

Growing

Guava

For Processing

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INTRODUCTION

The common guava, *Psidium guajava*, is native to tropical America and was introduced into the islands sometime during the period between 1790-1800 by Don Marin, a practical horticulturist, in charge of the Royal gardens at that time. The tree, which is familiar to all in Hawaii, is found widely distributed at elevations below 3,000 feet on all of the islands. It often becomes a serious pest in pastures and forest reserves where it is difficult to eradicate.

The guava has been referred to as the "apple of the tropics" by those familiar with improved types of dessert guavas cultivated in orchards and home gardens. In Hawaii, the fruit has not yet achieved as much popularity and esteem as elsewhere. At this time practically all of the guavas produced in Hawaii are from a variable population of wild seedling trees producing fruit that is often small, sour, seedy, or full of gritty stone cells. However, some of the wild types are excellent for processing. Others of superior texture and flavor are fine dessert fruits.

Much of the recent interest in the common guava has been due to its extremely high vitamin C content and nutritional qualities, in which it ranks far above many of the more highly esteemed fruits in Hawaii.

Good selected guavas contain four or five times as much vitamin C as fresh orange juice, and up to ten times as much as most of the tomato varieties bred especially for high vitamin C content. Guavas are also a relatively good source of vitamins A and B and a fairly good source of iron, calcium, and phosphorous. In addition to possessing valuable nutritional qualities, the guava blends exceptionally well in various processed fruit preparations. For these reasons a demand has arisen for uniform types of high quality fruit. Although jelly is by far the most widely known processed product, several other guava preparations are as good or better than the jelly and offer good prospects for expanded commercial development.

There are a number of good processed products which can be and are being manufactured from guavas. These products can be readily improved in yield, quality and nutritional value through the use of superior orchard-grown varieties of guava. Some of these products are: frozen guava puree, guava nectar base, improved canned nectars and jams. The manufacture of some of these products is explained in detail in publications of the Hawaii Agricultural Experiment Station.

The possibility of growing grafted or air-layered plants of dessert type guavas in the home garden has been largely overlooked. This field obviously deserves wider attention. As the general public becomes increasingly aware of the desirable nutritional and dessert qualities of improved types of guavas, their propagation by nurserymen and use as fruit trees in small home plantings, may be expected to increase.

Up to now guavas have not been cultivated in orchards in Hawaii. All of the guavas now processed come from seedling trees growing on waste lands or in pastures. The fruit from this source is variable in quality and supply. There is considerable doubt concerning the future reliability of this source of supply, as the use of chemicals to eradicate guava trees in waste lands and pastures becomes more common and effective. There is also a possibility that insects and diseases which seriously affect wild guavas may be introduced purposely or accidentally to aid in control of the plant as a pest. The wild fruits also serve as a breeding ground for fruit flies that would attack cultivated guavas and other fruits.

A substantial guava industry probably cannot be expected to develop unless a more reliable source of supply of uniformly high quality fruit than that from wild seedlings becomes available. Such conditions can be met only if vegetatively propagated varieties are grown in cultivated orchards where attention may be given to

cultural practices such as fertilizing and spraying. As has happened in southern Florida, processing interests may find it advisable to take the lead in demonstrating the possibilities of orchard cultivation of guavas. Commercial orchards amounting to several thousand acres of selected types of guavas also are being grown successfully in India, Brazil, South Africa, French West Africa, and British Guinea.

BOTANY AND HORTICULTURAL DESCRIPTION

The common guava, known botanically as *Psidium guajava*, is the most widely known and important fruit plant in the *Myrtaceae* or myrtle family. This family contains a number of other fairly well known fruits grown to a limited extent in Hawaii. These related fruits include: (1) the strawberry guava, *Psidium cattleianum* Sabine; (2) the rose apple, *Eugenia jambos*; (3) the Surinam Cherry or Pitanga, *Eugenia uniflora*; (4) the mountain apple, *Eugenia malaccensis*; and (5) the Java plum, *Eugenia cumini* Merr.

Under favorable growing conditions in Hawaii, the guava plant develops into a small tree. Well-grown trees on fertile soil often reach a height of 30 feet or more with about an equal spread. The trunk, which is usually short, branches freely near the ground and may reach a diameter of about 12 inches in larger specimens. The bark is scaly and greenish-brown to brown in color. The oblong leaves, arranged in pairs, are from 4 to 7 inches in length. They are smooth on the upper surface, but have numerous small hairs on the underside of the leaf.

The bisexual or perfect flowers are white in color and from 1 inch to about 1½ inches in diameter. They usually occur singly or in clusters of 2 or 3; rarely, 4. The stamens are numerous and pollen plentiful. Cross-pollination is frequently aided by bees and other pollen carrying insects. Self-pollination is possible, and isolated trees often set satisfactory crops of fruit without cross-pollination.

Botanically the fruit is a berry which may be round, ovate, or pear-shaped. The fruits vary from 1 to 4 inches in diameter and from 2 ounces to about 1 pound in weight. The skin color of the ripe fruit is usually yellow and the flesh color may be white, pink, yellow, salmon, or carmine. Guavas vary from thick-fleshed fruits with only a few seeds in a small center cavity, to thin-fleshed fruits with numerous seeds imbedded in a large mass of pulp. The fruits range in flavor from quite sweet in some types, to sour and highly acid in others. The characteristic musky guava aroma and flavor are quite evident in most forms, but in some types they are mild and pleasant. In others the aroma and flavor are almost too strong and penetrating for most tastes. The fruits usually occur singly but clusters of 2 or 3 are not uncommon.

The main guava crop usually ripens from May through August. A few ripe fruits can be found any month of the year however. Under favorable growing conditions in Hawaii, a small, fairly distinct second crop is often produced some time during the winter season. Trees which have been propagated by budding, air-layering, or other vegetative means usually begin to bear within two years after transplanting. Seedlings usually begin to bear the second or third year after transplanting.

SOIL AND CLIMATIC FACTORS

The guava is adaptable over a wide range of soil and climatic conditions. It often grows wild in places where other fruit trees would fail entirely. The fact that the plant becomes readily established as a weed in pastures and waste lands is ample proof of its natural hardiness and adaptability. It will survive flooding and continue to grow on soils that are temporarily waterlogged. Guava trees growing on infertile soil without much care, often show little apparent sign of distress although yields

may be low. They grow satisfactorily on moderately acid soils and also do well under slightly alkaline soil conditions. Although guava may be tolerant to rather poor soil conditions, it responds well to good soils and climate, and surprisingly well to both organic and chemical fertilizers. Trees growing in old barnyards and corrals where the soil is deep and fertile are usually outstanding, both in vegetative growth and fruit yields. Since flowers are produced on new wood there seems to be little danger of the plant becoming over-vegetative and apparently there are few soils that would be too fertile for guava.

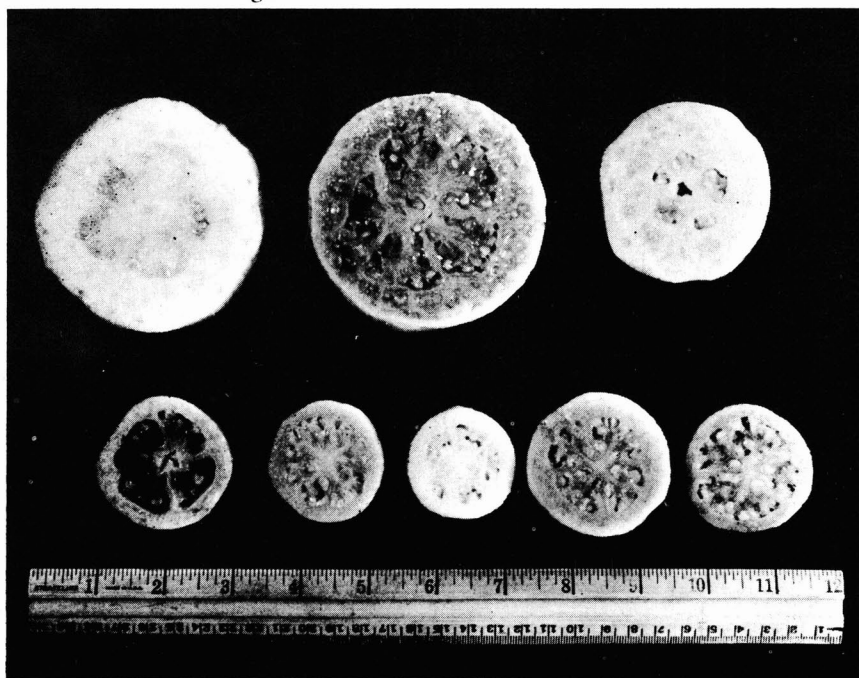
Climatic conditions suitable for guava growing are found in the Hawaiian islands between sea level and about 3,000 feet elevation. Annual rainfall between 40 and 150 inches appears to permit satisfactory growth. Windy slopes and ridges exposed to the tradewinds produce small stunted plants and are obviously not suitable orchard sites.

STANDARDS FOR SELECTING DESIRABLE PROCESSING GUAVAS

A few years ago the possibilities of orchard culture of guavas received little consideration in Hawaii. Today the picture has changed considerably. Commercial processing has increased and competition among manufacturers of guava products has resulted in the urgent necessity of improving and maintaining the quality and yield of fruit. It has become apparent that it is impossible to rely on supplies of wild fruit as the basis for a high quality product the year around. Uniformity of quality is of utmost importance in any product, and this in turn depends to a large extent upon the quality of fruit used. The wide range of variation between fruits of selected guava varieties and those from ordinary wild seedlings is illustrated in figure 1.

At the present time guava processors in Hawaii purchase fruit from pickers who collect guavas from various locations in the islands. As a consequence, the quality of fruit varies considerably even on the same day. It may be either sweet or sour, of good or poor color, of normal odor and flavor, or flat tasting. Chance will determine whether it happens to be high or low in vitamin C content. Processors realize this and are emphasizing the need for orchard cultivation of uniformly high quality guava varieties.

Figure 1. Cross sections of guava fruits. *Upper. Left* = Webber \times Supreme hybrid; *Center* = Rolfs; *Right* = Horne. *Lower.* Five fruits representing types commonly found on unselected wild seedlings.



Investigations and the experience of commercial processors have shown that there are certain characteristics desired in an "ideal" processing guava. These characteristics are listed in Table I as a goal or standard for use in selecting a suitable processing type guava to propagate vegetatively for orchard plantings.

TABLE 1. STANDARDS FOR SELECTING DESIRABLE GUAVA VARIETIES TO USE FOR COMMERCIAL PROCESSING.

Fruit Diameter	Diameter of Cavity	Fruit Weight	Seeds	Color	Flavor	Soluble Solids	Vitamin C*	Stone Cells
<i>Inches</i>	<i>Inches</i>	<i>Ozs.</i>	<i>Percent</i>			<i>Percent</i>		<i>Quantity</i>
3	1.5	7-10	1-2	Strong Pink	Pleasant, Palatable, characteristic guava flavor	9-12	300 or more	Few

* Mg. ascorbic acid per 100 g. fruit.

The standards set forth in Table 1 are desirable objectives to use in selecting good processing varieties. It is reasonable to expect that these objectives could be attained in an improved variety, since one or more of the varieties listed in Table 2 equals or exceeds the standards listed in Table 1 in each of the characteristics tested. The three most important fruit characteristics in which ordinary seedling guavas are usually found unsatisfactory and variable by processors are: (1) flesh color; (2) flavor; and (3) vitamin C content. Guavas which fall much below the standards given for these three important characteristics in Table 1 probably are not the type of vegetatively propagated varieties needed to supply fruit for commercial processing.

From a commercial standpoint, the manufactured product must have good flavor and aroma resembling the fresh fruit from which it came. Both flavor and aroma must be free from any objectionable or undesirable characteristic that originates from the fruit, from poor handling, or from processing techniques. Color is also a very important factor in the processed product and "eye appeal" should never be minimized. Smooth texture is one of the most important requirements of a good finished guava puree for freezing.

Other advantages that may be realized from the use of selected varieties of orchard grown fruit rather than ordinary wild type guavas may be listed as follows:

1. Higher percentage of recovery of finished guava puree. At present 75 percent recovery is considered good, but 80 to 90 percent can be expected, using larger guavas with smaller seed cavities.
2. Reduced waste disposal problems with seeds and stone cells. No commercial use has been found for either guava seeds or guava stone cells.
3. Guavas of improved varieties should yield higher soluble solids. This will represent a saving in sugar requirement to processors of guava products.
4. A strong pink color in selected varieties would eliminate the need for artificial coloring of guava nectar, allowing the processor to produce a superior natural product.
5. Greater uniformity in quality throughout the year because of less variation in odor, flavor, and texture of fruit used.
6. Using guavas of a known desirable range of acidity eliminates the extra step of acidification in making guava nectar, or nectar base.
7. Use of cultivated varieties with an ascorbic acid content of at least 300 milligrams per 100 gram sample would justify advertising the higher vitamin C content of guava products compared to citrus and other fruit products.

VARIETIES AND TYPES

Practically all guava trees growing in Hawaii at present are seedling plants. A wide assortment of oval, pear-shaped and egg-shaped guava fruits with pink, reddish or white flesh color occurs among these seedling trees. Certain types are often incorrectly referred to as varieties, but actually they are only types of seedling groups. Such common names as "apple guava," "lemon guava," "pear guava," and "sweet guava," are merely descriptive names and do not represent valid horticultural varieties.

There are no vegetatively propagated varieties offered for sale by nurseries in Hawaii at the present time. However, certain individuals who appreciate guavas as a fresh fruit occasionally grow plants of some of the better sweet guavas from suckers or root cuttings. The University of Hawaii Horticulture Department has imported a number of high vitamin C varieties from California, Florida, South Africa, and Brazil. Others have been selected from wild plants growing in the Territory. These varieties do not come true from seed and are being propagated vegetatively to determine their possible usefulness as commercial varieties. Unfortunately most of the named horticultural varieties are dessert type guavas. These are quite sweet and desirable for eating fresh, but they may not have enough acidity or a tart enough flavor to satisfy processing requirements. Characteristics of a number of introduced varieties, plus some of the local selections undergoing tests (figure 2), are given in Table II.

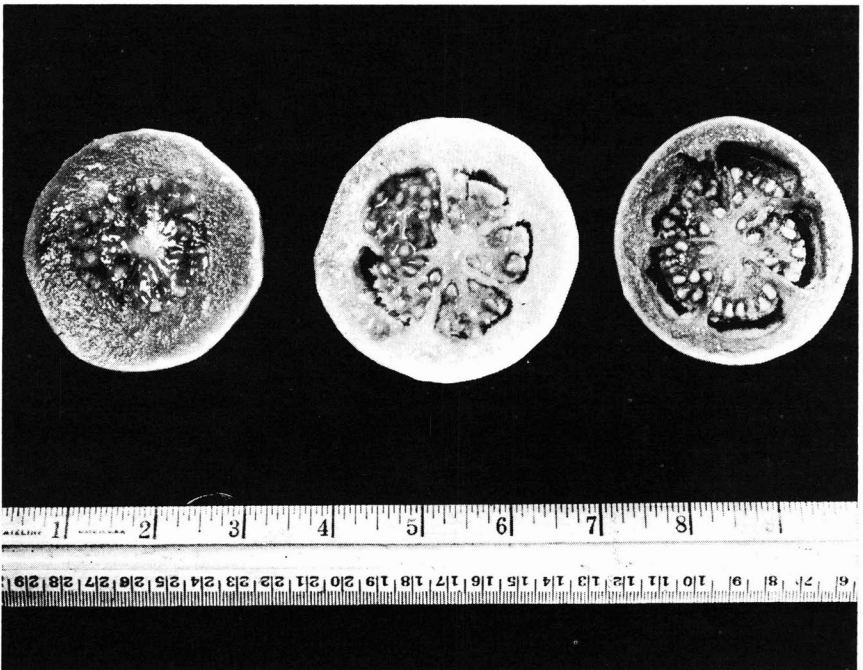


Figure 2. Large guava fruits selected from wild seedling trees. *Left* — Large, thick-fleshed type of fruit desirable for further testing as clonal variety. *Center* — Poorly colored fruit showing some puffiness and about average thickness of flesh. *Right* — Undesirable, thin-fleshed fruit showing considerable puffiness.

TABLE 2. AVERAGE FRUIT CHARACTERISTICS OF EIGHT SELECTED VEGETATIVELY PROPAGATED GUAVA VARIETIES.

Name	Source	Weight	Diameter	Diameter of seed Cavity	Seeds	Flesh Color	Flavor	Soluble Solids	Acidity	Vitamin C Content*
		<i>Oz.</i>	<i>Inches</i>	<i>Inches</i>	<i>Percent</i>			<i>Percent</i>	<i>pH</i>	
Malherbe.....	South Africa	6.3	2.8	1.6	1.0	Light Pink	Pleasant, sweet, very mild guava flavor	9.9	4.1	213
Fan Retief.....	South Africa	4.1	2.1	1.4	2.3	Light Pink	Pleasant, sweet, characteristic guava flavor	12.6	3.9	248
Rolfs.....	California	7.2	2.7	1.8	2.9	Strong Pink	Sweet, mild, bland mild guava flavor	9.9	4.0	252
8 B-30.....	Oahu	6.3	2.8	1.8	1.7	Medium to Strong Pink	Mild, sour characteristic guava flavor	8.6	3.5	154
D-31.....	Oahu	5.6	2.6	1.7	3.8	Light Pink	Sour characteristic guava flavor	10.3	3.2	146
Lupi 1.....	Maui	5.9	2.8	2.0	3.4	Medium Pink	Pleasant, sweet, mild guava flavor	9.8	3.7	492
P-1.....	Oahu	5.8	2.5	1.5	2.7	Strong Pink	Pleasant, sweet, characteristic guava flavor	10.0	4.0	298
No. 6229.....	Florida	8.8	3.1	1.9	2.0	White	Pleasant, sweet, bland, lacks characteristic guava flavor	10.4	4.0	285

* Milligrams of ascorbic acid per 100 grams of fruit.

PROPAGATION

SEED

Until suitable horticultural varieties become generally available it may be necessary to use seedling trees in the orchard. Although the seedlings are apt to vary in size, shape, and quality of fruit, guavas are still commonly propagated from seed. However, only seed, preferably self-pollinated, from the best selected type of guava tree available, should be used. It is relatively easy to self-pollinate flowers and label the fruits to be used for seed purposes. Self-pollination is accomplished by pollinating individual flowers on an especially desirable guava tree with pollen from the same flowers. Contamination from other pollen is prevented by tying a small paper or cellophane bag over each pollinated flower. Open-pollinated seedlings are usually so highly variable in fruit type and tree characteristics that the yield and quality of the fruit may be disappointing. However, open-pollinated seed is satisfactory for growing stock plants to be used for budding and grafting.

At the present time, seedlings of selected parentage will serve to get orchard developments into production in the shortest possible time. Undesirable and mediocre seedlings may later be converted to the best varieties by budding. Should superior seedlings be found they can be budded on vigorous young seedlings already growing in the orchard. Seedling trees usually begin to bear small amounts of fruit the second or third year after transplanting, at which time undesirable trees can be detected and marked for budding. These trees should be budded low on the trunk, preferably not more than 2 or 3 inches above ground level. Low budding is advisable in order to minimize the suckering tendency which is excessive in guavas top-worked by grafting higher up or on main branches. Budwood should be taken from the most desirable variety or seedling selection available, according to processing standards. Healthy young two to three-year old trees in a seedling orchard are not too large to be budded and will come into production again within two years after budding.

Seeds should be planted in flats of sandy soil and covered to a depth of about $\frac{1}{4}$ inch. When sterilized soil is not available, seed should be treated with cuprous oxide, or other suitable fungicide, to control damping off. When the young seedlings are about one and one-half inch high they should be transplanted into individual containers. Number 2½ cans or 4 inch clay pots are suitable for this purpose. Well-grown plants will be approximately 12 inches high in 5 to 7 months; at which time they are ready for transplanting into permanent locations in the orchard.

BUDDING

Perhaps the most satisfactory and efficient method of propagating a large number of guava plants true to variety is by bud grafting the selected variety on seedling stocks. Seedling stock plants for the budding operation should be from $\frac{1}{2}$ inch to 1 inch in diameter and growing vigorously in a nursery row or in large containers. Either the patch bud technique or the very similar modification known as Forkert budding may be used. Both succeed well when the piece of bark containing a large, well-developed bud is covered with a somewhat larger plastic patch which is bound in place over the bud by wrapping with a plastic budding band. A skilled propagator with experience in Forkert budding can usually get 90 percent take. Budwood about the same diameter as the root stock plants should be prepared by cutting off the leaves of selected branches 10 days to two weeks before removing the branches for bud wood. The buds become enlarged during this period and therefore grow more readily when budded.

In Forkert budding, illustrated in Figure 3, two parallel vertical downward cuts

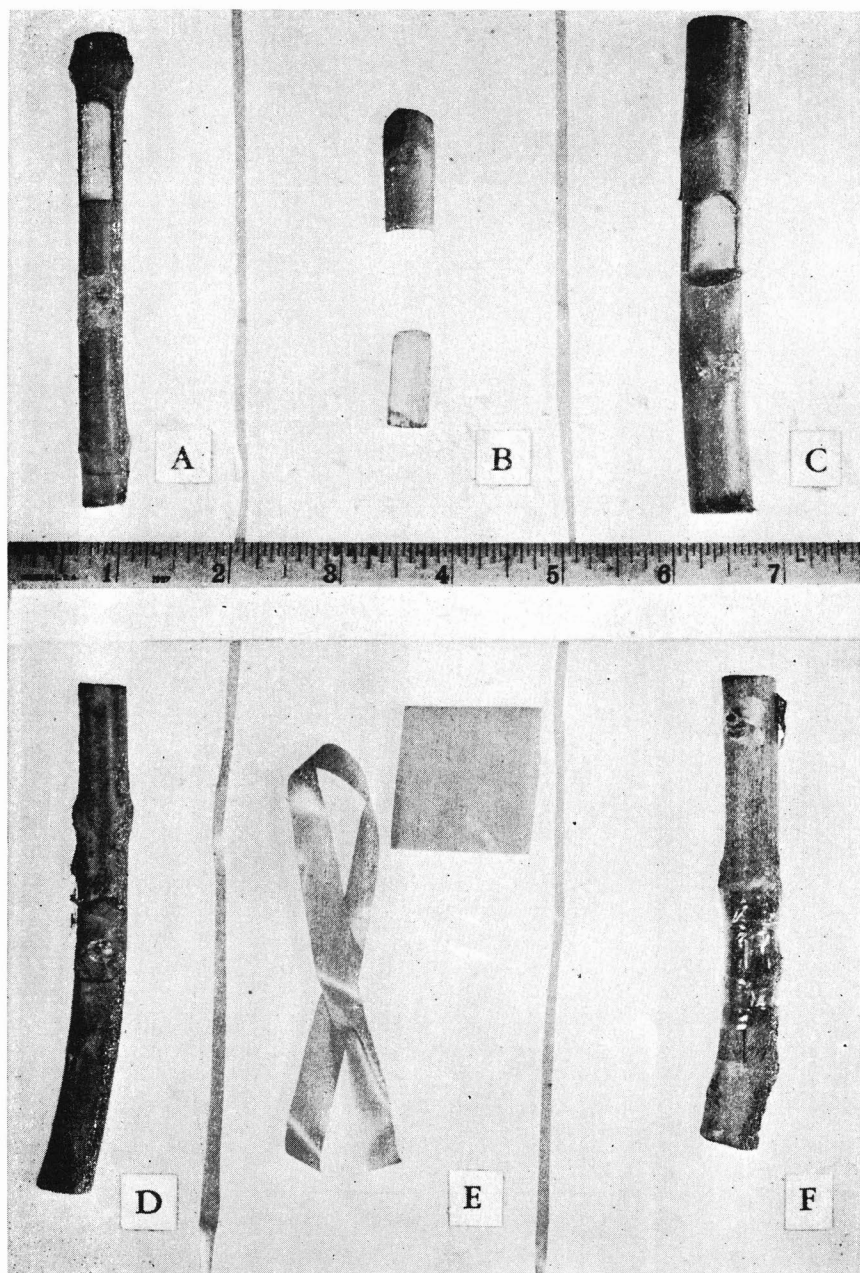


Figure 3. Steps in budding guava. *A* — Bud stick with one bud removed. *B* — Buds removed with bark shield (*top*, upper side of bud shield; *bottom*, underside of bud shield). *C* — Stock with the bark peeled back ready to receive bud. *D* — Bud shield inserted in place. *E* — Plastic patch and band used for covering the inserted bud and tying it in place. *F* — Completed budding operation with new bud covered and tied in place with plastic.

are made in the bark of the stock plant 2 to 3 inches above the ground level, with a sharp budding knife. These cuts are made about $\frac{1}{3}$ inch apart and are about $\frac{3}{4}$ inch long. An additional curved cut joining the two vertical cuts at the top is then made.

Then the following should be done: Take the bud stick (A) previously prepared, and cut a patch of bark $\frac{1}{3}$ inch wide by $\frac{3}{4}$ inch long containing a large, well-developed bud (B). Peel this patch of bark carefully away from the wood, prying it loose with knife-blade and fingernails. Beginning at the top, lift up the strip of bark previously cut in the stock plant and peel it back from the wood as shown in (C). Then quickly slip the piece of bark containing the bud in place under the raised flap of bark, after which the upper $\frac{2}{3}$ of the flap of bark is cut off as shown in (D). The short flap remaining at the bottom aids in holding the patch bud in place. Now place a piece of lightweight vinyl plastic (E-upper) of about $1\frac{1}{2}$ inches by 2 inches over the patch bud. This plastic patch should be carefully adjusted to extend over and cover all cut edges. The plastic acts as a water-tight seal over the budded section and prevents it from drying out. Finally, bind the patch bud firmly in place against the stock by wrapping tightly with a strong plastic band, about a quarter of an inch wide and 10 inches long (E-lower). Tying is not necessary, the plastic band being secured by slipping the free end under the last loop and pulling it tight. Cut off the top of the stock, leaving 6 to 8 leaves above the budded section. The completed job of budding is shown in figure 3F. In 3 or 4 weeks, cut a small hole in the plastic directly over the bud to allow the new shoot to emerge. The top of the stock is cut back gradually in two or more steps to force the new bud to flush and grow. All new shoots appearing above or below the budded section should be removed as soon as possible.

AIR LAYERING

This method of propagation, which is the usual method of propagating lychee plants, may be readily adapted to guava. Select limbs about an inch in diameter. Remove a strip of bark 2 inches wide all the way around the branch. This girdled section is enclosed within a ball of moist sphagnum moss which is then bound firmly in place with a piece of vinyl plastic about 12 inches square, and tied tightly at each end with string or twine. Roots usually begin to show through the plastic in a couple of months. If roots are not visible by this time, it is possible that the bark may have grown over the girdled section. The plastic wrap can be removed and the branch regirdled and wrapped again. This usually results in root formation in a few additional weeks. When a considerable number of roots are visible through the plastic, the air-layered branch can be removed, the top cut back, and the air-layered plant planted in a large can or pot. It should be grown in a shaded area until a new flush of growth appears after which it can be placed in a sunny location and grown until well enough established to be planted in the field.

GRAFTING

Side-wedge and side-veneer grafting are possible on young, vigorous stock plants, but usually the percentage of successful grafts is discouragingly low. It is also possible to topwork large seedling trees by cleft or veneer grafting on the main branches. However, older guava trees persistently send out large numbers of suckers below the graft union, so the practice of top-working large trees has little to recommend it. Inarching is possible, using seedling stock plants growing in containers. This method takes about as long or longer than air-layering and is generally considered to be a rather slow, inefficient method of propagation.

CUTTINGS

Root cuttings 4 to 6 inches long and $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter planted 1 or 2 inches deep in cutting beds, often give rise to new shoots. These shoots can eventually be transplanted and established as new plants. However, it usually takes about a year and a half to develop plants to transplanting size from root cuttings, and root cuttings from some varieties may fail entirely. Attempts to root stem cuttings have met with little success in Hawaii, although occasionally a few cuttings produce roots.

It is fairly easy to propagate a limited number of plants by cutting off some of the roots 2 to 3 feet from the trunk with a sharp spade or mattock. Plants will develop from sprouts which develop from the severed roots. These can be dug up and transplanted when they develop to sufficient size. While it is relatively easy to get a few plants by this method, cutting off these roots probably does considerable harm to the parent plant.

ORCHARD DEVELOPMENT

CHOOSING A SITE

Land where large, productive, wild guava trees are growing would be ideal for an orchard site, providing it is level enough to be readily accessible to equipment needed for land clearing and orchard cultivation. A number of protected slopes and small valleys on all the islands contain considerable unused land suitable for development into guava orchards. Much of this land is already overgrown with wild guava trees and other natural vegetation. The size and general appearance of wild guavas growing on the land is a valuable indication of its potential usefulness as an orchard site. Some of the larger, more accessible gullies and gulches on the windward side of the various islands in which wild guavas grow well, appear to be suitable for orchard sites if properly cleared. Guava plants which are planted on windy, exposed slopes or ridges, are slow growing and unproductive, and locations of this type should be avoided. A reasonable amount of wind protection is essential in growing guavas and sheltered locations are definitely desirable. If natural wind protection is lacking, planted windbreaks become a necessity. Box brush, *Tristania conferta*, the seedy type of banana known as *Musa balbisiana*, ironwood, *Casuarina equisetifolia*, Norfolk island pine, *Araucaria excelsa*, and a number of other tree species adapted to areas suitable for guava growing may be useful for windbreak plantings.

SPACING

Planting distances of from 18 to 24 feet between trees and between trees in the row are desirable for guava orchards of budded, grafted or air-layered trees. Under ideal growing conditions the wider spacing mentioned would probably result in a more satisfactory orchard than closer spacing, especially if the soil is fertile. In case seedling trees producing fruit of unknown quality are planted, it is probably a good idea to plant more trees per acre than are actually needed (see figure 4). When this plan is followed some of the poorer trees can be removed, or budded with more desirable varieties. The seedling trees which produce satisfactory fruit for processing can be retained in the orchard. If this plan is adopted, a spacing of from 18 to 24 feet between rows and 10 or 12 feet between plants in the row is suggested. Up to half of the trees in each row can be taken out, but there is no particular objection to leaving more than half of the trees if they bear desirable fruit. This plan does not leave an entirely uniform planting but the spacing between rows allows cultivation in one direction.

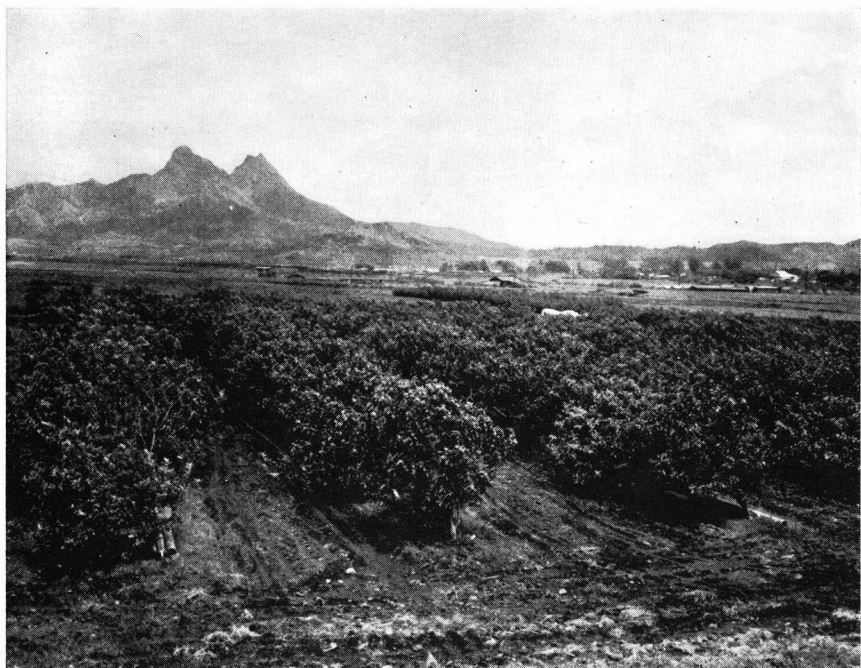


Figure 4. Young guava orchard of seedling trees. Spacing 20 feet between rows and 10 feet between plants in the row.

PREPARING LAND FOR PLANTING

Several months in advance of planting, the land selected for a guava orchard should be completely cleared of brush and trees by bulldozing or other means. The area should be plowed and disked several times until reasonably free of weeds. If the orchard site is on steep, sloping land where there is danger of erosion, the rows should be laid out on the contour and only a strip about 6 feet wide plowed for each row of trees. The remaining area between the rows is left in sod and weed growth to prevent the soil from washing away. The space between rows should be mowed often enough to prevent excessive growth of weeds and grass.

TRANSPLANTING

If the plants are well-grown and the weather favorable for transplanting, guava plants are not difficult to transplant. Transplanting young plants into permanent orchard locations is generally most successful during fall and winter months when both humidity and rainfall are relatively high. Transplanting holes should be dug somewhat larger than is needed to accommodate the roots or the soil mass containing the roots. Seedlings to be transplanted should not be grown in small containers for more than a few months. Guava plants grown in small containers become root bound rather easily and such plants are weak rooted and easily blown over in storms. When budded trees $\frac{3}{4}$ inch in diameter or more are produced for transplanting they should be grown in containers not smaller than 5 gallon cans or 10-inch pots.

In transplanting it is recommended that the holes be dug deep enough so that a large shovelful of compost or well-rotted manure can be mixed with the soil at the bottom of the hole. When compost or manure is not available, it is advisable

to mix about $\frac{1}{2}$ pound of a good general fertilizer, such as 8-8-8, with the soil at the bottom of the hole. In transplanting, hold the plant upright in the planting hole and plant at about the same depth as the tree grew in the nursery row or container. Use as much top-soil as possible to fill in around the roots. Pack the soil down firmly around the roots with the hands. A small basin is usually established around the base of each tree to catch rain water. Plants should be watered immediately after transplanting unless the soil is quite damp and the transplanting done on a rainy or cloudy day.

ORCHARD MANAGEMENT

CULTURAL PRACTICES

Clean culture is usually considered to be the most satisfactory practice in young orchard plantings. However, there is no important objection to intercropping in young orchards with vegetables or flowers for the first 2 or 3 years. Cultivation in guava orchards should be shallow enough to avoid root injury which results in large numbers of undesirable sucker plants. Cultivation should be frequent enough to control weed growth. In locations where there is danger of erosion, it is a good practice to plant a fast-growing legume cover crop between the rows during the winter months. This cover crop may be disked down the following spring to add organic matter to the soil. In orchards planted on steep, sloping land it may be necessary to maintain sod between the rows to control erosion. This should be mowed periodically to prevent excessive growth.

If the average annual rainfall in an orchard is less than 55 to 60 inches, the size of individual fruits as well as the total yield could probably be significantly increased by supplementary irrigation during and just before harvesting the main crop. Guava fruits ripening during a drought period are small, and supplementary irrigation at this time would probably be profitable.

Most of the weed growth under large trees in mature orchards is shaded out by the dense foliage. The small amount of weed growth that remains can be controlled by hand cultivation or by weed sprays. Diesel oil emulsion weed sprays are relatively safe to use in an orchard if used carefully and not sprayed directly on the trees.

Hormone weed sprays, especially 2,4-D, will kill or seriously injure guava trees and should not be used in orchards except to eliminate nearby wild guava trees which harbor insects and diseases.

Whenever possible, wild guava should be eliminated from a strip 200 yards or more in width around the orchard. Eradication of all nearby wild guava plants is the most effective and practical means of preventing the introduction and spread of insects and diseases from neglected wild trees, to the trees in the orchard. Perhaps the best way to get rid of wild guava plants is by using a commercial weed killer containing 2,4-D or a mixture of 2,4-D and 2-4-5-T in solution. These weed-killing compounds should be applied liberally to the bark of the trunk with a paint brush, painting a band of the material all the way around the base of the trunk, just above ground level. The manufacturer's directions should be followed with regard to concentration; and more than one application may be necessary to kill a tree. These weed-killing chemicals will kill guava trees quicker and with less suckering from the roots than any other method known.

PRUNING

The strong, well-branched growth habit of guava (figure 5) is such that very little pruning is needed to form a good tree other than to leave 5 to 8 strong, well-spaced main branches on a single trunk or leader. All surplus branches are removed from this trunk. Young trees should be trained to a single trunk branching 2 to 3 feet above the ground, rather than allowing several smaller trunks to arise from the same root. This means that suckers coming up around the trunk should be removed whenever they appear. Guava trees have a tendency to branch low, and all low hanging branches which touch the ground should be removed. About six well-spaced main branches distributed around the trunk of the tree are desirable. Some varieties of guava characteristically send out long unbranched shoots which eventually bend over and touch the ground. These branches should be cut back to wood about an inch in diameter. This heading-back serves a double purpose in preventing these branches from touching the ground and, at the same time, forcing out additional new fruiting wood.

Guava trees often grow to be 25 or 30 feet tall in a few years. Such trees can be advantageously pruned by cutting back the leader and upper limbs severely to wood that is $\frac{3}{4}$ of an inch or more in diameter. If judiciously done, this type of pruning will force out desirable new fruiting wood and, at the same time, keep the tree low enough so that most of the fruit can be picked from the tree without using a ladder.

It has frequently been observed that guava fruits tend to become smaller each year as the tree becomes older. Large fruit is usually produced on vigorous young branches which arise from wood that is two to three years of age and at least $\frac{3}{4}$ inch in diameter. By thinning out and cutting back branches of about this size in the upper part of the tree, the top of the tree can be kept low for ease of picking while at the same time, vigorous new fruiting wood can be forced out. The large sized fruits, which are usually most desirable, are produced on this type of fruiting wood.

FERTILIZERS

It is usually desirable to get trees in an orchard into bearing as soon as possible, and fortunately, young trees respond well to rather frequent applications of a complete fertilizer. Field experiments dealing with fertilizer requirements of guava plants on different soils are lacking, but a general fertilization program based upon observations has given good results.

During the first year after planting, about $\frac{1}{3}$ pound of 8-8-8 or 10-10-5 formula fertilizer may be applied around the base of the tree, four or five times a year. The rate of application can be increased to $\frac{1}{2}$ pound per application the second year and up to 1 pound the third year. Older bearing trees require heavier fertilizer applications. Relatively heavy applications of high nitrogen fertilizer, a month or more before the main flowering season, tend to increase the amount of new fruiting wood as well as the percentage of flowers which set fruit. For this reason it is believed that fertilizing bearing guava trees with a high nitrogen fertilizer such as 16-20 ammonium phosphate a month or more before the main flowering season in the spring, would result in larger crops.

INSECTS AND DISEASES

The most serious insect pest of guava in Hawaii is the Oriental fruit fly, *Dacus dorsalis* Hendel. This fly inserts its ovipositor into the fruit and lays eggs within the maturing fruit where they hatch into small maggots. These maggots burrow through the ripe fruit, making it unsuitable for human consumption. Introduced parasites



Figure 5. Well-grown, 4 year old tree, showing natural growth habit of guava.

have reduced the population of the fruit fly considerably, but at times a large proportion of fruits are still stung by this pest. Stung fruits can be utilized if they are picked slightly on the green side just as they begin to ripen. At this stage few of the eggs will have hatched. Needless to say, under orchard conditions, it is extremely important that unused fruits in which the flies have laid eggs, be removed from the orchard and disposed of promptly.

Another fruit fly, the Mediterranean fruit fly, *Ceratitis capitata* (Weid.), may also be an important pest in some areas. The damage caused by this fruit fly and measures suggested for its control are similar to that of the oriental fruit fly.

The most promising development in fruit fly control on guava is the effectiveness of bait sprays containing Malathion, a quick-acting insecticide, combined with a protein hydrolysate bait material attractive to fruit flies. Recent studies conducted by U. S. Department of Agriculture Fruit Fly Laboratory personnel, on guavas in Hawaii, have demonstrated excellent control of the Oriental fruit fly through the use of relatively small amounts of this type of bait spray applied at intervals of about 2 weeks. One of the outstanding features of this control method is that fruit flies are attracted to the poisoned bait material from distances of 50 feet or more so that thorough spraying is not necessary to secure good control. Experimental studies on the use of bait sprays for guava are still underway at the U.S.D.A. Fruit Fly Laboratory, but results to date have been so encouraging that more specific recommendations on the use of this type of spray on guava will undoubtedly be available by the time any commercial guava orchard is in need of protection against fruit flies.

There is also considerable experimental evidence on spraying wild guava to control fruit flies, and thorough high pressure spraying with either DDT or Methoxychlor has given effective control of both the Oriental fruit fly and the Mediterranean fruit fly.

Ants frequently become a pest on guava plants, not because of their direct effects, but because they are associated with the spread of aphids and scale insects. Ants can be controlled by spraying the trunk and main branches with an insecticide that kills them. The ground underneath the tree and around the base of the trunk should also be sprayed at the same time. Chlordane, and DDT, are effective spray materials for controlling ants. Applying a band of a very sticky compound, such as "Tree Tanglefoot," also serves to prevent the ants from climbing the tree. Low-hanging branches which touch the ground, permitting ants to reach the tree, should be removed. Aphids, scale insects, and sooty mold fungus may not develop into serious problems on guava trees if the ants are effectively controlled.

Sucking insects, such as scales and aphids, sometimes become numerous enough to cause some damage to guava trees. These insects injure the trees by sucking the sap, and certain types of scales are said to produce a direct toxic effect on some plants. Aphids and some scale insects secrete a sweet substance called "honeydew" which attracts ants who utilize it as food. The sooty mold grows and spreads on the honeydew secreted by scales and aphids. There are some indications that controlling the ants effectively will also control scale insects and aphids. Scales can be controlled by thoroughly spraying the trees at two week intervals with an oil emulsion mixture spray consisting of about 1½ gallons of summer oil and 1 quart of nicotine sulphate per 100 gallons of water. This spray also controls aphids.

Sooty mold fungus, the most common fungus on guavas in Hawaii, results in an unsightly black covering over the surface of the leaves and fruits. Inasmuch as sooty mold develops on honeydew, it can easily be controlled by eradicating aphids and scales which secrete the honeydew.

HARVESTING FRUIT

Guavas used for processing should be picked when they develop a yellow skin color but are still quite firm. Soft, over-ripe or moldy fruit should be avoided. The fruit should be harvested by picking it from the tree. Fruit that has fallen to the ground should not be used. Partly green fruit which has developed about $\frac{1}{2}$ of the yellow color of mature fruit can also be harvested and utilized. However, it should be stored at room temperature for proper ripening.

To avoid bruising fruits during transportation from the field to the processing plant, containers similar to the regular type shallow tomato boxes should be used, rather than the orange crates which are commonly used at present (figure 6). Tomato boxes are much shallower than orange crates and consequently the bottom layer of fruit bears less weight and is less likely to become crushed or bruised. Nailed wooden boxes are strong, easy to handle, and can stand rough treatment. These boxes should be made of wood that does not give off objectionable flavors or odors. The fruit should be transported to the processing plant without unnecessary delay soon after harvesting. If fruit is shipped from one island to another, arrangements should be made to have the fruit shipped at night whenever possible. If this is not done, the fruit must be kept covered or in the shade to protect it from the sun. Upon arrival at the plant the fruit can be stored in a cool location.

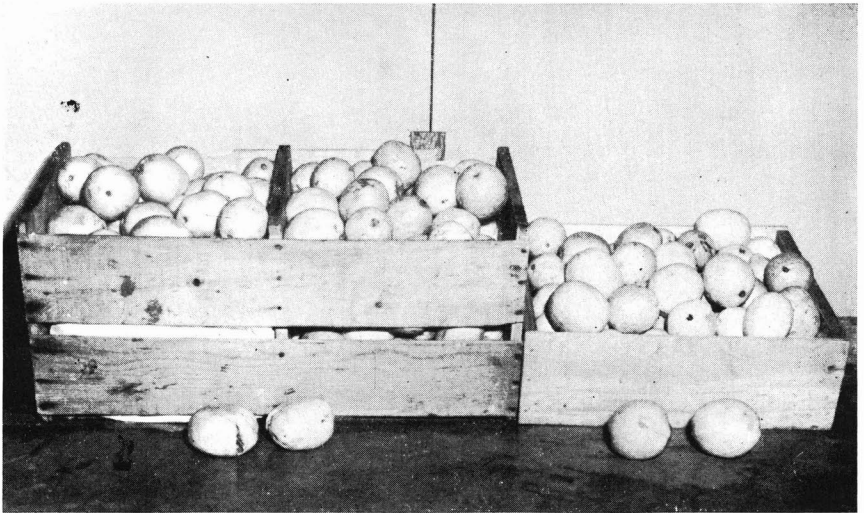


Figure 6. Containers used for packing of guava after picking and while being transported. *Left.* Orange crate with two guavas from bottom layer displayed in front, showing injuries from bruises and crushing. *Right.* Tomato lug container, with two fruits from the bottom layer displayed in front, showing relative freedom from bruises or crushing.

STORAGE OF FRUIT

All green and partially green fruit should be set aside in boxes and allowed to ripen in ripening bins well protected from dust, rodents, and insects. These bins should be constructed to permit good ventilation and protection from sun and rain.

Ripe fruit that is not being processed immediately may be stored at about 36° F.,

for as long as two weeks without injury. Storage at 45° F., allows fruit to be stored for about one week without appreciable damage. At temperatures below 0° F., ripe fruit can be stored for four weeks and probably longer without injury to the fruit or excessive loss of vitamin C.

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