and open. Fruit production reported to be good and consistent. Season, June-July. (Fig. 12.)

Smith: A seedling found growing at the home of John T. Smith at 1209 Wilder Avenue, Honolulu. Fruit, medium, ¾-1½ pounds, ovate; color, rich yellow ground color with bright crimson blush; flesh, juicy, spicy, and fiberless; seed, small, easily separated from flesh. Tree is spreading, thick, and vigorous. Season, July-August. (Fig. 13.)

PROPAGATION

Mangos are propagated either by grafting or by seed. Most varieties in Hawaii are propagated by grafting. Grafting is preferred because the desired variety can be propagated true to type; whereas planting of the seed may produce an entirely different type of fruit and tree. There are, however, some varieties which will reproduce true from seed. With these varieties, grafting is not required. Seeds of this type are polyembryonic. Usually, several young plants develop from a seed. Varieties which
Figure 10. Edwards.

Figure 11. Fairchild.

Figure 12. Georgiana.

Figure 13. Smith.

Figure 14. Left to right, top, Hawaiian or common, Itamaraca, Ono; bottom, Julie, No. 9 or Chinese, Fairchild.
fall into the polyembryonic category are Hawaiian, Paris, Julie, Shibata, Kurashige, and No. 9 or Chinese mango.

There are many techniques used in grafting mango seedlings. The most common methods used are the side-wedge or side-graft and the side-paste methods (Figs. 16 and 17). The side-paste technique is also called the side-veneer graft. Other methods used by nurserymen are inarching, side-tongue, and whip.

Vegetative propagation by budding has not become an established practice in the Territory. Air-laying has also been tried by various individuals. Some success has been reported, but in general, trees grown by this method are weak and slow growing.

**PLANTING AND SPACING**

The soil in which the mango tree is to be planted should be irrigated prior to planting so that when transplanting, the roots will be in contact with moist soil at all times, otherwise, the roots will dry out and set the growth of the tree back several months. The hole in which the tree is placed should be at least three times the width and twice the depth of the container in which the grafted plant is grown. When the tree is removed with the soil from the container, it should be planted with the soil around the root system and irrigated as soon as possible. The roots should be covered to about the same depth as in the container or slightly deeper. Newly planted trees should be irrigated at least once or twice a week, depending upon weather conditions.

Grafted trees that show mature leaves and evidence of well-swollen buds may be planted at any time of the year. Trees showing young immature leaves usually are not transplanted until the leaves are more mature, because they may be injured from the sudden change of growing conditions. In general, it is better to transplant trees during the rainy season; then trees are less likely to be set back in growth.

Mango trees should be spaced approximately 35-40 feet apart in a square in permanent plantings (Fig. 15). In order to have greater production during the first 15 years, it may be desirable to plant an additional tree in the center if the square system with trees spaced 40 feet apart is used. These temporary trees should be removed or cut back when crowding becomes apparent and fruit production of the permanent trees is affected.

**PRUNING**

Mangos are not pruned unless there is a definite need. Pruning is generally restricted to the removal of dead branches. When there are too many branches growing at the same level and crowding each other, these may be pruned also. Perhaps more important than pruning is the proper training of the newly planted tree. All branches below the 2-foot level on the trunk are removed. Then, 3 to 4 branches are allowed to grow from the trunk at different heights to form the framework of the tree.

Pruning is done when it causes the least stress on the tree. This is before the tree flushes or forms new growth. New growth occurs several times a year, so pruning may be carried out at any one of the periods prior to flushing. The present practice is to prune immediately after the fruiting season, which is usually from June through August and prior to a new growth flush.
FERTILIZATION

Specific information on mango fertilization is not available and only general recommendations can be made. Hawaiian soils usually lack the elements nitrogen (N), phosphorus (P), and potassium (K) necessary for normal plant growth. Hence, to ensure an adequate supply of all elements, a complete fertilizer containing all of these is recommended. Such a fertilizer is the general garden fertilizer (10-10-10), which contains 10 percent nitrogen (N), 10 percent phosphoric acid (P₂O₅), and 10 percent potash (K₂O). A fertilizer higher in potash is suggested for the lowlands and black soil areas. The following fertilizing schedule may be used as a guide:

First year
1st application at planting time ... ¼ lb.
2nd application 4 months old ... ¼ lb.
3rd application 8 months old ... ½ lb.

Second year
1st application 12 months old ... ½ lb.
2nd application 16 months old ... ½ lb.
3rd application 18 months old ... ½ lb.

Third year
2 or 3 applications ... 1–2 lb./application

Fourth year
2 or 3 applications ... 1–2 lb./application

Fifth year
2 or 3 applications ... 2–4 lb./application

The amount and kind of fertilizer to apply on bearing trees will vary with the condition of the tree, the size of the crop, and other environmental factors. Farmers and backyard growers tend to over-fertilize in wet areas and to under-fertilize in dry areas. Usually a tree with a heavy set of fruit will require heavier fertilization than a tree with a light fruit crop. Commercial growers should consult their County Agents for additional information on fertilization.
Figure 16. Side-paste, or side-veneer method of grafting.

Figure 17. Side-wedge method of grafting, also called side-graft.
The bearing habit of a tree is dependent upon such factors as variety, cultural practices, and environmental conditions. The amount of fruit setting on a tree is of paramount importance to the grower. The varieties with a higher percentage of perfect flowers usually set a greater number of fruits than those with a lower percentage. A panicle or flower terminal may contain as many as 3,000 flowers, but only a few of these flowers are capable of producing fruit. The Zill variety, which produces a greater number of perfect flowers than the average, usually has from 2 to 7 fruits on a panicle under good growing conditions. The Edwards, which has a very low percentage of perfect flowers, normally has 1 fruit on a panicle.

Much has been said about the poor bearing habits of the Haden mango and its irregular bearing characteristic. This is often confused with poor crops. Actually, Haden production is good and crops are usually large. The undesirable characteristic of this variety is that it has a strong tendency towards biennial bearing. Some believe that biennial bearing can be corrected by good cultural practice. This problem has not been solved.

Fruit setting is affected by environmental conditions also, such as wind and rain. An ideal location is one that is free from strong winds and rain during flowering and fruit setting. Favorable conditions such as these will increase the production of good
crops. These conditions are approached in the dry leeward sections of the Islands. Examples of such areas are Waimea on Kauai, Kawaihae and Kailua on Hawaii, Kihei and Lahaina on Maui, Kaunakakai on Molokai, and Ewa on Oahu.

Trees growing in the valleys and very wet sections of the Islands characteristically set few fruits. This low production is a result of diseases which destroy the flowers or the small immature fruits during the flowering and fruiting season.

Several orchardists have girdled their Haden trees during September and October to encourage annual bearing. Trees so treated have had as many as 10 fruits to a flower cluster. Girdling, however, has not been successful in all instances, and there is still some doubt whether it is effective at all. Observations indicate that if girdling is to be effective, a tree must be in a healthy and vigorous state and the terminals must be mature. The girdle is made by removing ¾ inch of bark around a large branch with a pruning saw. Usually, one half of the branches are girdled one year and the other half during the following year. Hence, a branch is girdled every other year.

Grafted mango trees usually produce a few fruits by the fourth year in the dry lowland areas. These fruits should be removed to permit the young tree to make better growth. In the valleys and wherever there is a great deal of moisture and cloudiness, the grafted trees may take an additional year or more to fruit. Crops of 25-400 pounds can be expected in the fifth to seventh year if flowering occurs. Yields of 200-1,000 pounds can be expected between 8 to 14 years. Trees that are 15 years or older have been reported to have crops over 1,000 pounds.

Trees that are exposed to sunlight continuously are usually heavier yielding than those grown under partial shade. Experiments with the Pirie mango have shown that it takes approximately 18 months for a terminal that has fruited to flower again. This accounts for the alternate bearing of the Pirie mango and probably other varieties which have the tendency to bear fruits on alternate years. Varieties which seem to bear fruit more consistently than Haden or Pirie are Joe Welch, Fairchild, Zill, Kent, Edwards, Ah Ping, Georgiana, and Gouveia.

WINDBREAKS

An area free from strong winds and suitable for mango production is seldom found in Hawaii. Therefore, it is desirable to plant permanent windbreaks in a mango orchard. Trees that are not protected are buffeted frequently during the flowering and fruiting season. As a result, production can be severely affected.

A windbreak that is permeable is more satisfactory than one that is a solid barrier. A permeable windbreak results in less eddying and thereby results in less damage to the trees and their crops. The distance between windbreaks will vary with such factors as location, type of windbreak, and contour and size of area. The distance between windbreaks is anywhere from 8 to 20 times the maximum height of the windbreak trees.

Trees which would be useful as windbreaks are Ironwood (*Casuarina equisetifolia*) (Fig. 18), Paper Bark (*Melaleuca leucadendron*), and Norfolk Island Pine (*Araucaria excelsa*).
The markets obtain their mangos from three sources: (1) backyard growers, (2) commercial growers, and (3) wholesalers. Backyard production is as great as or greater than all commercial production put together. As a result, when mangos are in full season, commercial growers and wholesalers have some difficulty in marketing their fruit. Prices that the commercial grower demands are usually higher than those of backyard growers, and many markets will obtain their mangos from the cheapest source. Wholesale prices for Haden mangos range from 35 cents a pound in May or June (early in the season) to as low as 5–7 cents a pound in July and August (mid-season). In mid-season all of the mangos do not reach the market, for only the high quality fruit is marketed. With the market situation as it is, potential growers should consider the possibility of planting varieties that come into bearing very early or very late in the season.

Mangos are usually packed in a paper carton which holds 14–16 pounds (Fig. 19). Materials such as excelsior and dividers are used by some growers in padding their fruits. As a result of high costs of cartons, some growers are using the standard tomato lug, which holds 25–30 pounds.
INSECTS

In general, insects are not very injurious to mangos. The fruit can often be grown without the excessive use of insecticides. However, at times, it is attacked by insects such as the oriental fruit fly (*Dacus dorsalis*) (Fig. 20), mango weevil (*Sternotettus mangiferae*), scales (*Ceroplastes rubens*, *Coccus viridus*), red-banded thrips (*Selenothrips rubrocinctus*), and mites (unidentified, probably *Paratetranychus yothersi*).

The oriental fruit fly does not attack all mango varieties to the same extent. Evidently, the fruit of some varieties is more susceptible to attack than that of others, although the location of the orchard with respect to other host plants also has some effect on the severity of attack. The most susceptible varieties are Hawaiian, Pirie, and Sandersha. In order to avoid damage by this pest, varieties other than those mentioned above should be planted.

If control of the oriental fruit fly is desired, the use of 3 tablespoons of malathion (25 percent wettable powder) in 1 gallon of water or 5 pounds per 100 gallons of water sprayed at weekly intervals for 3 months should give effective control. Where possible, the spray should be applied also to nearby trees and shrubs which might harbor the adult flies.

The mango weevil does not usually damage the fruit and, consequently, is not considered to be a serious pest locally. However, this pest is a hindrance to the
Figure 20. Left, oriental fruit fly; above, fruit fly maggots.
(Photo courtesy HAES.)
development of a fresh export crop for Hawaii. Because of this weevil and the fruit fly, a quarantine on Hawaiian-grown mangos has been put into effect.

The adult weevil lays its eggs on the small green fruit before it is half grown. Usually, several eggs are laid on the fruit. The eggs hatch and the larvae burrow into the soft, immature seed and remain there until they develop into adults. Then, after the fruit has ripened and the flesh decomposed, the weevils bore their way out of the seed (Fig. 21). The consumer often does not detect the presence of the weevils within the seed because there is no external evidence of infestation.

Chemical control of the mango weevil is difficult. Once the larvae have made their way into the fruit, there is little to be done in the way of control. From the standpoint of producing fruit for local consumption, the use of insecticides to control this pest is uneconomical because of the small amount of damage it causes. However, from the standpoint of exporting fresh fruit, it is desirable to control the mango weevil effectively. At the present time, there is no method of controlling this pest so that mangos can be shipped to the mainland United States.

Mites are at times a pest of mangos grown in the drier areas. Without proper control, damage to the tree and fruit can be severe (Fig. 22). Affected leaves are unhealthy in appearance and show tiny light-colored spots on the upper surface of the leaves. Control is obtained by spraying with 5 tablespoons of wettable sulfur in a gallon of water or about 5 pounds per 100 gallons of water.

Figure 21. Left, healthy seed; right, seed infected with weevil.
Red-banded thrips are frequently found on mango trees (Fig. 24). The varieties commonly attacked are Hawaiian and Pirie. The thrips are easily controlled by spraying malathion (25 percent wettable powder) at the rate of 3 tablespoons per gallon of water or 5 pounds per 100 gallons of water.

Scales are also pests of mangos (Fig. 23). At times they may be found abundantly on the stems and foliage, but usually there are enough predators and parasites about to keep them well under control. If spraying is desired, malathion is recommended at the same concentrations used to control thrips.
Figure 24. Leaves injured by thrips. (Photo courtesy HAES.)
DISEASES

Anthracnose

Anthracnose (*Colletotrichum gloeosporiodes* Penz) is the most serious disease of the mango (Fig. 25). It causes flowers and fruits to turn black and to drop prematurely. In high-rainfall areas, only varieties showing resistance to anthracnose are recommended for planting. Examples of resistant varieties are Paris and Fairchild. In areas with little rainfall, anthracnose is not so serious a problem. Chemical control of this disease is obtained by using the fungicide Captan. This is applied at the rate of 3 pounds per 100 gallons of water during the blossoming and fruiting season. Six ounces of a sticker such as Triton B 1956 is added to the spray. The fungicide is sprayed every 7 days. In very wet areas, it may be necessary to spray Captan more frequently.

Stem Rot

Stem rot is a term applied to mangos that show a blackening of the stem end of the fruit (Fig. 26). It occurs on fruits that are ready to be harvested. Oftentimes, external discoloration of the stem end of the fruit is not visible. The skin around the stem may show small blackened spots which are slightly depressed. The cause
of stem rot is not fully understood. However, it is the opinion of some that stem rot is caused by a deficiency, or lack of moisture.

Sooty Mold

Sooty mold is a fungus disease brought about by scale insects. Affected leaves and fruits have a sooty black appearance. A heavy infestation of sooty mold can severely affect the producing capacity of a tree. The best means of controlling this disease is by controlling the scale insects. Malathion used to control thrips and fruit flies is effective against scales also.

Tip Burn

Leaves affected by tip burn are dry at the tip and light brown in color. However, the discoloration and drying of the tissues may progress to the point where more than one half of the leaf is dead (Fig. 27). Severely affected trees are more frequently found in the dry leeward sections of the Islands. Tip burn is associated with potassium deficiency. It may be corrected by the application of a potash fertilizer such as muriate of potash. More frequent irrigation is also helpful in correcting tip burn.
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