

today in Central America. To Edward Simmonds we owe the Simmonds avocado, to my way of thinking the best variety of the West Indian race we are presently cultivating, and to George B. Cellon we owe the Lula, a late-ripening variety now one of the most important in Florida. (I remember well the trouble Cellon had in getting people to call this *Lula*, his wife's name, instead of *Lulu*). And we owe to other workers many of the fine Guatemalan x West Indian hybrids which are proving so satisfactory with us. We should not forget, of course, that California has given us numerous avocado varieties for higher elevations, such as Fuerte, but none of these has yet attained great importance in our part of the tropics. And speaking of California, we should also remember that workers in that State, especially Dr. C. A. Schroeder and Dr. George Zentmyer, have given us much information regarding cultural problems and diseases of the avocado.

Finally, I want to mention the excellent work Florida is doing in training young Latin Americans in the techniques of fruit growing. In the hands of these young men lies, to an important extent, the future of commercial production of such species as the mango, the avocado and numerous others in Central America.

CURRENT METHODS OF VEGETATIVE PROPAGATION OF AVOCADO, MANGO, LYCHEE AND GUAVA IN FLORIDA

S. John Lynch and Roy O. Nelson¹

THERE ARE TWO general ways to reproduce the higher forms of plant life, namely, sexually (by seeds) and asexually (by cuttings or graftage). Because most of our fruit crops do not reproduce true to type from seed, they are propagated asexually by some vegetative part of the

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plant. This can be a root or sprout therefrom; a section of the stem or branch used as a cutting or an air layer; or, most important from the horticultural viewpoint, by placing a portion of the plant on a congenial rootstock by some form of graftage. Practically all of our commercially grown fruit-bearing trees today are reproduced by the last-named method.

The art of plant propagation probably had its beginning in the more tropical and subtropical areas of the world. Much of the early literature indicates that the Chinese were adept in many of the present day practices. It is an incongruity, however, that the science of plant propagation has had greater research in the temperate and more developed western areas of tropical and subtropical horticulture than it has in the areas of its inception. It can be said, without a great deal of controversy, that the state of Florida has been the center of several departures from some of the recognized Temperate Zone practices of grafting, budding and marcottage. This has led to great advances in the propagation of tropical plants in numbers sufficient for the large scale plantings demanded in modern horticulture in these rapidly developing areas.

The thinking in research and practice of propagation of the evergreen tropical fruits has been a departure from that of the propagation of the deciduous species of the Temperate Zones, wherein long periods of time occur when storage of graftwood and cuttings is a general practice. Very seldom has budding and grafting been attempted in the Temperate Zone using "juvenile" rootstocks or scions under the conditions of dormancy which exist in those areas.

Vegetative propagation is approached with the idea in mind of producing a new plant, whether from cuttings or union of scion and rootstock, either by using stems or graftwood containing a large amount of stored food and being in a fairly mature stage, or by using stems in a rather immature stage when the cells are to a great extent undifferentiated. The latter approach in either cuttings or graftage requires more attention to providing an environment under which this rather succulent type of plant material does not dehydrate before either rooting occurs in

cuttage or union of scion and stock occurs in graftage. In the graftage of avocado, mango, lychee and guava immature scions make more rapid union with the stock, and in the guava this has been found to be the determining factor in the success of the operation in the nursery.

Another reason for using young stocks and succulent scions in the production of nursery grown trees, especially on plants such as avocados, is that the trees are ready to plant in field formation in three to five months after grafting is done. The rapid growth of the young tree, although it does not have the height and breadth of leaf spread which was once thought so desirable in avocado and mango trees, gives a sturdy, small, vigorously growing young plant which, when placed in grove formation, especially on new land, makes rapid growth and thus establishes a tree better able to overwinter. It is more economical in the development of acreage. This is not to be construed as recommending the use of these small trees as replacements in established orchards where it has been found more practical to use one to one and a half-year old grafts, which are better able to survive winds, insects, etc., the principal hazards in establishing replacement trees.

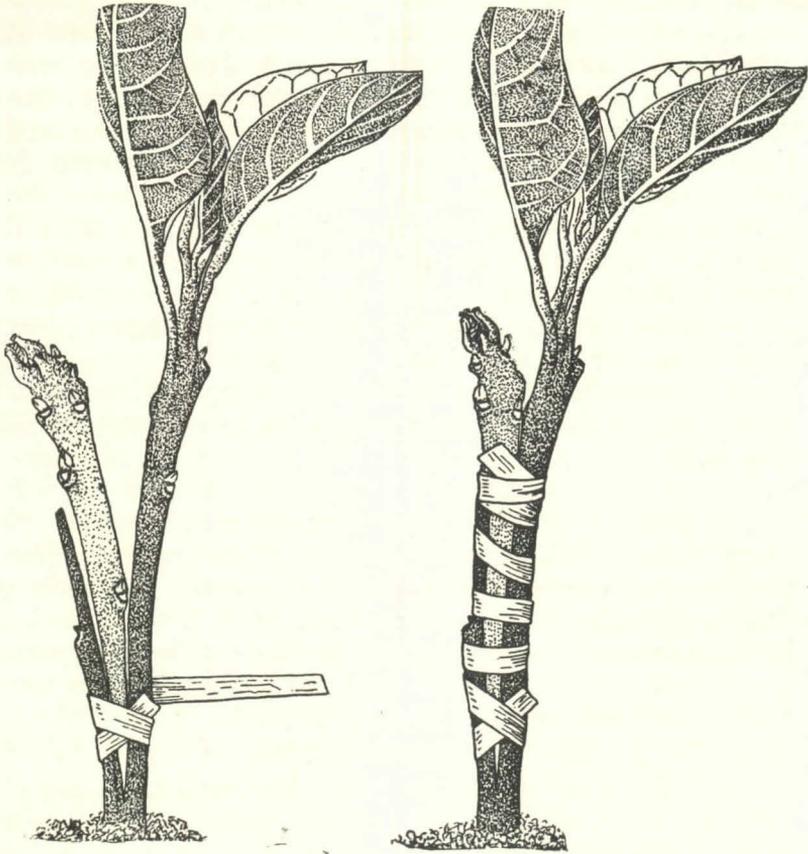
One of the recent important developments which aids in supplying an atmosphere about the uniting stock and scion congenial to union has been the use of plastic film. These plastic films, preferably of the vinyl or polyethelene type, retain a considerable degree of moisture around the scion and, at the same time, apparently allow much of the debilitating metabolic gases from the plants, such as carbon dioxide, to diffuse out. Of course, if a heavier film is placed around the graft, especially during humid weather, there is often a concentration of moisture next to the scion favoring rapid growth of decay organisms which result in the loss of the graft. The use of these films, however, has greatly increased the "take" on many of the tropical species previously difficult to graft, as well as providing a means of overwrapping which can be applied rapidly and economically.

AVOCADO PROPAGATION

Avocados have been propagated by graftage in the Western Hemisphere for about fifty years. Since the turn

of the century when George B. Celson (13) first grafted the avocado commercially by the use of shield budding, a number of methods for budding or grafting the avocado have been tried. California still depends heavily upon shield budding, but in Florida and a number of the Caribbean avocado growing areas the tendency is toward the use of the sidegraft on succulent young rootstocks (16). This method has superseded practically all others in Florida, where it has probably reached its highest point of perfection. Well trained plant propagators who are able to obtain terminal growths in the proper condition may expect from 98 to 100 per cent "take". This method is occasionally supplemented by the use of the side-veneer or the small cleft graft, where the stock has become too mature for the side-graft.

Stocks for the side-graft method are usually of the West Indian race whose normally large seed produces sturdy pencil-sized stems suitable for grafting from two to four weeks after germination of the seed. The stocks are planted in gallon or five quart containers. When the stems are six to 10 inches high and about the diameter of a lead pencil, but still in a red succulent stage, they are ready for grafting. The terminal scions, or "tips", two to three inches long, should be from the last mature growth just as it starts to flush. The terminal buds should be quite plump. The leaf petioles are cut off close to the stem, especially on the lower portion of the scion. The latter is cut with a long wedge-shaped lower portion and is inserted into a sloping cut made diagonally down the stock, to at least the center of the stem. The scion is inserted deep enough so that the entire cut portion is covered by the exposed tissues of the stock. Thus, we have a union ready to form between very active growing immature stock tissue and relatively succulent and active scion tissue. The scion is held snugly in place by overwrapping with a rubber grafting strip. The terminal bud of the scion will flush in a few weeks. After the scion has made a growth of three to four inches, the stock is cut smoothly back to the upper portion of the scion where union of stock and scion has taken place, to allow the scion to make a smooth union with the stock.



Side grafting the avocado. On the right, the graft is completed and tied with rubber grafting strip

The tree will be ready for setting in the field in five to seven months from the time it is grafted. If these young trees are kept another year in the original gallon container, they become root-bound and are very unsatisfactory for planting in the field. Should it be desirable to hold the trees longer, they should be transferred to three — or five — gallon containers at the end of the first year.

Veneer grafting in the nursery is sometimes practiced if the young succulent reetstocks become too hard or too old for the side graft. These stocks can be of pencil size or even twice to three times that diameter. Where they have attained considerable size transfer should be made to larger

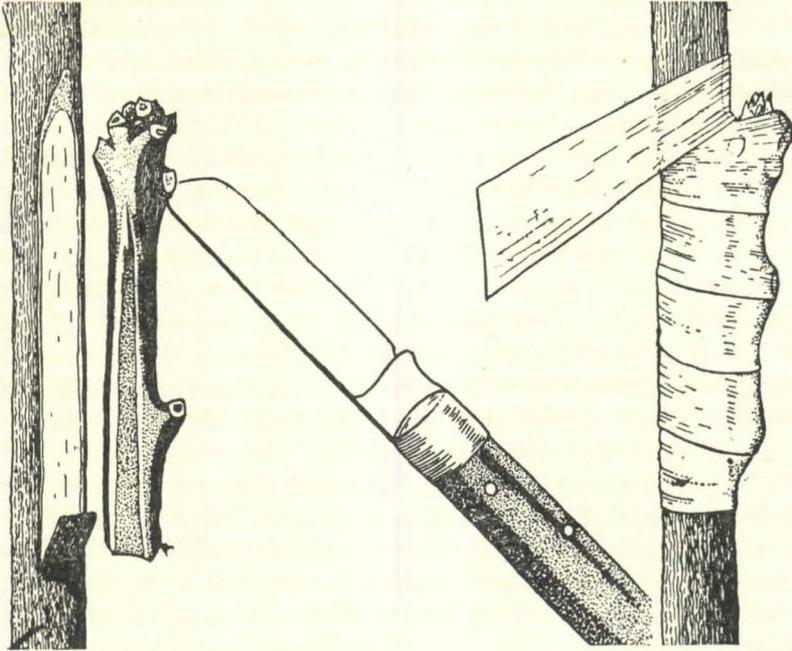
containers. The method is also used when top-working older avocado trees that have been topped to force sprouts of suitable tissue and diameter for grafting. The regular side-veneer is used with a scion two to three inches long, terminating in a healthy swelling terminal bud. It has been found that holding the scion in place and covering it completely with a strip of 0.0035-inch vinyl film, leaving the tip of the terminal bud exposed, allows the graft to remain moist and at the same time leaves an opening for the springing bud to emerge without unwrapping as quickly as in most grafting operations. Trees from this type of graft are ready to plant in the field from three to five months after grafting.

TOP-WORKING. Top-working avocados in Florida has not changed in general practice from the cleft-graft method described by Krome in 1916 (2). The work is still done during the cooler season of the year, November through March; as the warm season approaches, the percentage of "takes" decreases. This method is used to work over seedling trees that are found undesirable or to replace one variety with another. A ten year old avocado grove top-worked by cleft grafting will bear commercial crops within two years. The growth of top-worked trees is prodigious. Within two years the top will be 12 to 15 feet tall with a spread of the same size and will have a trunk diameter almost equal to that of the stock.

MANGO PROPAGATION

The successful budding and grafting of mangos in Florida within the last ten years has advanced rapidly with the demand for the newer varieties originating in this State. Several skilled nursery propagators and research workers have developed techniques that are used to grow thousands of trees each year.

The principal methods used are side-veneer grafting, chip and modified chip budding, and side grafting. The use of these techniques is determined chiefly by the diameter and age of the stock plant. Mango stocks are grafted in Florida from the growth period when the seedlings are still succulent, with a red or purple color, continuing through the successive growth stages until well defined cambium has formed.



Details of veneer grafting the mango. On the left, scion ready for placing on the stock plant. Note the notch at the lower end of the cut on the stock, useful in holding the scion in place while wrapping proceeds. On the right, the graft has been wrapped with vinyl film, leaving only the tip exposed so that the terminal bud may break into growth.

Side-veneer grafting and chip budding are the two methods most in use at the present time. The technique of wrapping, budwood selection, and "springing" of the bud vary with the individual propagator, but standard procedures are gradually being established. The majority of trees grown in containers are grafted or budded when the stock has a stem in the "green" stage of maturity. This stage is reached in four to six weeks after the seedling has germinated and continues over a period of several months. The seedlings that are not grafted in the first green stage during the months of July, August and September are held over until the spring and early summer months. Graftage during the cold months is not advisable because growth of the scion is slow and the percentage of "takes" low.

Regardless of the particular method of graftage selected, disease and insect control on the stock and parent trees, season of year for the operation, and careful selection of scions for proper maturity are important to the success of the operation.

The choice between using terminal scions or lateral buds depends chiefly on the abundance of graftwood. The use of budding methods allows a greater number of trees to be produced when economy of graftwood is a factor. This is usually the case when the increase of a new variety is first attempted. Also, the particular technique with which the propagator is most proficient influences the choice of methods. Many prefer the terminal scion because springing is more rapid. Others use the budding method entirely because the scion length of the chip-bud requires a shorter cut and less wrapping material. Speed of the operation is also a factor which favors budding in comparison with the side-veneer graft. Springing the bud requires different procedures than are required with the terminal scion, but this can be successfully done by any of several methods used in Florida.

SIDE-VENEER GRAFTING. This technique was more exclusively practiced during the period when the Haden variety dominated the mango plantings. With the advent of newer varieties and the greater demand for trees, budding methods are now practiced almost as extensively as the side-veneer, if not tending toward more extensive use.

Side-veneer grafting may be started when the seedling stock has a defined cambium and has formed enough wood to have rigidity. The appearance of the bark will vary from a greenish-pink to a definite green color, and as further maturing occurs, the bark will appear grey with a corky condition noted on older trees where considerable bark sloughs off. The side-veneer graft is also used on large limbs or tree trunks in top-working.

The scion used is almost always a terminal stem two to three inches long. The degree to which the terminal bud is developed gives the best indication as to its suitability. An enlarged terminal that will "spring" in 10 to 14 days is ideal. Leaves are removed as the scions are taken from the parent tree. The scions are placed in damp peat or sphagnum moss until the grafting operation. The cut on the scion

is seen as an exposed area of stem tissue, starting from just below the terminal bud and extending to the basal end of the scion. The opposite side of this long cut will have an oblique cut at the basal end to allow the scion to fit the cut on the stock which is similar in appearance to the one made on the scion, except that a slightly larger area of tissue is exposed. The cambial areas of the scion and stock are placed so as to coincide, and a strip of 0.0035-inch vinyl film is overwrapped, leaving a small opening at the top of the wrap through which the terminal may emerge. The scion is then secured by underlooping the end of the film and pulling it tightly.

When the scion begins to protrude through the opening left at the top of the wrap, the upper third of the stock can be removed, thus forcing the bud to grow rapidly. After several weeks, the wrap can be removed and the stock gradually cut back, finally removing the entire part of the stock above the graft union. In nursery practice the side-veneer graft, using terminal scions, is very seldom staked, as it tends to grow upright. Frequent spraying for fungus and insect control is necessary.

SIDE GRAFT. This resembles the side graft technique used in avocados. The wrap used is plastic film of any one of several thicknesses. Preferred is the 0.0035-inch vinyl film torn into strips of most workable width and length.

The seedlings used are in the period of growth when the tissue is succulent and undifferentiated, a condition usually found two to three weeks after germination. A diagonal cut is made in the same manner as described for the avocado side graft.

The scion is a terminal branch with a well swollen terminal bud, but in contrast to the side-veneer scions, terminals of a smaller diameter must be used due to the small size of the stocks. The scion is trimmed in the same manner as is the scion in avocado side grafting.

CHIP BUDDING. The use of this method has been stimulated by the need for large numbers of trees when there is a limited source of plant material for scions of popular new varieties. Chip budding is used exclusively in many of the larger nurseries. Certain procedures have previously been described by Lynch and Nelson (5).

To germinate the seeds, first remove the hulls and place the seeds in a flat of peat moss. The seeds may be transferred to individual containers when viability is determined. When the seedlings (stocks) are four weeks or older, the stems will have green bark and the cambium will be fairly well defined.

The cut or incision on the stock is made inward only as far as the woody cylinder, thus exposing an area of cambium cells along each side of the cut. The chip of wood is removed by slicing downward and notching inward at the base of the cut at approximately 45°. The chip bud is cut to a size and shape to fit the prepared stock. The wrap is of 0.0035-inch vinyl film.

The best budwood is obtained from terminal flushes still retaining a slight reddish tint but matured to the extent that enough wood has formed to give rigidity to the stem for ease in handling the bud during the budding operation. The percentage of buds that will "spring" usually declines as the distance from the terminal increases, those buds toward the basal portion being depressed by auxins produced by the terminal buds. Most of the lateral buds from a vigorous terminal stem will eventually spring but some require an extended time to develop this tendency. Certain procedures may be employed to hasten springing. It is sometimes desirable to remove the terminal bud and the several adjacent buds near the terminal bud, a week to 10 days before the budding is attempted. This will cause the lateral buds to swell and be in condition for springing.

After union between bud scion and stock is accomplished, the young seedling stock should not be cut back too rapidly, since stunting of the plant will result in the event that springing of the bud is delayed. Any of the following three methods can be used to force the bud to spring after bud union is assured.

1. Cut young seedling back to two leaves. Growth of the bud after springing will be rather slow for several months.

2. Instead of cutting back the top immediately after union of bud and stock is assured, allow the seedling to continue to grow for several months, thus establishing a large root system with considerable amount of stored food.

Enlargement of the bud takes place as well as development of vascular tissues between the bud and stock. When it is determined, through experience, that conditions are right for springing of the bud, the seedling may be topped completely just above the bud or it may be lopped as done with citrus trees. This method may be considered rather clumsy nursery practice, that is, leaving the bud dormant for several weeks or even months; but it accomplishes the springing of a vigorous sprout in contrast to the rather slow growth derived from method N° 1. It will have to be determined which method will work best for the individual attempting it.

3. When it is fairly certain that union between scion and stock has taken place and the bud is advanced enough that it seems highly probable springing will take place in two to three weeks, the stock may be cut off completely just above the bud. However, it is generally considered safer to follow either method N° 1 or N° 2 because delay of springing may stunt the plant or, in some instances, kill it.

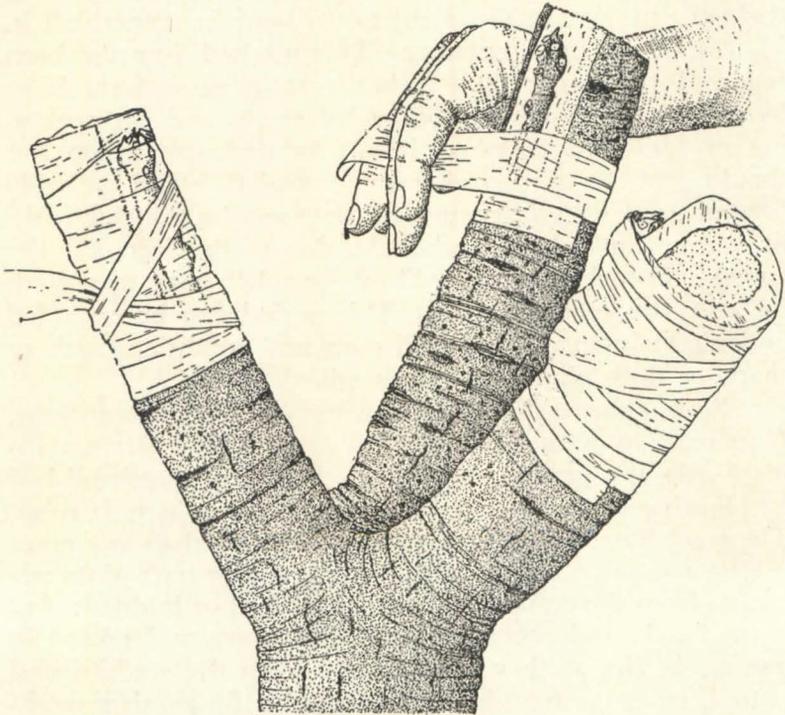
MODIFIED CHIP BUDDING. This method has also been reported previously (5, 6), but certain procedures have been improved in the sprouting of stocks and the springing of buds. The method is not in widespread use but should greater numbers of trees be needed, it will probably become more widely accepted. It does require grafting within a more limited time schedule, due to the fact that the young rootstock is in a "red" or "purple" stage of growth for only two to three weeks. This period can be extended under certain specialized environmental conditions such as shade or deep planting in the seedbed.

Sprout the seeds after removing the hull, in peat moss. If increase in diameter of stock is desired for easier manipulation in the grafting operation, it can be accomplished by planting the seed six to eight inches deep in peat moss. These seedlings, before leaves have developed to any great extent and the plant still receives the major part of its nutrients from the cotyledons, can be grafted or budded: (a) immediately and replaced in the peat moss and potted in one week, (b) as they are removed from the seedbed and potted, or (c) a few days after potting. By another workable procedure, seeds may be placed in peat moss to determine viability (5) and as soon as the radicle begins to protrude, potting of the germinating seed can be done. Graft-

ing or budding can then be done as the seedlings reach the proper stage of development for the operation. This budding operation consists of making a slanting two-inch cut into the succulent seedling which extends diagonally downward and inward, reaching to almost the center of the stem. The bud is cut like the conventional chip bud except that the front of the shield just below the bud is cut so as to expose tissue in addition to that exposed on the opposite side. The wedge-like bud is then inserted into the slanting cut on the stock and wrapped with vinyl film, 0.0035-inch thickness, and of a suitable width and length.

The same procedures for graftwood selection and post budding care are recommended as for the chip bud.

TOP-WORKING. The need for top-working the less desirable varieties of mangos has stressed the importance of reliable procedures whereby a quick top conversion is



Top-working the mango by means of veneer-grafting on large limbs which have been cut back for the purpose.

possible. Cleft grafting, while accomplishing this on many fruit trees, has met with rather poor results for the mango.

The practice of topping or heading back the stock to allow suckers to sprout and then grafting these is a reliable method, although rather time consuming in establishing a new top.

Three methods where top conversion is much quicker than waiting for the suckers to sprout have been reported by Nelson, Goldweber and Fuchs (11) as follows:

METHOD 1: *Step 1.*—Cut off limbs or main stem completely, at point scion will be placed. No other cutting back will be needed except to trim off the suckers that will sprout out for a considerable time until the new graft becomes dominant. *Step 2.*—Paint cut surface immediately with a material that will keep it from drying out. This will also protect it from rot-producing organisms. Warmed paraffin and beeswax in 50-50 proportions by weight works very well. *Step 3.*—Expose cambial area either by a cut as is done in the side-veneer or as is done in bark grafting. *Step 4.*—Cut the well developed terminal scion in the usual manner, as is done in the side-veneer graft, and place it in contact with the cut surface of the stock so that the cambial areas of the scion and stock coincide. *Step 5.*—Use 0.0035 vinyl film in a width and length of strip best suited to size of stock as a wrap. Wrap tightly and in a manner that allows for a small opening at top of wrap for the terminal bud to emerge. *Step 6.*—Leave this wrap in place for six to eight weeks. *Step 7.*—As the young shoot will grow very rapidly, due to the large root system of stock, care must be taken so that wind or weight of the succulent new graft itself does not break it off. When shoot reaches approximately 8 to 10 inches, the terminal bud should be pinched out to force branching. This delay of growth will allow the graft to become more woody and capable of supporting the subsequent growth. The branches resulting from the previous cutting back will, in turn, have to be pinched back to slow down the rapid growth taking place.

METHOD 2: Follow same procedure as above except in *Step 1.* Instead of removing entire top, allow one branch to

remain. This procedure is followed when it is believed the rootstock will be shocked too much by complete top removal. Experience will determine this decision.

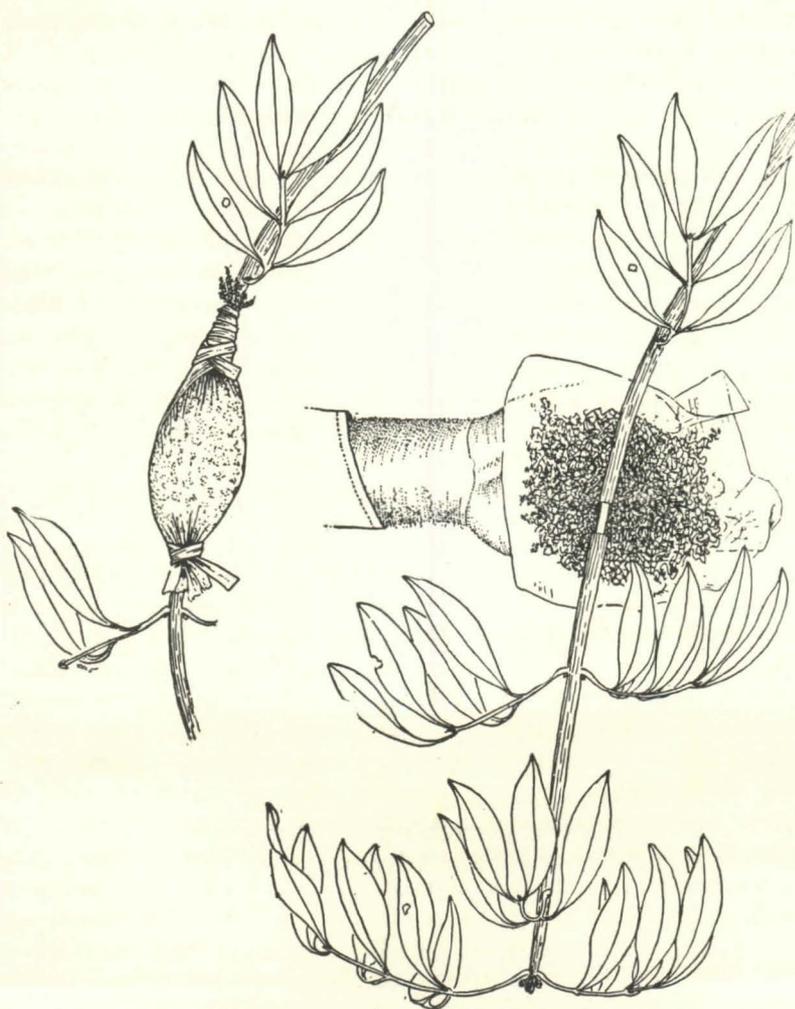
METHOD 3: On smaller rootstock, where branches are from 1 to 2 inches in diameter regular side-veneer procedure is recommended. The top is not removed until the scion is springing. After one year the scion will attain a height of four to eight feet and the stump will begin to callous over.

LYCHEE PROPAGATION

Vegetative propagation of the lychee has undergone very few basic changes in two millenniums. Of course, in the last few years, some strides have been made in improving the basic methods of propagation, air layering and grafting, by mechanical improvements and better knowledge of plant metabolism. The general use of vinyl plastics as a wrap for air layering was described by Colonel Grove in 1947 (1). The use of this film, which is semi-permeable to moisture and yet allows gas exchange, has shortened the time for rooting and reduced the cost for each air layer. Less time and work are involved in putting on the air layers by this procedure.

Investigations in the refinement of methods of making and growing-off air layers were begun at the University of Miami in 1948. There had always been loss of air layers which failed to root on the tree as well as those which were lost in establishing the rooted air layers in soil media. The loss of limbs due to failure of roots to form was easily corrected by putting the parent trees in healthy growing condition. This was usually accomplished by two or three foliage applications of zinc and manganese as well as adequate ground applications of nitrogen, phosphorous, potash, and magnesium. It was found (10) that the use of a lighter grade of vinyl film, 0.001 to 0.0025 inch thickness, compared to the regular 0.0035 gauge, permitted rooting in approximately two weeks less time than by the use of the thicker film, especially during the spring and summer months in Florida. The more rapid and vigorous rooting which takes place with the thinner films probably is due to

the greater gas exchange, which makes more oxygen available for promoting root formation. There is a reduction of one-half to one-third the cost of film per air layer by using the lighter films. It has also been observed that the air layer should be removed from tree when three to five roots are visible through the film. If the roots are allowed to become too profuse and start to darken and lose their original fresh



Air layering the lychee. Dampened moss is placed around the girdled branchlet, then wrapped with Vinyl film to retain moisture

creamy-white color, there may be some slowness in the growing off of the air layered plant.

Considerable improvement has been made in growing lychee air layers by the use of a high humidity environment during the hardening-off process. This was discussed by Nelson (7, 10). The use of a timer to control alternate periods of fogging with periods where fogging was discontinued gave a better environment for potted air layers than where fogging was continuous. It also eliminated the water soaked soil or "water logging" which was one of the drawbacks of continuous fogging or mist. Under these conditions, dehydration of the immature plant is prevented and the stems and leaves which are normally removed may be retained, giving a larger plant and a more rapid increase of the root system. The flush of growth usually resulting when a plant is severely pruned back, is delayed under high humidity conditions until the time that the root system is better able to furnish the moisture requirements of the young leaves. The intermittent fogging system has given the best results, as stated above. Strainers to keep the fogging nozzle from becoming clogged, solenoid valves, and an electric timer capable of being set to short intervals are the integral parts of this system.

The timer used at the University of Miami may be set at any multiple of 12 seconds, on or off, during the sixty 12-second intervals comprising the 12 minutes used for one revolution of the clock. The settings best suited are determined by weather conditions such as temperature, wind and relative humidity where the plants are grown. As an example, in 1954, the settings were two minutes of fogging and four minutes without, during the first two weeks the plants were potted; then changing to two minutes of fogging and 10 minutes without for the third week, and the fourth week the fogging was discontinued. Much work needs to be done to determine the most advantageous fogging intervals, and it is fairly certain that these have to be correlated with local conditions.

Lychees have been grafted or inarched for over half a century (8); however, the methods used were rather crude and apparently a high percentage of "takes" did not result. At the present time, practically all lychee propaga-

tion in Florida is by air layers. As new varieties appear by introduction or are developed from native seedlings, their propagation in large numbers presupposes the use of graftage. As the lychee will be grown on a variety of soils in Florida, it may be necessary to use a specific rootstock produced either by air layers or cuttings. Lychee seedlings observed by the authors have proved to be very irregular in growth habits and vigor and would probably prove unsatisfactory as rootstocks.

We have tried several types of buds in propagating the Brewster variety, including shield budding, chip budding and side-veneer grafting. We have also used a slight modification of a veneer graft cut in a manner similar to that used in guava graftage (9). This type of scion cut has an advantage over the other methods in that the bud may be wrapped so that a slight opening is left at the top to allow emergence before the wrap is removed. The vinyl plastic film of 0.0035 inch thickness, cut in one-half inch strips, is used for wrapping the buds in a shingle-like manner. To force springing of the bud, the stock should be lopped over in the manner used in citrus budding. The lychee, being slower in growth habits, should not be lopped until one month after budding.

The selection of scions of proper maturity appears to be more important than the method used. They should be from vigorous flushes of terminal wood still retaining some green color and with prominent axillary buds. The lychee stem on the stock is very adaptable to shield budding, as the bark slips readily on rapidly growing stocks. Chip buds and side-veneer grafts also work very well. Lychee buds should be ready for field planting in nine to 18 months after propagation.

GUAVA PROPAGATION

The common guava has usually been propagated by seeds. These have a high viability, consequently, great guava thickets have developed in many regions. Seedlings of the common guava do not come true to type and hence there are great numbers of plants in existence producing fruits of poor quality. Two decades ago some better types of guavas came to the attention of horticulturists and need was seen for reliable asexual reproduction of this plant.

Very indifferent success was obtained with cleft grafting, side grafting, side-veneer grafting and budding, and even poorer results with both stem and root cuttings. With the advent of vinyl film wraps for air layers, Ruehle (14), in 1948, set forth the application of air layering to the guava and its success. Trees can be made ready for planting in the field by this method in four to five months. However, a rather generous portion of the parent tree must be used in taking off an adequate air layer. This method allows for the establishment of clones in moderate quantities, but where only a single parent tree is available, several years are required to produce a few thousand propagations.

Shortly after 1950, mist-type plant propagating frames found favor in the rooting of cuttings and the establishing of air layers (4, 7). Mist-type propagation was refined somewhat by the use of hydroponics in irrigating the cutting media (12). Kuperberg (3), using the hydroponic mist-type propagator, found that cuttings made from terminal succulent growth produced the greatest number of rooted cuttings, with a five-node length proving superior to the three-node length. The over-all percentage of cuttings to strike root in the experiment was less than six per cent. The highest amount to root was 18 per cent, where just the water mist was used and not the nutritional mist. Again, as with the air layering of guavas, a vast amount of propagating material must be available to produce several thousand plants of a clone starting with a single tree.

The theme running through literature on guava graftages has been a continual reiteration of failure. Work was started at the University of Miami Experimental Farm in the spring of 1950 in an attempt to devise or establish a method of guava graftage that would fit itself to commercial nursery practices. Nelson published, in 1954 (9), a method of graftage that has proved to give a high percentage of "takes" and the type of union which makes a fast developing desirable tree. The recommendations suggested are as follows:

Stocks: Seedlings of a vigorous variety of guava should be grown in seedbeds or three-inch clay pots and later transferred to N° 10 cans or to felt paper tubes of comparable size. If nursery plants are to be field grown, it is advisable to move them from containers to the field rather

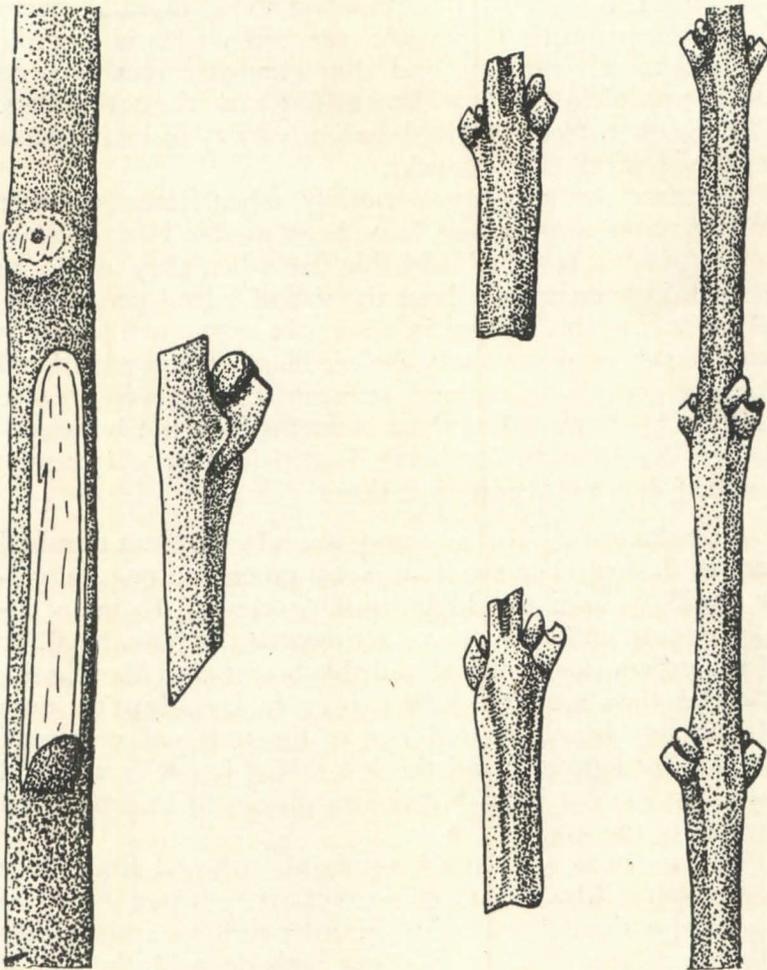
than from a seedbed, thus insuring more rapid recovery from transplanting. If possible, the better plan is to grow the plants in containers and thus eliminate root pruning and the problem of root suckers arising from the cut rootlets. The seedlings from the Red Indian variety of guava have furnished excellent rootstocks.

Guava seedlings grow rapidly when frequent water and fertilizer applications have been made. The seedlings are considered to be of workable size when they are $\frac{1}{4}$ to $\frac{3}{8}$ inch in diameter or about the size of a lead pencil, usually reaching this caliper in about six or seven months. It may be necessary to spray the seedlings with a nutritional mixture containing copper, manganese, and zinc, before graftage is attempted, if these elements have not been adequately furnished by fertilizing. Insecticides for scale insects and leaf tiers are required at times.

Graftwood Selection: Scions are selected from terminal growth flushes when the stem is still green and quadrangular. Axillary buds should be well developed. In many instances both bud eyes (leaves are opposite in guava) will be of the proper development and this bud-stick with opposite eyes may then be split to form two scions. Usually at the time of budding, however, only one of the two bud eyes is of proper development, and the less desirable eye is trimmed off when the cut is made prior to placing it in contact on the cut of the stock.

In order to get a good supply of budwood from older parent trees, it has been found necessary to prune the latter back approximately one third in order to force sprouts that develop a large number of scions with desirable bud eyes. Younger parent plants produce growth flushes that are suitable for scions without this procedure. The forcing of this type of "juvenile" growth furnishes a larger diameter stick of budwood containing more scions than can be found normally on older parent trees.

Cutting the Stock: The cut on the stock for receiving the scion is made as in the chip bud or veneer method of grafting. The length of the cut will vary, depending on the length of the scion. The slice of tissue removed to expose the cambial region is made by cutting a notch at the lowest point where the scion is to be placed, slanting at approxi-



Veneer grafting the guava. Note the well-developed bud in the leaf axis.

mately 45° inward, and then moving the knife upward 1½ to 2 inches, and a downward cut made to the notch, thus removing a slice of bark and exposing the area of cambium. A properly made cut will not extend inward farther than the woody cylinder. However, it should be made certain that no bark remains on the cambial area where the scion is to be placed.

Cutting the Scion: Scions are usually cut into lengths of $1\frac{1}{2}$ to 2 inches as they are removed from the parent plant. They are then stored in damp sphagnum moss until grafting is undertaken. Usually only one of the two opposite bud eyes is in the proper stage of development for use as a scion. The less desirable of the bud eyes is then removed by making a cut parallel with the surface of the scion and enough stem tissue is removed to expose the area of cambium. The scion, $1\frac{1}{2}$ inches in length, will now have one bud eye which will be located on the upper $\frac{1}{2}$ inch of the scion. There will be approximately $\frac{1}{4}$ inch of stem below the eye. In the event that both eyes should be of proper development on a scion, the cut can be made by simply splitting the stem, thus giving two suitable scions.

The graft is wrapped with a vinyl plastic strip $\frac{3}{8}$ to $\frac{1}{2}$ inch wide and of suitable length for the stock size used. It is wrapped in a manner that leaves a small opening at the top through which the bud emerges. After three weeks, the stock can either be lopped over as in citrus budding, or the top half of the stock can be removed. This will force more rapid springing of the bud. Staking and tying is done as with other nursery trees. After four to six weeks, the film is removed. The stub of the stock above the bud can be pruned back when the scion has attained four to six inches of growth. It should be painted with wax or some other suitable tree wound paint. Graftage on stocks from $\frac{1}{4}$ inch up to four inches, using the type of scion described, has been accomplished successfully.

Top-working guavas can be accomplished either by cleft grafting, by the Medora method for avocados (2), or by cutting back the stump, allowing shoots to spring, and grafting the shoots as described above. Tamburo (15) found that cleft grafting was much more successful in the spring than in the fall. His highest percentage of "takes" was from the chip budding method described by Nelson on sprouts, using succulent scions. As to the time consumed, he found that cleft grafting took about three times as long per stump as the chip budding. One of the problems still facing the grower in top-working guava trees is the tremendous number of suckers which persist in springing from adventitious

buds below the top-worked union. Probably this will always be a problem until a method of top-working is devised that brings the graft very close to the ground surface.

The preceding discussion of current methods of plant propagation in Florida is primarily a description of progress in the art of plant propagation. Most of the basic fundamentals of this section of plant culture were laid down centuries ago. As time progressed, refinement of the techniques of budding and grafting to approach nearer to 100 per cent success and to continually lower the costs in time and labor of the vegetative propagation of plants have made large acreages of standard quality fruit tree crops of the modern day a common occurrence.

The methods in use today that produce a healthy plant rapidly and economically satisfy the needs of the average nurseryman. However, there is a growing awareness that more investigation is necessary regarding the processes of growth after the graft union. The formation of this union and the differentiation of adjacent tissues influenced by the type of cut and the stage of maturity of stocks and scions at the time of grafting is perhaps as important as the influence of the variety of rootstock itself.

We must be able to answer such questions as: "Does a budded mango tree grow as efficiently, produce fruit as well and carry on life processes for as many years as a tree in similar circumstances that was side-veneer grafted or one that was inarched?" Certain aspects of disease and mineral deficiency control are probably influenced by methods of vegetative propagation. These problems may, we hope, be answered in part at least, when current investigations are concluded at the University of Miami and at research stations elsewhere.

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