

THE FLAVOURS OF PARADISE: THE TASTES OF FABULOUS, EXOTIC TROPICAL FRUITS!!

Of the many thousands of fruits in the Tropics, most of the best have been fairly well distributed, although even these are frequently underutilized. Nevertheless, there are good fruits still to be distributed, still to become part of every backyard scene in the Tropics, and still to be commercialized in the Tropics and the Temperate Zone. Of these, most are from the American Tropics, and the rest are from the Asian Tropics. From the African Tropics have come many thousands of minor but very few major fruits.

The discussions concerning care of tropical fruits with potential have not been complete with respect to fertilization because in most cases good information is not available for minor tropical fruits and because tropical soils vary so much in fertility. Nevertheless, it can be assumed that all trees need added nutrients to obtain maximum growth and production. Tropical soils with sufficient nitrogen are rare.

As a general rule, a 10-10-10 fertilizer (nitrogen, phosphorus, potassium) can be used when trees are small. This is applied several times a year at the rate of 100 to 200 grams per centimeter of the trunk diameter at each application. The area under the tree is cleaned of vegetation: and the mineral fertilizer is placed on the soil well under the outside edge of the crown. It is sometimes buried in shallow holes or is broadcast after very light disking. Fertilizer applied to the surface should be carried into the soil by a penetrating irrigation.

The same fertilizer mixture can be applied to mature orchards at the maximum rate of 2,000 kilograms per hectare per year.

Organic materials such as compost and manure, when well rotted, can be applied on the soil, under the ground, or carefully disked into the soil. They should not be applied near the trunk.

Careful observations should always be made so that the appropriate amounts of fertilizer to stimulate growth without damaging the foliage are learned with experience.

No single judge is capable of selecting the fruits that will be great in tomorrow's world. Some of the commonest, most extended fruits in the Tropics - the tamarind, for example - are not great. It is tempting to believe that some really great fruits just wait to be discovered. There is no sharp line between fruits of great potential and just ordinary fruits, part of the difference depends on human actions. Three such borderline fruits worthy of mention are the black sapote, the morang, and the okari nut. These fruits are discussed in the final parts of the following sections concerning tropical American and Southeast Asian fruits.

Fruits of the American Tropics

The mamey sapote, *Pouteria sapota* (family Sapotaceae), is one of the most notable and talked about fruits of the Tropics. While not appealing at first to all palates, its flavor is rich and distinctive, and very much appreciated by its fans. Little known outside the American Tropics, the mamey sapote is found chiefly in Mexico, Central America, northern South America, Cuba, Haiti, and the Dominican Republic. It is also found in Florida, where its popularity is increasing. It is not well known in Puerto Rico or the Lesser Antilles. Occasional trees are found elsewhere throughout the Tropics, but nevertheless the species can be considered poorly extended.

The mamey sapote is an attractive medium sized tree seldom reaching 20 meters in height and 45 centimeters in trunk diameter in very old age. It tends to be uniform and hemispherical.

The leaves are entire, obovate or oblanceolate, and 20 to 45 centimeters long. They are dark green and shiny on the upper surface, with yellowish veins, and light green on the underside. The leaves are grouped in whorls of 8 or 10 near the ends of young branches.

The flowers, small and almost sessile, develop in large numbers along bare branches below young leaves. The calyx consists of 8 to 10 imbricated sepals. The corolla is 5 white petals united in a tube. Within are five fertile stamens, five staminodes, and a conical, pilose pistil terminating in a simple stigma. The ovary consists of five carpels with a single ovule in each cell.

The fruit is ovoid or ellipsoid. The calyx persists at the base; and sometimes the remnants of the pistil are seen at the apex. The fruit is 10 to 25 centimeters long and 8 to 12 centimeters wide and has a thin but strong exocarp with a rough, rusty brown surface. The pulp is from salmon to reddish brown in color, thick, and very sweet and aromatic. Usually, a fruit contains only one seed, ellipsoidal or spindle shaped, 5 to 6 centimeters or more long with a hard, shiny testa and a large cream colored or opaque hilum, but fruits of some varieties commonly contain 2 or 3 seeds.

Varieties of mamey sapote are being developed. In the past the species has been propagated almost exclusively by seedlings, which are quite variable, especially with respect to form and size of the fruit, and the color and quality of the pulp. In El Salvador, 'Magana' is known for its very large fruit (up to 1.5 kilograms). This variety was introduced in Florida in 1962 and is now cultivated commercially. Another variety in Florida is 'Cubana No. 1', with fruits up to 23 centimeters long and 1 kilogram in weight. Several other selections are being evaluated at Homestead, FL.

Very good trees can be obtained through sexual propagation, although this technique is not recommended as explained above. If attempted, the seeds should be planted free of flesh but fresh from the fruit because viability decreases rapidly as the seeds dry. Increased and more uniform germination has been achieved by removing the testae carefully and planting the seeds in a sterile medium.

Asexual propagation, though difficult, is preferred. The most successful technique is approach grafting. The seedling that is to be the stock is suspended in its container near the branch that is to be grafted. Similarly sized and shaped portions of the stems are cut from the stock and the branch, and the two are carefully pressed together, wrapped with tape, and sealed with vinyl tape. After months the grafted branch is progressively cut from the mother tree until it is entirely supported by the stock.

The mamey sapote is best adapted to tropical lowlands, but its adaptation is wide, and the tree is also found in the subtropics and in tropical highlands. It does not tolerate frost. It seems to be well adapted to various soils and has been found growing in sands, calcareous soils, and heavy clays. The optimum soil seems to be fairly deep and acid, with moderate permeability, good drainage, and at least average fertility.

Trees should be transplanted about 6 to 8 meters apart in prepared fields at the beginning of the rainy season. Seedlings are generally larger than grafted trees and need more space.

Young trees need regular fertilization. Liquid 20-20-20 should be applied during the first year at the rate of 25 grams per tree each 3 months. The fertilization rate should gradually be increased to about 5 kilograms per year, with half applied at the beginning of spring rains and half at the beginning of flowering. Although the mamey sapote is

somewhat resistant to drought, young trees should be watered regularly, and weeds should be removed. Very little pruning is necessary.

Because the mamey sapote has not been grown in large plantings, little is known of its diseases and pests. Termites make their nests in the trees. Anthracnose (*Colletotrichum spp.*) is a rare but severe disease. The sugarcane root borer, *Diaprepes abbreviatus* L., sometimes damages roots. No treatments are registered for these conditions in the United States.

Healthy seedling trees begin to produce after about 7 years, while grafted trees produce earlier. The fruits mature after 10 to 15 months on the tree. Maturity must be judged carefully by the size of the fruit and a slight internal color change, which can be revealed by scraping the fruit with a fingernail. An immature fruit is green inside, while a mature fruit is yellow or reddish. The fruits should be picked when mature but still hard. They will then ripen in a few days. The pulp is normally consumed fresh, but it is also used in drinks or milkshakes and in jellies and preserves.

The canistel, *Pouteria campechiana* Baehni (family Sapotaceae), is a widely adapted yet little known fruit that, while delicious, and requires some development of appreciation. It has several relatives somewhat similar in appearance and usage.

The canistel is best known in Mexico, Central America, and the Greater Antilles except Puerto Rico, southern Florida, and northern South America. It has been introduced in various other tropical countries, where it is usually no more than a curiosity in the botanical garden.

The climatic requirements of the canistel are flexible. The tree prefers rather dry tropical lowlands but nevertheless is found up to 1,800 meters of altitude and in humid climates with frequent heavy rainfall. In Florida it adapts very well to the superficial soils on limestone rock. It can also be grown on very sandy soils and heavy clays. Its best development occurs where soils are not too heavy and rainfall is moderate.

The tree is small to medium; in deep soils it is rarely very large. The crown is usually somewhat open and thin. The branches tend to hang downward with age, especially when fruiting heavily.

The leaves are alternate, oblanceolate on a short petiole, smooth, and 10 to 25 centimeters long. They occur in rather loose clusters near the tips of young branches.

The flowers are small and inconspicuous. They occur among the leaves of young branches and are usually produced at the beginning of the rainy season or a little later. The calyx consists of four to six sepals, and the corolla, of five to six petals. There are five fertile stamens and five staminodes. The ovary of six carpels is topped with an erect style. Fruits are often produced over a long period of the year.

Outside, the mature fruit is yellow, orange, or pinkish. The exocarp is thin and easily damaged, and may be slightly rough. The fruit is spherical to slightly elongated, often prominently pointed at the stylar end. The pulp is yellow or orange and mealy or very smooth. Some compare the pulp's appearance with an egg's yolk. The seed (there may be one or several in a fruit) is large, with a thick, smooth, shiny, dark brown testa. The hilum is lighter brown.

Very little has been done to develop better varieties of canistel. There are great differences among trees, and outstanding trees with high yields of large, flavorful fruit containing seeds can be propagated easily by grafting branches onto seedlings. The cleft graft has proved very useful in Puerto Rico; veneer grafting has given good results in Florida. Propagating from cuttings or air layers is difficult. Propagation by seeds is still

the chief technique and gives rise to some excellent trees. Seeds should be cleaned and planted while quite fresh, for the dried seed loses its viability rapidly.

Little is known about the nutritional requirements of the canistel. In deep soils of normal fertility, a balanced mineral fertilizer such as 10-10-10 should be used each 3 months at the rate of 50 grams per application per tree, and this should be increased as the tree grows. Mature trees need nitrogen (up to about 0.5 kilogram of pure nitrogen) two or three times each year, potassium once a year, and phosphorus about every 3 years. In poor sandy or calcareous soils or in shallow soils, these quantities should be doubled.

The trees should be planted 7 to 12 meters apart, 7 meters being more appropriate for grafted trees because they will fruit while still quite small. Newly planted trees should be watered frequently until well established. Mature trees need no pruning except to shape them as desired and remove dead branches.

Because large orchards have not yet been developed, there has been little opportunity to study pests and diseases. White scales may reach serious proportions and may encourage the growth of fungus that disfigures the fruit. Rust is occasionally seen and may cause the loss of mature leaves. The fruits are relatively resistant to fruit flies

The canistel should be harvested just before it is fully ripe. It is eaten out of hand when soft, sometimes with a little lime juice. The pulp is used to flavor milkshakes, ice cream, and baked goods. Cooking intensifies the flavor. The fruit is a good source of vitamin A and carbohydrates.

The peach palm, *Guilielma gasipaes* (H.B.K.) Bailey (family Palmae), is poorly named, for neither the tree nor fruit bears any resemblance to the peach. The fruit is delicately flavored, making it perhaps the best of the palm fruits after the coconut and the date. The plant is economically important for its heart of palm as well as its fruit. It is almost unknown in the Eastern Hemisphere and it is not as widely distributed in the Western Hemisphere as its value merits.

The peach palm is distributed chiefly through the tropical lowlands of Central America and northern South America, especially in Costa Rica, Panama, Venezuela, Colombia, and Ecuador. It is also found in tropical South America, where it is believed to have been introduced, although its origin is uncertain. A few trees in Puerto Rico have grown and fruited very well. We believe that the peach palm could be grown successfully in many areas of the Tropics, even at elevations up to 1,500 meters.

The trees are tall, reaching 20 meters in exceptional cases. They tend to be straight and slender (diameters of 15 to 20 centimeters). Most trees are protected by wide circular rings of long, sharp, black spines, but some are spineless. Spines make harvest more difficult. The trunk is unbranched but tends to sucker at the base, so that several mature trees will often be found in a clump. These suckers can be used as new plants. Many trees do not form suckers readily, and these are difficult to propagate asexually.

The leaf is pinnately compound, 3 to 4 meters long, and graceful in appearance. Its large rachis often is slightly spiny. The flowering clusters are produced among or just below the leaves. A spathe opens and falls when the flowers are ready to open.

Both male and female flowers, small and yellowish white, are produced in large racemes. There are many more male than female flowers. The male flower consists of a small lobed corolla and three pairs of stamens. The female flower is characterized by a leathery calyx, a three-lobed corolla, and a three-chambered ovary with three short stigmas.

The fruits occur in clusters of 10 kilograms or more. Several clusters are produced each season. Since several stems are often in a clump, the total production per tree can be very high. Fruits need about 6 months to mature and may change color slightly on

maturing. The fruits are conical or ovoid and from 2.5 to 5 centimeters long. The leathery calyx is persistent. The outer skin is thin but tough and may be green, yellow, or red. The flesh around the seed is dry, firm, and mealy, or may be slightly to very oily, and varies from yellow to dark orange. The large angular seed is black, with a kernel resembling a coconut.

Peach palm is adapted to areas of medium to strong tropical rains. It is generally found on fairly heavy clay soils typical of many areas of the Tropics. Although the method is not recommended, many trees are propagated from seed. Seeds should be cleaned of pulp and planted while fresh. The offspring will vary in size and fruit quality as well as in yield and tendency to sucker. Seedless varieties, which are the most highly valued, cannot, of course, be propagated this way.

The best propagation method is planting suckers taken from the base of top quality trees. On separating the suckers from the mother plant, care should be taken to avoid damage to either. Suckers should be grown in containers or nursery beds to permit the establishment of a good root system before transplanting. The transplanting should be done at the beginning of the rainy season, and the trees should be placed 5 to 6 meters apart. Newly planted trees need considerable care, especially watering.

As the tree begins to grow, some of the suckers that develop at the base are left to form a clump. Others are removed for propagation or to keep the clump from becoming too large and therefore unproductive. A tree will begin to fruit in about 6 years and will produce for 10 to 75 years. However, as individual trunks grow in height, the harvest of the fruit becomes progressively more difficult. Therefore, old trunks are removed and few suckers are allowed to grow.

The mature fruits are marketed in bunches or are cooked and sold in small amounts, often as a snack food. The uncooked fruits last for about 2 weeks. The fruits need a long boiling time, about 3 hours, in salt water. They are then used in many ways. The mealy flesh is eaten. The boiled fruits may be retained for several days before eating, or they may be dried and stored for months and then reconstituted by boiling again. The dried fruits may also be ground into a meal. The kernels of the seeds are also eaten.

The food value of the pulp is high (roughly 3 percent protein, 7 percent fat, 41 percent carbohydrate), and indeed the fruit is a staple food in some parts of Latin America; at times little else may be eaten. There is much interest in this palm as a source of hearts of palm. Selections that sucker freely are particularly desirable for this purpose.

The asai, or Para palm, *Euterpe oleracea* Mart. (family Palmae), is neglected outside of Brazil, but it is a tree of much promise for other parts of the Tropics. While it has been introduced into India, Sri Lanka, Malaysia; and to a lesser degree elsewhere, it remains unknown to most people in the Tropics. It is a tree of many uses, considerable economic value, and much potential.

The asai is at its best in tropical lowlands. In the Amazon basin, it occurs in frequently flooded lowlands as well as on firm land. In many parts of Para, Brazil, it is the principal and dominating tree of the landscape. It occurs in large clusters of up to 25 trunks or more because it suckers at the base. A cluster generally consists of trunks of all ages, and as older trunks die, younger trunks grow to fill their places. Thus, a clump of trees has an indefinitely long lifetime.

The individual trunk is slim and tall (reaching 20 meters). The long pinnate leaves have pendulous segments. The tree is elegant in appearance, a choice palm for gardens. It flowers and fruits the year around, but during the dry season the fruit is most abundant.

The fruit, in large clusters, is small and round, 12 to 15 millimeters in diameter. Its collection from large trees is a difficult and dangerous task.

The fruit pulp has an unusual flavor described as similar to raspberries or blackberries but with a nutty taste also. It can be eaten fresh, out of hand. It is very popular crushed in drinks, and it is made into a syrup or sauce to be used with other food. In Brazil it is especially appreciated cooked with cassava meal. The fruit is also used in many baked products.

In addition, the asai is one of the best sources of palm cabbage. Because the tree occurs in clusters, old trunks can be removed for cabbage without destroying the tree itself.

The fruit pulp is high in calories because of its starch and sugar contents. It is also a good source of vitamin A. Its calcium, phosphorus, and iron contents are significant.

The buriti and miriti palms, *Mauritia vinifera* Mart. and *M. flexuosa* L. (family Palmae) are closely related trees of great potential value. They are found almost exclusively in equatorial Brazil, the former at low elevations in acid soils. They occur in groves, characteristically along rivers and around lakes, as if planted by design. They are said to be the most majestic trees of the Amazon basin.

The trees are tall (25 meters) and have thick trunks (30 to 60 centimeters). The crown consists of 15 to 20 feathery fan shaped leaves arranged openly. These fall to the ground as they age. The inflorescences of the two species differ in detail, but in both they are large and pendent, with up to 100 fruits each. Five to eight of these fruit bunches, in various stages of maturity, can be found in a tree at any one time.

The fruit of both species are globose or oblate, covered with rhomboidal shiny brown scales. The mesocarp is a rather thin cap of sponge like pulp around the large, hard seed. The fruits fall from the tree mature but still unripe.

The fruits are used chiefly to prepare a drink. They are immersed several days in water to make it easier to remove the skin. During this period, they soften. The pulp is crushed to remove the juice, which is then used in drinks and in desserts and baked products. The pulp is also used to make a thick jellied candy.

In addition to these uses for the fruit, the trunk is a source of starch similar to sago. The sap is used as a drink or is fermented to yield a wine. The leaves are used as a source of fiber for cords and ropes.

The mamey or mamey-apple, *Mammea americana* L. (family Guttiferaceae), is widely adapted throughout the American tropics. It probably originated in the West Indies, where wild trees are still common. It must have been introduced very early into South America, for it has spread throughout the Amazon basin. It is usually grown as a dooryard fruit and is often harvested from the wild.

The attractive tree is medium to large, occasionally reaching 25 meters. The dark trunk is straight and upright, with large lateral branches having dense foliage. The leaves are paired, elliptical in shape, with short, thick petioles. The blade is coriaceous and shiny, with the margin entire. Trees bear either hermaphroditic or male flowers. The hermaphroditic flowers are several centimeters in diameter, with calyx and corolla spreading. They consist of many stamens around a simple pistil.

The fruit is large, weighing up to several kilograms. It is covered with a thick, brownish, leathery exocarp that can be cut open easily and peeled away. This exocarp protects the fruit well during transport. Within, the flesh is yellow to dark orange, firm and meaty, slightly aromatic. It is appreciated by most people, even on first contact. Imbedded in the

fruit are one to four very large seeds (each 100 grams or more in weight). These have rough woody testae.

The mamey is found in many tropical climates, but not at high altitudes. It appears to do best where the rainy season is long and strong followed by a pronounced dry season. Its soil requirements seem to be flexible, for trees are often found in sand, sterile laterites and heavy clays.

Mamey trees are most easily grown from seed. Seeds germinate on the forest floor under conditions of heavy rainfall. Seeds should be selected from trees that produce large quantities of high quality fruit. They are best planted in a permanent site, 10 meters apart, in a rich soil mixture that includes perhaps moss or organic material to help maintain humidity. The seeds germinate in 2 to 3 weeks and produce vigorous seedlings rapidly. These need lots of water until well established, and then they are relatively drought resistant. Mamey is also propagated by bud and terminal grafting of good trees, but formally propagated varieties are almost unknown.

Little information is available on post planting care of the trees. Protection from weeds and regular fertilization would of course be necessary. Pruning should rarely be necessary. Young trees begin to bear at 7 or 8 years of age.

When ripe, the fruits fall to the ground and are often damaged. Damage can easily be avoided by harvesting the fruit when it is mature but not ripe. It is not possible to determine the degree of maturity by color, but fortunately the time of harvest is quite flexible. Mature fruits ripen satisfactorily after harvest.

The fruits are normally eaten fresh, out of hand, or sliced for serving. The best are sometimes compared to apricots. The pulp is also stewed as a preserve, incorporated into pies, or made into a liqueur.

All parts of the mamey have insecticidal properties. Although the fruit is widely eaten, it may be detrimental to health in large, regular amounts. Even so, it appears to have many good qualities and must be considered a neglected potentially great fruit.

The giant granadilla, *Passiflora quadrangularis* L. (family Passifloraceae) is a relative of the common yellow passion fruit, *Passiflora edulis flavicarpa* Deg. While it is extensively distributed throughout the Tropics, it is not well known anywhere. But it has many attractive qualities that should serve commercial purposes, if carefully handled.

The giant granadilla is a vigorous woody vine having a fairly short lifetime (5 to 10 years). The stem is quadrangular and with its large ovate leaves, serves to distinguish it from other *Passiflora* species. The vine climbs with tendrils, and so it is best maintained on a trellis that limits its height. Flowering is seasonal. The flowers are large (10 to 12 centimeters in diameter) and attractive, in shades of purple and maroon.

The fruit of the giant granadilla is up to 10 centimeters in diameter and 15 to 30 centimeters long. It is light green, with a thin, easily damaged epidermis over a soft pulp. The cavity of the fruit is filled with seeds surrounded by juicy arils.

The giant granadilla is summer flowering, and to assure good fruit set, hand pollination, easily accomplished with a small brush, is recommended. The species appears to be self-compatible. On the other hand, some plants set fruits well without hand pollination. These can be propagated by rooting stem cuttings.

Many forms of the species are quite similar. Variation could be introduced by crossing with the related *P. alata* L.

The young fruits of the giant granadilla are cooked as a vegetable. A drink is made from the juice of the arils. A common technique for eating the fruit is to prepare the juice and sprinkle it over cubes of the pulp. The flavor is pleasant, aromatic, and subacid.

The atemoya (family Annonaceae) is an excellent fruit that is widely adapted in the Tropics and subtropics and has promise for widespread cultivation in the future. It originated as manmade hybrid between the sugar apple, *Annona squamosa* L., and the cherimoya, *A. cherimola* Mill. The best varieties of atemoya combine the best qualities of both parent species and are adapted to a wider range of environmental conditions than either of them. The atemoya is well known now in Australia, Central America, Florida, India, Israel, New Zealand, into the Philippines, South Africa, and South America, and has been introduced into many other places.

The plant is a small tree. Mature specimens can reach a height and spread of 10 meters, but for successful commercial production the tree is kept smaller by periodic pruning. The leaves are alternate, 10 to 20 centimeters long and 4 to 8 centimeters wide. They may be lanceolate, elliptic, or ovate. The tree loses its leaves for a time each year, the length of time depending upon climatic conditions. The trees make one main bloom per year and usually an additional minor bloom. The period from bloom to fruit maturity is 5 to 6 months.

The fruit is spherical, conical, or ovate, with a weight of 250 to 600 grams. The shape and surface texture of the fruit are quite variable, even among fruit from the same tree. The fruit surface may be relatively smooth, or the distal ends of the individual carpels may project as rounded protuberances. The fruit has a thin green rind that becomes yellowish green at ripeness. The flesh of good varieties makes up a large proportion of the fruit weight. It is very sweet, with a pleasant flavor, and is soft when ripe. The hard black seeds are 10 to 15 millimeters long, and there are 15 to 40 of them per fruit.

The atemoya is a relatively new crop, and little work has been done on selection and propagation of superior varieties. Some named varieties are 'Mammoth'; or 'Pink's Prolific', and 'Island Gem' (Australia); 'Bernitski', 'Gefner', 'Hette', 'Kabri', 'Kaller', and 'Malamud' (Israel); and 'Bradley', and 'Page' Florida, U.S.A.

Seedling progeny of atemoya are extremely variable, and possibilities for further variety improvement are excellent. It is advisable to grow seedling populations in all areas where this crop is adapted and to make selections that are adapted to local conditions.

The best method of vegetative propagation is grafting. The best time appears to be near the end of the dormant period, but it can be done at other times if necessary. Successful rootstocks include pond apple, *Annona glabra* L.; custard-apple, *A. reticulata* L.; and atemoya seedlings.

The atemoya tree is adapted to a variety of soils. Trees on atemoya or custard apple rootstocks should be planted in well drained sites, but trees on pond apple rootstocks can tolerate poor drainage to some extent. Where the soil is infertile or fruit production is heavy, the trees respond well to fertilizer, particularly nitrogen. The tree is best adapted to areas of moderate rainfall but can be grown in dry areas

with irrigation.

The fruit can be harvested when mature but still firm and will ripen to excellent eating quality. This allows it to be shipped to distant markets successfully. The fruit finds a ready market wherever people are acquainted with it. Most people like the flavor at first trial. The atemoya is a superb fruit for fresh consumption. The pulp can be used in sherbets and ice creams. The fruit is a good source of phosphorus and a fair to good source of thiamine and ascorbic acid.

The white sapote, *Casimiroa edulis* La Llave et Lex. (family Rutaceae), surely ranks among the really good but neglected fruits of the world. A native of the highlands of Central America and Mexico, the white sapote appears to be well adapted and can be found from the warm Temperate Zone to the hot lowland Tropics. Although the literature often reports that it is of limited value in the Tropics below 900 meters of elevation, we have seen the tree grown successfully at low elevations in Florida, Hawaii, and Puerto Rico. A relative, the wooly leaf white sapote, *C. tetrameria* Millsp. is found in the highlands of South America. It also grows and produces very well in Florida. We believe that the white sapotes have not yet been widely enough introduced and tested.

The white sapote is a medium sized spreading tree with a much branched trunk. The alternate leaves are palmately compound, normally with five leaflets. They are light green and have undulated but usually entire margins. The very small flowers are produced on terminal or axillary inflorescences, and the fruits follow, sometimes in clusters of 10, 12, or more.

The fruits vary from 4 to 9 centimeters long at maturity, usually according to the number of seeds they contain. The fruit is green at first but ripens to a pale yellow. The epidermis is thin and easily damaged.

The pulp of the fruit is white, cream, or yellowish and very soft, without fiber. It is sweet but has a characteristic bitter taste that some people do not like. Varieties vary in bitterness and acceptability; the most bitter, distasteful fruits to some are the most delicious to others. Within the fruit there are usually one to five large seeds, but some trees consistently produce small seedless fruits.

The white sapote prefers a subtropical climate. It is adapted to many soils, however, and to poor fertility; and will tolerate a heavy rainy season. It is normally planted from seed, although improved varieties developed in California and Florida can be propagated by budding and grafting. These include 'Blumenthal', 'Coleman', 'Dade', 'Harvey', 'Pike', 'Suebell', and 'Wilson'. Trees from seed fruit in 7 or 8 years; grafted trees fruit in 4 or 5 years.

The jaboticaba, *Myrciaria cauliflora* Berg. (family Myrtaceae), is a common everyday fruit in some parts of Brazil, including Rio de Janeiro; but one that has hardly been introduced elsewhere. As far as can be seen at the present time, the jaboticaba is subtropical; although introductions made so far in humid tropical lowlands grow very well, they do not flower. The fruit is attractive, readily accepted, and marketable, and it would probably be of much use in other tropical countries. Collection of a wide range of germplasm, including related species, appears desirable so that adaptable forms can be obtained for all parts of the Tropics.

Although the jaboticaba reaches a height of 12 meters, most trees in cultivation are much smaller and indeed begin to fruit when only 2 or 3 meters tall. The tree has an irregular, ill defined, very much branched trunk with a very smooth bark. The leaves are simple and opposite. The leaflets are 2.5 to 8 centimeters long, sessile or almost so, ovate and entire, very dark green, and leather-like.

Small white flowers are borne on the trunk and main branches in small clusters. The fruits grow rapidly and mature in 1 month. They are almost spherical, dark purple to black, and 1.3 to 5 centimeters in diameter. The skin is tough; the pulp is very soft, juicy, and subacid. One or a few seeds are found in each fruit. The flavor is attractive and said by some to resemble that of grapes. The fruit is eaten fresh or made into jellies. It makes a good red wine. Several fruit crops can be produced each year.

Jaboticabas are grown perhaps exclusively from seeds. These germinate readily to produce small, slow growing trees similar to the mother tree. Nucellar embryony is

believed to be the cause of the similarity. Trees can be maintained for up to 2 years in plastic bags or other containers, until they are ready for transplanting to the field. Plants may require 10 years or more to flower and fruit, a principal obstacle to their popularization. Young trees in Florida grow better in peat with complete mineral nutrients added. Approach grafting of mature trees on younger seedlings is sometimes done to stimulate earlier fruiting.

Jaboticaba seems to be well adapted to sands, acid soils, and even heavy clays. It appears to tolerate very wet climates, but it sets fruit poorly in dry regions.

The lucmo, *Pourteria obovata* H.B.K. (family Sapotaceae), is one of the excellent fruits of South America that has hardly been distributed from its area of origin. It is quite similar to the canistel, but judged by many to be superior. A fruit of many uses and with a distinctive flavor, it is not readily appreciated by adults who try it the first time, but introduced gradually it becomes a favorite.

The lucmo is from the low Andes and the foothills and even coastal plains of Chile, Peru, Ecuador, and Colombia. It is most highly developed in areas of moderate rainfall, but it is not as widely adapted as the related canistel. The temperatures where it occurs are cool to warm. It is very important for the lucmo to have good drainage; the tree will not stand flooding.

The lucmo is a large tree of the forest, but it begins to produce when quite small and can be maintained small. The tree has a straight strong trunk and numerous lateral branches. The crown is hemispherical and attractive. The alternate leaves are elliptic, lanceolate, or oblanceolate, tapering at the base to a short petiole; they reach 25 centimeters in length and 10 centimeters in width. The margins are entire, and the surface is dark shiny green. The petioles and young twigs are pubescent.

The hermaphroditic flowers are 1 centimeter wide and 2 centimeters long. They are borne in moderate numbers among the lowermost leaves near the tips of branches.

The fruits are more or less spherical or somewhat flattened, often with a prominent point on the stylar end, and 4 to 17 centimeters in diameter. They are green colored but often change to a pale yellow or orange as they ripen. The epidermis is smooth to wrinkled and may be slightly scaly; it is thin and easily broken. Inside, the pulp is yellow, smooth, mealy, soft or hard according to the variety, and dry. Several large seeds are embedded in the pulp. The odor of the fruit is strong and penetrating, and intensifies with cooking.

The lucmo is propagated from seeds. In common with many tropical fruit seeds, they should be planted while fresh and before drying. In Peru they are stored and stratified before planting, but this may not be necessary. Seeds can be started in seedbeds, and the seedlings can be transplanted to containers until large enough for planting in fields.

Seedlings about 1 centimeter in diameter are used for grafting. Although the scion can be obtained from any tree with high yields and good fruit quality, selected varieties (stocks) are now available in Peru. Trees to graft are kept rather dry for about 3 weeks before grafting, and then they are well watered the last few days to initiate new growth. The terminal cleft graft is suitable for the lucmo.

Newly grafted trees need special care until the graft union is well formed. Four to six meters should be left between transplanted trees. Newly planted trees need regular irrigation but within a short time can stand short periods of drought.

Fertilization has hardly been studied, and general recommendations are difficult to make. Mineral fertilizers at the rate of 50 grams four times a year may be applied to each tree the first year. Thereafter, fertilization should be twice yearly. Weeds must be controlled to

give the young trees the opportunity to grow rapidly. Pruning is done chiefly to form the tree and in later years to restrict the growth of the tree. Diseases and insects will vary from one place to another, so general procedures cannot be given.

The fruits should be harvested before they are completely mature. They can then be handled and transported easily. Mature fruits ripen 6 to 10 days after harvest.

The fruit is often eaten fresh, and it has great potential for cooking in pies, cakes, preserves, breads, puddings, etc. The fruit is rich in carotene, niacin, and carbohydrates.

The cupuazu, *Theobroma grandiflorum* Schum. (family Sterculiaceae), is a very important fruit of the Amazon basin of Brazil. Related to the cocoa, *T. cacao* L., the cupuazu is generally used for its pulp, although the seeds are sometimes used to make chocolate. They contain good quantities of the stimulant alkaloids caffeine and theobromine. The cupuazu is almost unknown outside Brazil, where, in some regions, it is found in almost every dooryard.

The tree fruits when quite small (6 to 10 meters) but has the potential of reaching 20 meters in height. The leaves are 25 to 35 centimeters long, coriaceous, and short petioled. The flowers occur singly or in small groups in the axils of the leaves or along the bare branches. The fruit is ellipsoidal or oblong, 12 to 25 centimeters long, 10 to 12 centimeters in diameter, and up to 1.5 kilograms in weight. The woody pericarp is easily broken open to expose the edible aril around the individual seeds. The mature fruit can last for about 10 days. The pulp is used fresh or in wines, is made into fresh drinks, or is stewed.

The bacury, *Platonia insignis* Mart. (family Guttiferaceae), is almost unknown outside its native Brazil and Paraguay, where it is well distributed and widely used. It is a large (25 meters) tree that tends to become weedy, to spread, and to dominate adjacent vegetation.

The trunk is strong and straight, supporting an inverted cone shaped crown. The leaves are opposite, elliptical, thick, and shiny green, with slightly undulate margins.

The attractive, pink flowers are large (7-centimeter diameter) and have five petals and numerous stamens partially united in five groups. The flowers are produced during the dry season and mature as the rainy season begins.

The fruit is large and ovoid or almost globose and weights about 900 grams. The fruit contains one to several segments (like those of an orange) of white pulp with an agreeable flavor. Each segment may contain one large seed, but some fruits are seedless; these are preferred. The pulp may be eaten fresh, out of hand, or it may be made into a drink or stewed.

The tree is considered very easy to grow and may sprout from the roots. Because of its weedy tendency and persistence, it should be tried in new regions with extreme caution.

The caimito, *Chrysophyllum cainito* L. (family Sapotaceae), is a widely distributed tree, but the fruit is not used extensively in any region, including its native West Indies and Central America. Individual seedlings are sometimes of excellent quality, and the preservation and distribution of these as clonal varieties would probably make the species successful. This can be done by marcottage, inarching, or cleft grafting.

The tree prefers coastal forests where monsoon climates prevail, but it can probably be found, at least occasionally, throughout the Tropics. It has been introduced into Brazil and Guiana, where it is both cultivated and wild.

The tree, medium to large, with open spreading crown, is attractive. The alternate elliptic leaves of medium length (10 to 12 centimeters) are usually dark green or bright on the upper surface and orangish or rusty brown below. The brownish color is caused by a fine silky pubescence. The inflorescence consists of 10 to 30 small flowers in axillary umbels. Flowering and fruiting may occur several times a year.

The fruit is a spherical berry 6 to 9 centimeters in diameter, light or dark green, often tinged or colored deeply purple by anthocyanin. The pulp of the mesocarp is somewhat jellylike, greenish or purplish, and amply supplied with white latex, which becomes less as the fruit ripens. The pulp is sweet and free of acidity, and has a weak distinctive taste. Within the pulp are 1 to 10 flat seeds 1 to 2 centimeters long. Ripe fruits do not fall from the tree but must be handpicked when mature but beginning to soften.

The black sapote, *Diospyros digyna* Retz (family Ebenaceae), is a popular fruit in subtropical and tropical reaches of Mexico, and it has been introduced into Florida and, to a small extent, the West Indies. The tree is small, with dark glossy leaves, and grows rapidly when well taken care of. The fruits are up to 8 centimeters in diameter, with a green exterior, a thin skin, and a soft blackish-brown pulp. The appearance discourages some people, but the taste is attractive. This fruit, while eaten fresh, could well be used in puddings and ice creams, where its contribution would be appreciated. It is rich in vitamin C

Fruits of Southeast Asia

The mangosteen, *Garcinia mangostana* L. (family Guttiferaceae), is surely one of the world's best fruits. It is so aromatic and delicious that everyone who tries it enjoys it. The tree itself is attractive and would make a fine ornamental in any garden. Nevertheless, the mangosteen is almost unknown in the Western Hemisphere. It merits extensive trial throughout the humid tropics.

The mangosteen is a fruit of the hot, humid regions of tropical Asia, especially the Malay peninsula, Indonesia, Cambodia, Vietnam, Thailand, and the Philippines. It has been introduced on a small scale into Central America and the Caribbean, where it has adapted very well in hot, humid areas.

The tree is small, with a columnar or slightly pyramidal form. It reaches a height of 12 meters and a trunk diameter of 0.6 meter only in advanced age. The straight, very dark trunk produces numerous upright or horizontal branches.

The evergreen, opposite leaves are large (7 to 13 centimeters wide and 15 to 25 centimeters long), and elliptical and oblong. They are coriaceous and smooth, with entire margins.

The attractive flowers, solitary or in pairs, are 3.8 to 5.0 centimeters in diameter and female; male flowers are not produced. The flowers have four thick petals and four sepals.

The fruit is almost spherical or slightly flat and 5 to 8 centimeters in diameter. The cortex rapidly changes color from a rusty green to a dark purple as the fruit matures. Inside, the fruit is divided into white, juicy, translucent segments, the largest of which contain seeds. The seeds vary in size.

The mangosteen does not grow in a wide variety of soils. It definitely fails in sandy soils, calcareous soils, soils with poor water holding capacity, and soils that are subject to frequent drying out. On the other hand, it tolerates relatively heavy soils and high water tables, but it should not be flooded frequently. A high content of organic material is desirable. Trees are frequently found growing by lakes and streams.

The mangosteen is propagated from seeds; grafting and vegetative techniques have not been successful. Since the seeds are asexually produced, all trees are exactly like the mother tree. The only disadvantage of propagation from seeds is that the trees grow very slowly. During the first 3 years, seedlings may produce no more than four or five pairs of leaves.

Seeds for planting should be cleaned as free of pulp as possible and should soon after be placed in loamy soil. The best technique is to plant several seeds in the site a tree will occupy when mature. (This site can be improved with better soil; and so on.) Only the most vigorous seedling should be permitted to live. Since the mangosteen is such a small tree for many years, the distance between trees need only be 5.5 to 7 meters. Mangosteens grown in containers are difficult to transplant. First of all, the containers should be deep, and transplanting should be done on a cool or cloudy day, with much care. The trees should then be watered regularly, probably the most important cultural requirement, for they will die back during the dry season otherwise. Light shade should be provided during establishment and should not be removed-then only gradually-until the tree is 3 or 4 years old.

During the first few years of growth fertilizer requirements will be light but important. Twenty-five grams of 20-20-20 should be applied three or four times a year to each tree. Later, fertilize twice a year, when growth begins at the start of the rainy season and when flowering begins. About 6 to 8 kilograms of mineral fertilizer per year is needed for a mature tree.

Mangosteen trees should be kept free of weeds. They are so small and slow growing that a few weeks of weed growth can completely hide them. The trees require little pruning except to remove deadwood and repair injuries.

Few pests have been found attacking mangosteen. A tree exposed to light and air movement seldom is attacked. After diseases and insects have been identified, treatments used for other species can be tried.

Under very good conditions a mangosteen tree may begin to produce fruit in 7 years, but most trees require 10 to 15 years. The trees are still small when they begin to produce; with time and care, a tree will produce from 500 to 1,500 fruits a year.

The fruit's purplish color increases with maturity. When the pericarp softens slightly, the fruit may be picked. It can be opened with a cut around the "equator" or can be pried open with the thumbs. Mangosteens are eaten out of hand.

The durian, *Durio zibethinus* Murr. (family Bombacaceae), is perhaps the most controversial fruit of the Tropics. To those that love it, there is no better fruit. To those who can't eat it, even the odor is offensive. In areas where the fruit is used, restrictive laws have been passed to protect those who wish to avoid it. From Southeast Asia to the Philippines, everyone knows the durian, and whether it is loved or not, it is always talked about.

The durian is distributed through the hot, humid Tropics of Asia, especially in Indonesia, the Philippine Islands, Malaysia, and Thailand. It is scarcely known in Africa or the American Tropics. It should be a remarkable fruit wherever it is introduced, if given a reasonable chance to establish itself and become known.

The durian is strictly tropical in its growth requirements. It is found from sea level to about 300 meters of altitude. It prefers a humid climate and especially a very long rainy season. Little is known about optimum soils, but durian does occur where soils are acidic and heavy and where organic material has accumulated.

The tree ranges from medium to very tall (20 to 40 meters). At times it is pruned to maintain a single straight trunk with a few lateral branches, but at other times large principal branches are allowed to develop. The crown is irregular and dense. The dark gray bark has conspicuous fissures and a tendency to flake away in large pieces. The small branches are covered with fine scales colored from copper to gray.

The leaves are alternate with short petioles. They are more or less elliptical to obovate and measure 6 to 25 centimeters in length by 2.4 to 9 centimeters in width. The thick leaves are smooth, dark green, and shiny on top and finely pubescent and gray to yellowish on the underside.

The flowers are produced on the lateral leafless branches, close to the trunk. They fall the day after blooming unless fruit set occurs. They have a bad odor, which attracts insects and bats that pollinate them. Self-pollination may occur within the bud.

The fruits vary in size from that of a grapefruit to an unhusked coconut. They are covered with short, thick, pyramidal spines. As the fruits mature the color changes from green to clear yellow, and with over maturity, to copper brown or cream-and-coffee. When the fruit is sufficiently ripe, a slight pressure will break it into five valves, or segments. These consist of a white cortex and a chamber for the seeds. Each chamber contains one to three seeds, each surrounded by an aril colored from white to yellow. This pulp is soft, smooth, and attractive, but it has a strong odor. The seed, too, is attractive, with a brown or cream seedcoat and a broad area where the pulp is attached.

Most durian trees in Asia are grown from seed, and in general, the exact parentage is unknown. Almost all of the fruits are edible, although some have an odor that is just too strong for comfort. In Thailand and Malaysia excellent varieties are known, and these are conserved by asexual propagation. A good variety of durian is characterized by high yields, large fruits with small or rare seeds, and abundant pulp. The best varieties have only a touch of the strong odor that characterizes this fruit, and have a light, agreeable appearance. Improved varieties have been introduced into the Western Hemisphere only as isolated instances, and they are not now available.

Until improved varieties are available, the best way to establish durian is by seed. These should be obtained from fresh, mature fruits. The pulp is removed and the seed is washed well. The seed can be superficially dried but should not be completely dried before planting. The seeds retain their viability only 3 or 4 days under normal circumstances, but their lifetime can be prolonged for 2 to 3 weeks at cool temperatures. A seed should be planted under 3 to 5 centimeters of humid soil. Germination begins within days. The first sign of germination is the emergence of the crooked neck of the hypocotyl, and this may need several weeks to emerge completely. (It is useful to establish seedlings in containers of 4 to 5 liters of soil until they are ready for field planting.) Seedlings can be grafted at 1 year of age by bud or wedge techniques.

Planting is best made at the beginning of the rainy season, with normal precautions. Very little experience with fertilization is available, but the soil used for transplanting should be fertile, and mineral fertilizers as well as organic materials can be used as the tree becomes established. Newly planted trees should be watered regularly and copiously. Light shade is useful during the first year or two of growth. Diseases and pests are almost unknown in the Western Hemisphere, but they will probably occur as soon as orchards are established.

The trees grow rapidly and begin to produce in 7 or 8 years. The fruits mature during the rainy season, and if not harvested from the tree, fall to the soil 1 to 4 days before opening and can be injured. Therefore, almostripe fruits should be harvested. The ripe fruit is delicate and cannot be easily transported long distances.

The pulp is eaten fresh or, in Indonesia, in a fermented dish made from rice, sugar, salt, onion, and vinegar, and cooked. The seed is eaten also roasted or sliced and fried.

The pummelo, *Citrus grandis* (L.) Osbeck (family Rutaceae), is an extremely appealing citrus fruit more characteristic of the Tropics than are most related cultivated species. It originated in subtropical China and evolved in Thailand, Burma, Malaysia, and Indonesia. It is easy to produce, easy to use, and easy to enjoy.

The pummelo is widely distributed and well known in the Asian Tropics; it is known but not widely distributed in tropical Africa and in the Americas. In Asia it is best known in China and Thailand, where the best varieties have developed, but it is also well known in Malaysia and Indonesia.

The pummelo is one of the most versatile of the citrus species. It is more frost tolerant than lime, more or less like grapefruit, and can be grown in both wet and dry regions of the Tropics. It grows in the warmest parts of the United States. Nevertheless, the pummelo grows best in the hot, humid Tropics.

The tree is large for a citrus, ranging from 5 to 19 meters in height. The central trunk is very much divided into principal branches with brown bark. New branches are angled and pubescent, and often have long spines.

The leaves are thick, coriaceous, shiny, alternate, large, ovate or ovate-elliptic, with the tip blunt, the base rounded broadly or subcordate, and the principal vein frequently pubescent. The wings of the petiole are broadly extended, sometimes continuous with the leaf blade.

The flowers, also, are very large for a citrus, measuring from 3 to 7 centimeters in diameter. They develop singly or in small groups in the axis of the leaves, or as subterminal inflorescences. They are white or cream and have 5 sepals and 5 petals, 20 to 25 stamens with large anthers, and a globose ovary of 12 to 18 segments.

The pummelo is probably the largest citrus fruit, for it reaches 60 centimeters in diameter and 10 kilograms in weight, although most fruits are 20 to 25 centimeters in diameter. The fruit is globose, oblate, or pyriform. The peel is very thick; green, yellow green, or yellow; and easy to remove. The segments of the fruit are easily separated, and the membrane, while tough, is easily separated from the juice sacs without spilling liquid. The pulp is white, pale green, pink, or red. The seeds are large, thick, and rough.

Although there are many varieties of pummelo, few are known outside of their area of origin. They can be divided into three groups, the Chinese, the Thai, and the Indonesian, distinguished by form, quality, and minor details. The principal varieties in the Western Hemisphere are 'Nakon', 'Kao', 'Panne', 'Kao Phunag',

'Tong Dee', 'Chandler', 'Reinking', 'Mato Butan', 'Amoy', 'Banpeiyu', 'Her ado Butan', 'Pandan Bener', 'Pandan Wangi', 'Red Shaddock', 'Webber', 'Tambun', and 'African'.

Although the pummelo is frequently propagated from seeds, the quality of the seedlings is quite variable and is usually inferior to that of grafted, named varieties. Both bud and terminal grafts are satisfactory, and seedlings of any variety can be used for the stock. A few varieties, such as 'Tresca,' in Puerto Rico and Florida, can be propagated easily by cuttings. Air layering is also used. Trees are normally established in plastic bags before field planting.

The pummelos of Thailand are grown in heavy soils with a high water table and are exposed to and tolerate high levels of salt. Most varieties tolerate a wide variety of soils

and even grow well in soils not usually used for agricultural purposes (tin tailings in Malaysia, for example).

Rambutan is apparently native to Malaysia, and its chief variations appear from Thailand to Indonesia. It is less common in India, and it has apparently been introduced into Madagascar. About 20 fruiting trees are found in Puerto Rico.

Young trees are normally planted 7 to 10 meters apart at the beginning of the rainy season. A good mixture of soil should be used to fill the holes so as to stimulate growth. Trees should be watered at planting and regularly thereafter. Once trees are established, about 100 grams of a balanced mineral fertilizer should be applied each 4 months. For minor element fertilization and pest and disease control, local recommendations for other citrus species should be followed.

Young trees should be pruned to a few principal branches, and a mature, spreading form will gradually emerge. Little other pruning is required.

Normally, the peel color will change slightly as the fruits ripen, and in a cool climate, the color change will be more pronounced. Since the ripe fruit does not fall, it is necessary to know the proper time and stage for harvest. The fruit of some cultivars will dry out if left on the tree too long. The fruit lasts well and can be transported with minimum risk.

The tree is almost always eaten fresh as a dessert or snack. First, it must be peeled carefully, the segments separated, and the membrane removed. The pulp is sweet and aromatic, and appeals to everyone. The rind is often made into a citron-like candy.

The rambutan, *Nephelium lappaceum* L. (family Sapindaceae), is another well known fruit of Southeast Asia that is still almost unknown in the Western Hemisphere. A relative of the more familiar litchi and the lesser known pulasan, the rambutan is the most tropical of the group and probably adaptable to even the hottest parts of the Tropics. Sporadic introductions have shown that while seedlings are hard to establish, mature trees can be produced and are fruitful in the American Tropics.

The tree is of medium stature, reaching about 10 meters at maturity, but trees as small as 5 meters can be found. The trunk, which reaches 30 centimeters in diameter, is upright, with rather large branches. The bark is very dark and rugose. The crown is somewhat open.

The leaves are pinnately compound and consist of 2 to 4 pairs of leaflets and sometimes a terminal leaflet. The leaflets are oblong or elliptical; shiny dark green above and lighter below. The leaf measures 5 to 10 centimeters in length and 2 to 10 centimeters in width.

The flower cluster consists of terminal or axillary panicles. Trees are male, female, or mixed. The male flowers have five to eight stamens 3 to 4 millimeters long with pubescent anthers. The female flowers consist of a pistil formed by two carpels. Normally a fruit develops from only one carpel, although bicarpellate fruits are sometimes seen.

The fruit is an ovate or ellipsoidal drupe 3 to 8 centimeters long and 2 to 4 centimeters wide, with a short, thick pedicel. The pericarp is red or yellow and is covered with smooth appendages that look like curved thorns but that are soft and flexible. The interior aril is smooth, white, translucent, juicy, and sweet. The seeds, usually one to a fruit, are ellipsoidal and 2 to 3 centimeters long.

The rambutan is strictly tropical and prefers a long rainy season. It does not do well in subtropical areas such as Florida, even where other tropical trees thrive, Its soil requirements are generally not demanding except that a chlorosis apparently stemming

from poor mineral nutrition is common in small seedlings, A cure for this condition, which can be fatal, is not known.

Named varieties of rambutan are well known in their native regions, As in the case of many fruits, the grafted varieties are far superior to the average seedling.

But when propagating from seed, clean and plant the seed promptly after its removal from the fruit, Seedlings can be started in seedbeds and transplanted to plastic bags for establishment. They need 8 to 12 months before they are transplanted to the field or are used for grafting. The patch bud technique, cleft graft, approach graft, and aerial layering (marcot) are all successful propagation techniques. Young trees should be planted 7 meters apart.

Little information on fertilization is available, and many trees in Southeast Asia are not fertilized or are treated only with mulch and manure. Nevertheless, regular fertilization of young trees is recommended to avoid the chlorotic condition previously described. Applications of mineral fertilizer should gradually increase to a maximum of 8 kilograms per tree per year,

Because the rambutan is a tree of the hot, humid tropics, it needs regular irrigation, especially during transplanting, establishment, and prolonged droughts, Weed control is also necessary, Pruning to shape the tree and remove deadwood should be done as necessary.

Rambutan trees may begin to bear as early as the third year of growth, but they normally begin after 5 or 6 years. The fruits can be collected when they begin to turn from green to reddish. The greater part of the harvest is eaten out of hand, In Southeast Asia some rambutan is canned, alone or with other fruits. While it is not great, the rambutan is a pleasant fruit that everyone likes.

The longan, *Nephelium longana* (family Sapindaceae) is well known and esteemed in Asia, where it is cultivated from southern China to India. It has been introduced widely into the tropical and warm subtropical areas of the world, but it has not yet become an important crop outside Asia. It has good potential as a commercial crop elsewhere.

The tree, a handsome evergreen with a dense, rounded canopy, grows to a height of about 12 meters and a spread of about 14 meters, The dark green leaves are pinnately compound, with 6 to 1 to 2 leaflets up to 30 centimeters long, The small greenish-yellow flowers are borne in large terminal panicles, Bloom occurs once a year, and the fruit takes about 4 months to mature, The fruit, borne in large clusters, is spherical to ovoid and 2 to 4 centimeters in diameter, and has a thin, leathery, brown pericarp. The edible pulp is a translucent, clear to whitish aril surrounding a single dark brown shiny seed. The pulp is juicy and sweet, and has low acidity.

Superior varieties have been propagated vegetatively in Asia for a long time, particularly in China and Thailand.

Some of them are 'Blackball' (China); 'E Bure,' 'E Daw', and 'E Haw' (Thailand); and 'Shek Kip' (Hong Kong). In the United States, 'Kohala' was developed in Hawaii. In Florida, no varieties have been selected yet because of the erratic bearing of all the plantings made so far.

Trees can be grown from seed easily, but since they require 6 to 9 years before bearing and since their fruit quality is not predictable, seedlings are not recommended for the home garden or commercial planting. Air layering is widely used in Asia for vegetative propagation. It is also used in Florida, but grafting has proved to be more dependable there. Longan seedlings are used as rootstocks.

The longan tree grows best in a well drained soil of good fertility, but its requirements are not exacting, and it can be grown in a variety of soils. Like the lychee, mature longans can tolerate brief exposure to temperatures a few degrees below freezing without severe injury. For successful flowering, the tree needs prior exposure to cool weather, so it does not flower dependably in lowland areas where the temperature is uniformly high the year round.

The longan blooms and fruits erratically even where environmental conditions are favorable. Bearing in alternate years can be partly corrected by removing some of the flower clusters in years of heavy bloom. The consequent reduction in crop size evidently reduces the depletion of the tree's reserves and increases the chance of an adequate bloom the following year. Thinning of flower clusters has the additional advantage of increasing the size of the fruit; fruit size is greatly influenced by the total production of the tree.

The fruit can be eaten fresh, frozen, canned, or dried. It is a fair source of vitamin C.

The langsat, *Lansium domesticum* Correa (family Meliaceae), is a tree of the wet forest and seems to resist cultivation away from other trees. The fruit's unique appearance and flavor are widely appreciated.

The langsat is best known in Malaysia, Indonesia, and the Philippines; it is less frequently seen in India and other parts of the Asian Tropics. It has been introduced into a few isolated spots in the Western Hemisphere, where it appears to have adapted. It has great promise as a new fruit for the American Tropics.

The tree is erect and symmetrical, reaching about 15 meters of height. The branches are horizontal or slightly inclined toward the ground. The bark is greenish brown to brown, with long fissures. When cut the trunk exudes a white latex.

The leaves are large and pinnately compound, with five to nine leaflets. The entire leaf reaches 30 to 50 centimeters in length; the petiole is an additional 5 centimeters. The leaflets are 15 to 30 centimeters long by 7 to 13 centimeters wide. The upper side is shiny dark green, whereas the lower is pubescent and light green. The inflorescence is a spike up to 30 centimeters long that is produced on the trunk or the large branches. The yellow flowers are perfect, 1 to 1.5 centimeters in diameter, and have 5 petals, 5 sepals, and 10 united stamens. A panicle usually produces 10 to 30 fruits.

The fruit is ellipsoidal and up to 5 centimeters long. It is first green but changes to a light yellow or a grayish yellow as it matures. The peel is rather parchment-like and, while tough, is easily peeled away. Inside the peel are five segments of usually different but sometimes equal size. They are whitish, translucent, juicy, and subacid. The larger segments contain soft seeds that may reach 2 centimeters in length.

Langsat does not tolerate cold or long dry seasons, and is not recommended for altitudes over 650 meters; it is at its best in a monsoon climate with a short dry season. Judging from its growth in different countries, it seems to tolerate a variety of soils, but it prefers a slightly acid soil rich in organic material.

The varieties we have seen in the Western Hemisphere do not vary much. A special type, duku, which is preferred in Indonesia and Malaysia, differs from the usual types by being a more spreading tree with less latex and having larger, rounder fruit, with a thicker peel. Both the regular and duku types are grown from seed. The seeds are short lived and should be well cleaned of pulp and planted immediately without a chance to dry. Reproduction has not been studied much, but it may be by apomixis. The seed germinates readily and needs no special care. Trees are also propagated by grafting, from cuttings, and from air layers.

The trees should be planted about 8 meters apart in their permanent site when they are about 1 meter high. Experience in Puerto Rico suggests that light shade is desirable at first. This can be gradually reduced as the tree grows, but some shade may always be desirable. Newly planted trees need careful and frequent watering until well established.

Insect pests that have been seen in Puerto Rico are the sugarcane root borer, *Diaprepes abbreviatus* L.; various scales; and spider mites (*Tetranychus* species). Anthracnose caused by *Colletotrichum* species is the only important fungus disease that has been seen.

The langsat fruit is most often eaten out of hand, but it may also be candied.

The salak, *Zalacca edulis* Reinw. (family Palmae), grows wild in the dense shade of lowland Asian rain forests, and it is also cultivated widely for its fruits. Although geographical range would be restricted by its particular climatic requirements, there are many areas of the Tropics where it could be grown. At the present time salak is almost entirely confined to the Asian Tropics, from Malaysia through Indonesia to the Philippine Islands. It is particularly popular in Java. The fruit is attractive in appearance and taste, and while it is not great, it would normally be appreciated on first taste and should find a ready market.

The salak is a small compact palm. It seldom reaches 5 meters in height, and it produces its fruit only a few feet above the ground. The palmate fronds are long, with long petioles. All parts of the plant except the flowers and fruit are covered with long, sharp spines that make fruit harvest hazardous.

Male and female inflorescences are borne on separate plants. These develop at the base of the fronds and consist of large numbers of flowers, in panicles, on short rachises. Pollination is probably by wind, and to insure good pollination, one male palm is needed for each five or six females.

The fruit is produced in large clusters very close to the trunk among the bases of the fronds. The fruits vary from 2.5 to 10 centimeters in length and from 5 to 8 centimeters in width and are globular or top shaped. The fruit surface is covered with overlapping scales like the skin of a reptile. These are dark brown, shiny, and attractive. The scales can be easily peeled away to reveal a translucent whitish or yellowish flesh.

The salak palm can be propagated from seeds, but asexual propagation of trees known to produce high quality fruit is recommended. Seeds should be obtained from a tree that produces good fruit and from a fruit with two or more seeds because single-seeded fruits produce mostly males. The seeds should be cleaned free of pulp and planted while fresh and undried. Unlike many palm seeds, salak seeds germinate readily.

The easiest vegetative propagation technique is layering: the trunk is placed horizontally on the ground and new plants grow from the nodes. Basal shoots can also be used for propagation, but they are difficult to remove from a palm without damaging it.

Salak palms prefer the wet, heavy soils of the rain forest. They can best be seeded or planted from offshoots directly in their permanent site, perhaps below the shade of larger fruit trees. Sunny locations should be avoided. Extra shade can be provided by temporary plantings of banana around the new trees. The palms should be protected from weed competition, watered frequently, and fertilized regularly.

The fruits can be shipped and handled easily. In Asia they are readily sold. They are eaten when fully ripe and softening, and by then they are delicate and easily split. Most fruits are eaten out of hand, but they are also stewed or pickled.

The gandaria, *Bouea macrophylla* Griff. (family Anacardiaceae), is well known in Southeast Asia for its many forms of sweet or sour mango-like fruits. A careful attempt should be made to obtain representative materials for transfer to the Western Hemisphere, where the species is almost unknown.

The gandaria is a medium sized tree about 10 meters in height. The trunk is thick, dark, and often branched near the base. The young branches are horizontal or drooping. The leaves are opposite, 10 to 35 centimeters long, thick, and glabrous; they resemble a mango's leaves. The small flowers are male or hermaphroditic and occur in large clusters.

The fruits are ovoid or ellipsoid, smooth surfaced, yellow or orange when ripe, and 3 to 5 centimeters long by 3 to 4 centimeters wide. The epidermis is thin; the pulp is thick and juicy, orange or yellow, and resinous in flavor like that of many mangos.

The gandaria is planted from seeds. Selected clones are known; however, and any special tree can be propagated by the techniques used for mangoes. Orchards are unknown; so far, the gandaria is strictly a dooryard tree.

The sweet forms of gandaria are eaten out of hand. Sour forms are pickled or used in chutneys.

Some *Spondias* species (family Anacardiaceae) are valued for their fruit. The most important of these are the ambarella, or golden apple, *Spondias dulcis* Parkins; the yellow mombin, *S. mombin* L.; and the red or purple mombin, *S. purpurea* L. The ambarella is native to the islands of the South Pacific, while the yellow mombin and red mombin are native to tropical America. All of them have been distributed widely in the Tropics and are potentially important because of their wide adaptation and abundant production of nutritious fruit.

The ambarella and yellow mombin are large trees; the red mombin is relatively small. All have open, spreading canopies and pinnately compound leaves. The trees lose their leaves for a time during the year. The wood of the trees is weak, and the limbs are easily broken by windstorms, but the trees recover from such damage rapidly.

The small flowers are borne in panicles, either terminally on new growth or laterally on small or large branches. The fruit occurs singly or in clusters of a few to many. The fruit of the ambarella and the yellow mombin is yellow. The red mombin has both red and yellow forms. The fruits are ellipsoid to obovoid in shape and range in length from 2.5 to 4 centimeters for the red and yellow mombin to 5 to 7.5 centimeters for the ambarella. The yellow pulp adheres to a single seed, which in some varieties is smooth and in others is rough, with strong woody fibers projecting into the flesh.

All of these species may be grown from seed, but vegetative propagation is preferable because some of the superior trees have few viable seeds and, in any case, the species do not breed true. The most widely used method is the rooting of mature cuttings. Large limbs cut from the tree and set directly in the ground will form roots and grow if conditions are favorable. The *Spondias* species can be propagated by grafting and budding also.

There is much variation in fruit quality in the *Spondias* species. Superior selections have been made and propagated in some areas, but they have not been described in the literature or disseminated to other areas. There are great possibilities for improvement of these crops through collection and dissemination of existing selections. The various forms of the red mombin probably have the greatest possibility for future development.

The *Spondias* species are primarily plants of hot lowlands, although the red mombin can be found up elevations of 1,500 to 1,800 meters. They are not well adapted to cool

climates. Small trees are killed by exposure to freezing temperatures. Larger trees are injured severely by frost, but they will recover quickly if conditions are favorable.

The Spondias species are well adapted to a variety of soils. Usually they are grown without application of fertilizer, although they will respond well to fertilizer application in infertile soils. The trees tolerate dry conditions very well.

The fruit of better varieties is sweet and has a pleasant flavor. Most is consumed fresh. Where the trees are widely planted, the fruit is sold in local markets and undoubtedly is an important part of the diet when in season. The fruit can be dried or made into jellies, sauces, or preserves. The fruit is a good source of minerals and vitamin C.

The mabolo (also known as velvet apple and butter fruit), *Diospyros discolor* Willd. (family Ebenaceae). is perhaps the best of the tropical persimmons (The kaki must be regarded as temperate to subtropical.) It is native to the Philippine Islands and is cultivated to a smaller extent in Malaysia and Indonesia. The mabolo has been introduced widely, but always on a small scale, and so remains almost unknown.

The mabolo tree is medium to large, reaching 25 meters in height. It begins to flower when small to medium. Unless pruned, the tree is upright, with a heavy dark trunk and numerous drooping branches.

The attractive leaves are simple, alternate, long (25 centimeters by 8 centimeters wide), with short petioles, shiny, and usually elongate or elliptical. They are evergreen, somewhat coriaceous, and slightly pubescent below.

The trees are male, female, or hermaphroditic. Isolated female trees usually bear seedless fruits, but at times, a few fertile seeds are produced, probably because the trees have occasional male flowers. The flowers are small (male, 0.60 centimeter in diameter; female, 1.2 centimeter) white, waxy, and aromatic. They are borne on the axils of the leaves or the undersides of young woody branches.

The fruit, about the size and often the shape of a peach, is covered with a thick soft pubescence (which can sting the skin) colored from orange to black, or in some cases, from pink to red. Seedless fruits are flat or top shaped. The rind is thin and easily broken open to reveal a dry, cream colored, mealy pulp. Up to eight brown seeds are embedded in the pulp.

The mabolo is most often propagated from seeds, which germinate readily and give rise to rapidly growing, healthy trees. Beyond its being a strictly tropical species, little is known about its growth requirements. It does appear to be more drought resistant than many tropical fruits, yet it also grows in very wet areas, so it appears to be broadly adaptable. It shows iron deficiency symptoms in the calcareous soils of Florida, easily corrected with iron chelates.

The fruits are generally eaten when ripe and soft. The mealy flesh has a strong odor and unusual but pleasant taste.

The champedak, *Artocarpus integer*. (family Moraceae), the breadfruit, and the jackfruit are the three best fruits of this large genus. But whereas the breadfruit has been introduced throughout the Tropics and the jackfruit is sporadically distributed, the champedak is almost unknown outside tropical Asia. The fruit has many uses, and is liked by almost everyone.

The tree is medium sized (up to 18 meters), somewhat smaller than the jakfruit. The trunk is straight, with smooth grayish bark. New shoots, including petiole and pedicels, are

covered with thin, brown, wiry hairs. Like its relative, the sap is milky in appearance and sticky. The tree is widely branched with a full crown.

The leaves are evergreen, alternate, with short petioles, sometimes three lobed, but on older trees obovate or elliptical and entire. The upper side is green and shiny and almost glabrous, and the lower side is covered with long brownish hairs and short white ones. The leaves are about 5 to 25 centimeters long and 5 to 10 centimeters wide.

The small flowers are borne in dense spikes that later become the fruit. Male and female flowers are borne in different inflorescences, the females on large branches or the trunk itself.

The large multiple fruit is quite similar in appearance to jakfruit but much more cylindrical. The fruits reach 35 centimeters in length and up to 15 centimeters in diameter. Thus, the fruit is much smaller than most jakfruits and much more convenient to utilize. The rind is covered with hundreds of polygonal raised projections similar to those of the jackfruit. Beneath the rind is a very attractive yellow pulp in which 30, or more, large seeds are embedded.

The champedak can be easily propagated from fresh seeds chosen from good trees. It is also possible to propagate good trees by bud grafting. Because of the latex of the tree, the modified Forkert method is used.

Even trees grown from seed bear fruits in 5 years. They need very little attention and are successful in many soils. They are, however, limited to the hot, humid Tropics.

The fruits of the champedak must be watched very carefully and harvested when they begin to soften. The fruit is sliced near the stem end and the core is pulled out. The seeds with their fleshy arils can then be easily removed. The fleshy aril is eaten as a dessert. It is soft and pleasantly aromatic. The seeds are eaten after boiling or roasting.

With its simple growth habits, the champedak should be easy to introduce. What is needed is a modern Captain Bligh.

The carambola, *Averrhoa carambola* L. (family Oxalidaceae) has been cultivated since ancient times, but only recently has it been considered to have commercial potential in the Western Hemisphere. It is grown extensively from southern China to India, and although it is known throughout the Tropics, it is relatively rare outside Asia. Small commercial plantings have been made in Florida in recent years.

The tree is relatively small, reaching a maximum height of 7.5 to 9 meters and a spread of 6 to 7.5 meters. The canopy is dense and attractive. The leaves are alternate, pinnately compound, and dark green. The leaves are retained on the tree throughout the year. The small pink flowers are borne in clusters on young branches, older branches, or the trunk of the tree. There are several flushes of bloom during the year and hence several successive crops of fruit. Mature healthy trees can produce 130 to 180 kilograms or more of fruit per year if they receive good care.

The fruit is ovoid to ellipsoid, with four to six prominent longitudinal ribs; in cross section it has a star shape. The fruit is 7 to 15 centimeters long and 5 to 10 centimeters wide, and when ripe, it may be white, yellow, or orange. The flavor varies from sweet and acidless to very sour. The rind is thin and tender and is generally consumed with the pulp. The surface of the fruit is smooth and waxy. The fruit attains best eating quality if ripened fully on the tree, but it is easily injured at this stage by handling during harvest. Fruit harvested when it is not quite fully colored is easier to handle without injury and will ripen to good eating quality.

Seedling trees require 6 to 10 years to come into bearing, and their fruit quality is likely to be poor. Therefore, it is best to grow vegetatively propagated trees of superior varieties such as 'Dah Pon', 'Mih Tao', and 'Tean Ma' (Taiwan); 'Maha'; 'Fwang Tung' (Thailand); 'Golden Star' and 'Newcomb' (Florida, U.S.A.). The most reliable method of vegetative propagation is grafting on carambola seedling rootstocks. Air layering is used extensively in many areas, but under some conditions it is less dependable than grafting.

The carambola tree grows best in warm tropical lowlands with medium to high rainfall and a well drained, moderately acid soil. In soils of high PH, deficiencies of zinc, manganese, and iron are likely to occur. The tree will tolerate a seasonal dry period well, but if dry conditions are severe and prolonged, some irrigation is needed to prevent defoliation and maintain fruit production. Mature trees can survive a brief exposure to temperatures a few degrees below freezing, so the carambola can be grown in areas where frost occurs occasionally, provided that the climate is otherwise favorable.

Research in Florida indicates a probable self-incompatibility and cross-incompatibility associated with a condition of distyly in the flowers. So to assure good yields of fruit, it is advisable to plant trees of more than one variety together, although some varieties are known to bear a satisfactory crop in isolation.

The carambola tree is a beautiful ornamental, and the fruit has good prospects for expanded commercial production. The green immature fruit can be cooked and eaten as a vegetable. The ripe fruit is eaten fresh or squeezed to make a refreshing juice. The fruit can be preserved in both the immature and mature stages. It is a good source of vitamin C and a fair source of vitamin A.

The morang, *Artocarpus odoratissimus* (family Moraceae), is native to and best known in northern Borneo; it is somewhat known from Thailand to the Philippine Islands. The fruit resembles in many ways a jakfruit. The fruits are smaller; however, and the pulp is white. The pulp is sweet, aromatic, and much more delicate than that of jackfruit. The seeds are roasted, as in the case of related species.

The okari nut, *Terminalia kaernbachii* Warb. (family Combretaceae), is a large tree of Papua New Guinea, the Solomon Islands, and scattered locations in Southeast Asia and the Pacific Islands. It is a handsome tree with large leaves covered below with a rusty colored pubescence. The large, somewhat flat fruit, 10 centimeters long, contains a single seed with a large (5 to 6 centimeters in diameter) edible kernel. Unlike the common *T. catappa* L., the fruit can be easily split open to release the kernel. It is considered a prize nut wherever grown.