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PROPAGATION OF FRUIT PLANTS

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The Commercial Fruit Grower

who wishes to apply the principles of propagation by budding and grafting in his orchards will find the necessary instructions in this circular. He will also find information on the propagation of fruit plants by hardwood cuttings, layering, suckers, and runners.

The material should also be of interest to the nurseryman and to the home gardener.

The circular is divided into two parts:

I. Temperate-zone fruits, chiefly deciduous (grown in both northern and southern California). This section is mainly a discussion of plant propagation methods to be used with all fruits.

II. Subtropical fruits (grown chiefly in southern California and in the warmer areas of the state). This section discusses special treatment required for certain of the subtropicals.

For a complete list of subjects covered, see Table of Contents on page 57.

I. Temperate-zone Fruit Plants[1]

PLANTS may be propagated in two general ways: by seeds and by vegetative propagation. As a rule, the use of seeds in the propagation of fruit varieties, though simple and economical, is not satisfactory; the seedlings produced are usually different from the parents, especially in size, shape, and quality of the fruit. In addition, the various seedlings are likely to differ from one another. This great variation, though undesirable to the plant propagator, is a valuable aid to the breeder who is trying to produce better plants. Fruit varieties that would come reasonably true from seed could be obtained by selection and breeding over several plant generations; but, since each generation requires a number of years, the time necessary would be prohibitive. The fruit-plant propagator, then, must use a vegetative method; that is, he must root some part of the parent plant, such as stem or root (cuttings, layering, and similar processes), or must place a part of one plant on another in such a way that it will grow (grafting and budding). Since a portion of the parent plant is simply growing in a different location, a plant propagated by a vegetative method will ordinarily be identical with the parent.

Placing a piece of branch—a section a few inches long—in soil or in sand so that it will form roots and new branches is not difficult or expensive. This method—propagation by cuttings—is used for the quince, fig, pomegranate, grape, currant, gooseberry, and certain other fruits. Unfortunately some of the principal tree fruits (for example, pears, apples, cherries, peaches, apricots, almonds, walnuts, and most plums) will not form roots at all by means of cuttings or similar methods, or so few roots will grow that the procedure cannot be followed economically. These plants, therefore, are usually propagated by first growing seedlings and then budding or grafting the desired variety upon them. Seedlings are usually uniform enough for this purpose, but vegetatively propagated plants are sometimes used to secure disease resistance and uniform vigor. The plants upon which fruit varieties are budded or grafted are called rootstocks.

Many additional varieties would be propagated by cuttings or similar methods and, hence, would be on their own roots if this procedure were possible or economical. Sometimes, however, it would not be desirable. For example, certain rootstocks now available are more resistant to insects, diseases, or adverse soil conditions than are the varieties on their own roots.

[1] This section, describing the methods of propagation which are generally applicable to all fruit plants and discussing their use with temperate-zone fruits, was prepared by C. J. Hansen.

SELECTING ROOTSTOCKS

The rootstocks in use are discussed below, and some information is given concerning the source of seed.

Apples.—In the past, rootstocks for apples have been grown to a great extent from "French crab" seed, obtained mostly from France. The "French crab" trees are principally seedlings whose fruit is used for cider. In recent years, however, seed of domestic commercial varieties has been utilized in large quantities; at present such seed accounts for almost the entire United States supply of rootstocks for apples. The nurseries that grow most of the apple rootstocks for California, Oregon, and Washington obtain the seed chiefly from such varieties as Winesap, Rome Beauty, Delicious, Stayman Winesap, and Yellow Newton. Jonathan seed is also used, although some nurserymen think that the seedlings obtained are not completely satisfactory. A number of agricultural experiment stations have tested the ability of the seed of many commercial varieties to germinate and to produce desirable seedlings. Most of the stations are satisfied with the seed of Rome Beauty, Delicious, Ben Davis, Whitney, and Winesap. On the other hand, they do not recommend the seed of Baldwin, Rhode Island Greening, and Gravenstein.

If dwarf apple trees are desired, the grower should use certain types of Paradise rootstock, which can be propagated by layers and root cuttings. The East Malling Research Station in England has sorted out and tested the various strains of Paradise and similar stocks. Each of these bears the name Malling, followed by a number. The one best known in the United States is Malling IX, a dwarfing stock suitable for gardens. Some of the semidwarfing types are being tested in this country for possible commercial value, but work is still experimental.

Almonds.—The principal rootstocks for the almond are almond and peach. Almond seed sometimes is obtained from bitter-almond seedlings, but usually from commercial sweet-almond varieties, such as the Texas. The rootstock chosen depends upon the experience of growers in the district where the trees will be planted; but if root-knot nematodes are present in the soil, a nematode-resistant peach rootstock should be selected. Myrobalan plum (*Prunus cerasifera*), although sometimes employed, usually does not make a commercially satisfactory rootstock for the almond.

Certain seedling selections of Marianna plum have recently been used in an effort to adapt the almond to wet spots in an orchard. This work is still in the early experimental stage, but results obtained so far indicate that certain varieties of almonds will make fair growth on these roots. However, some varieties, including the Nonpareil and Drake, have made unsatisfactory growth. These new rootstocks are propagated by means of hardwood cuttings.

Apricots.—The chief rootstocks for the apricot are apricot and peach. Blenheim or Royal apricot seeds, easily obtained from drying yards and canneries, are commonly used. If root-knot nematodes are likely to be present, the apricot root or one of the resistant peach rootstocks should be chosen. Apricot root, however, is more subject to gopher injury than is peach. Myrobalan, though not used extensively, should probably be favored on heavy soils that tend to be wet. Apricot trees on myrobalan root, however, have not been wholly satisfactory. A small percentage have been broken at the graft union by heavy winds, and dieback has sometimes occurred.

Recent trials indicate that certain seedling selections of Marianna plum may be satisfactory for use as apricot rootstocks in soils that are too heavy or wet for

apricot or peach roots. However, most of the apricot trees growing on these roots are less than 10 years old, so additional testing will be required before it will be known whether they are entirely satisfactory. These new rootstocks are propagated by means of hardwood cuttings.

Cherries.—Mazzard (sweet cherry) and mahaleb are the common rootstocks for sweet cherries. Of these two, the mahaleb gives the trees more resistance to buckskin disease and drought, but is more subject to root-knot nematode and gopher injury.

A sour cherry, the Stockton Morello, has been used somewhat for adapting sweet cherries to heavy, shallow, or wet soils. Although this rootstock is considered commercially satisfactory, Chapman and a few of the less important varieties sometimes do not do well on it. The most noticeable effect of the rootstock is a definite dwarfing of the sweet-cherry top. Suckers, which are usually produced in abundance, are generally considered the most practicable means of propagation. The use of this rootstock is not advisable, however, unless virus-free stock is available. Seeds of Stockton Morello should not be used.

Peaches and Nectarines.—The peach and the nectarine are propagated almost entirely on peach seedlings grown from seed of commercial varieties, principally Lovell, and from seed of special rootstock selections, such as Shalil and S-37. Although apricot seedlings are sometimes employed in sandy soils to resist root-knot nematode injury, the union is not always successful. Seedlings of the Shalil peach are moderately resistant to root-knot nematodes. Being of the same species (*Prunus persica*) as the peach varieties grown commercially in California, it should, presumably, make a good rootstock. According to some evidence, however, certain peach varieties, in soils not infested with root-knot nematodes, may grow more slowly on Shalil than on Lovell seedling roots. In some sections where young trees seem particularly susceptible to crown rot in wet-soil situations, or where a covercrop has kept the soil and the tree trunks moist during prolonged rainy spells in late winter and spring, trees on Shalil appear to be more susceptible to crown rot than do those on Lovell. It would seem advisable, therefore, to use this stock only on sandy soils infested with root-knot nematodes or likely to become so. Recent observations indicate that S-37 roots are more resistant to root-knot nematodes than are those of Shalil. However, the oldest orchard on S-37 roots is only nine years old, so it will still require a number of years to determine if this rootstock will be entirely satisfactory under all conditions.

Pears.—The French pear (*Pyrus communis*) is the usual rootstock for pears. In the past, the seed has come largely from Europe, but recently almost all of it has been obtained from American canneries. Most of the seed is from the Bartlett (a named variety of *Pyrus communis*), since this is the principal canning pear. Old Home (a blight-resistant variety of the same species) may be used for the framework branches with French pear seedlings as the rootstock. Even a severe blight infection would not affect the resistant framework, on which a new top could later be built.

In California, the Japanese pear, *Pyrus pyrifolia* (*P. serotina*), has been an unsatisfactory rootstock because of black-end trouble. Black-end is also produced by *Pyrus ussuriensis*, another Oriental species. Only a slight amount of black-end has been found in orchards on *Pyrus calleryana* root, and the trees showing the trouble are possibly replants, not on true *Pyrus calleryana*. Since, however, this Oriental species does not have a clear record with respect to black-end, it may well be avoided even though it is more blight resistant than either French pear or quince.

If dwarf trees are desired, quince root is used. Since the Bartlett variety does

not make a good union directly with quince, it is necessary to double-work with Hardy (Beurré Hardy)—that is, use a short piece of Hardy stem between the quince root and the Bartlett top. Old Home trees grafted directly on quince root sixteen years ago are still growing satisfactorily. This preliminary evidence suggests that quince root, blight-resistant Old Home framework, and Bartlett top, might perhaps be used without the Hardy intermediate.

Plums and Prunes.—One important rootstock for plums and prunes is the myrobalan plum (*Prunus cerasifera*). The seeds are usually obtained from trees growing in California. Peach is the other important rootstock; nearly all varieties do well on it. Almond, which has been used to some extent, is satisfactory with many varieties, provided the soil conditions are suitable for it. Many varieties do well on apricot root, which is sometimes used in soils infested with root-knot nematodes; but the plums discussed below are now preferred.

Recently there has been considerable interest in selected types of myrobalan and Marianna plums that may be propagated by hardwood cuttings. One such myrobalan plum rootstock, Myrobalan 29, grows vigorously and is not injured by root-knot nematodes. Although it is a little more resistant to oak root fungus than are most seedling myrobalan plums, a considerable proportion of trees have died when planted in infected soils. A vigorous Marianna seedling selection called Marianna 2624 appears to withstand oak root fungus better than do other plum roots thus far tested. Unfortunately, some Marianna 2624 roots have been killed by oak root fungus, so it will still require a number of years to determine whether this rootstock has enough resistance to justify its continued use for this purpose. It is not injured by root-knot nematodes.

Walnuts.—Northern California black walnut seedlings have for many years been used almost exclusively as rootstocks because of their vigor and resistance to oak root fungus. English walnut seedlings have been substituted in a few instances where crown-rot disease occurs, but where oak root fungus is known not to be present.

STRATIFICATION OF ROOTSTOCK SEEDS

When removed from the plant, the seeds of most deciduous fruit trees ordinarily will not germinate, even under ideal conditions of moisture and temperature. This is caused partially by the fact that the seeds are in a rest which must be broken by cold. In addition, the seeds of many plants are covered with a stony layer which must be softened before germination begins. The usual method of breaking the rest and softening the hard coat is to put the seed in a cool place between alternate layers of moist sand or other materials, such as soil or peat moss. This treatment, called stratification, is usually begun in the fall (about the first of November), and the seeds remain in the sand until the latter part of January or February, when they are planted in the nursery. For almonds and apricots a shorter period—3 to 4 weeks—seems sufficient. The size of the container (fig. 1) used for stratification depends upon the quantity of seed to be treated, and may vary from that of a small box to a large pit in the ground. The seeds illustrated are in layers because that is the easiest way to place them in the box. Slightly better results might be obtained by mixing the seeds and sand thoroughly so that each seed would be surrounded by a maximum amount of sand, but most nurserymen do not consider this step necessary. Sometimes the boxes or pits must be covered with wire screen for protection against birds or rodents. Better germination may be expected with some seeds if they are stratified in cold storage at a temperature above freezing, especially when the winters are warm.

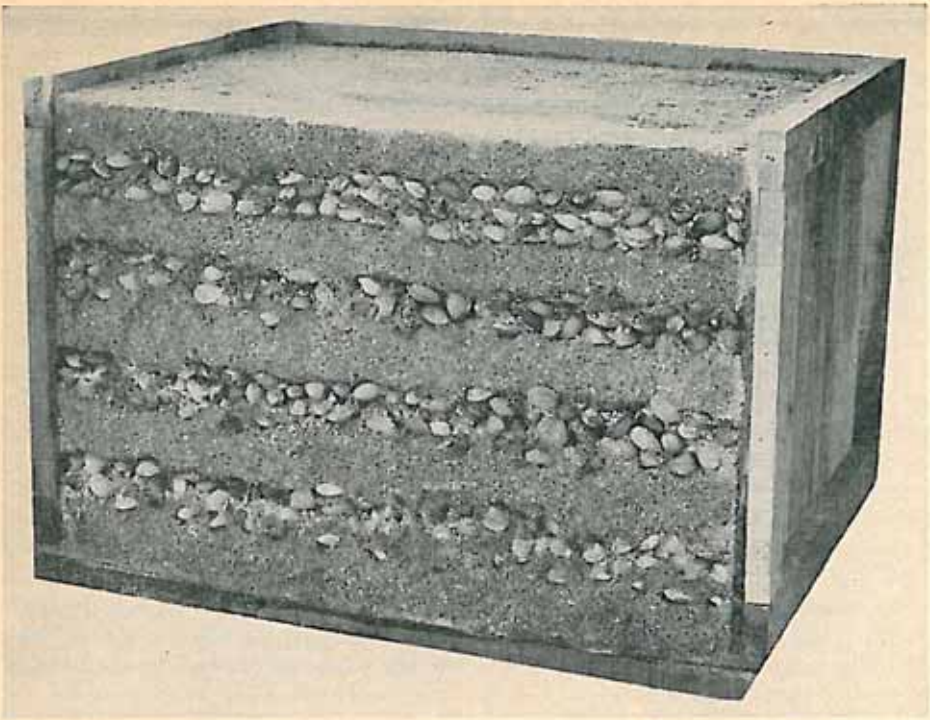


Fig. 1—Side of box has been removed to show how seed of deciduous fruits may be stratified in moist sand.

PLANTING ROOTSTOCK SEEDS

There are two methods of planting fruit-tree seeds: (1) some are planted directly in the nursery row after the stratification period is complete, and the resulting seedlings are budded the same year; (2) others are planted thickly in a seedbed, and the seedlings are moved to the nursery row the following winter or early spring. The second method produces trees with roots one year older than those produced by the first method. For either method, the planting is usually done in the latter part of January or in February. The details of procedure and the rootstocks involved are discussed below.

The rootstock seeds that are planted directly in the nursery row after stratification are apricot, almond, peach, walnut, pecan, and sometimes myrobalan plum. The rows are usually 4 feet apart, and the seeds are planted about 4 inches from each other in the row. If experience has shown that certain kinds of seed tend to germinate poorly, the grower may decide to plant them much closer than 4 inches and to thin later if necessary. The large walnut seeds are usually placed 4 to 6 inches deep; the medium-sized apricot, almond, peach, and pecan about 3 inches; and the smaller myrobalan plum about 1½ inches. To prevent drying out, seeds are usually planted deeper in light than in heavy soils, but this precaution may not be necessary if irrigation water is available at all times. In a few instances seeds have been planted directly in the nursery row in the fall, without stratification. This method is not common, however, because it is difficult to maintain favorable moisture conditions in the field, rodents may destroy many seeds, and the

weeds that grow during the winter may be difficult to remove without disturbing the seeds.

The rootstock seeds that are grown one season in a seedbed and then transplanted to the nursery row are apple, pear, cherry, and sometimes myrobalan plum. The type of seedbed varies considerably, but the commercial producers of seedling trees generally plant in rows far enough apart for the convenient use of horse- or tractor-drawn cultivators. A stand of 10 to 15 seedlings per foot is usually needed to keep the trees from growing too large for satisfactory transplanting. If large numbers of seedlings are not required, the seed may be broadcast or planted in rows in beds of convenient size. The apple and pear seeds are planted about 1 inch deep, and the cherry and myrobalan plum seeds about 1½ inches. The effect of heaviness of the soil and availability of irrigation water on the depth of planting for the larger-sized seeds has already been mentioned. Immediately after being transplanted to the nursery row, the larger seedlings should be cut back to approximately 8 or 10 inches above the ground. It is usually not necessary to prune those with tops less than 8 or 10 inches long.

Vegetative Methods of Propagation

The chief vegetative methods of propagation used for deciduous fruits and discussed in the following pages are budding, grafting, layering, and the use of cuttings, suckers, and runners. Often a plant may be propagated by more than one of these methods. The nurseryman knows, from experience, how to secure the most plants for the least outlay in cost and materials. A fruit grower may, however, sometimes use a method that would not be practical on a large scale.

BUDDING

Budding is the placing of a single detached bud upon a plant called the stock. This method is used by the nurseryman to propagate his plants and sometimes by the grower to change trees over to another variety. Some of the names given to methods of budding are based on the time of year the work is accomplished; spring budding is usually done in March or April, June budding in May or the first half of June, and late-summer or fall budding in July and August or a little later. Other names used are based on the method of cutting and inserting the bud: there are shield budding, patch budding, H budding, chip budding, and some other methods of less importance. In all these processes, success depends upon joining the cambiums of the stock and the bud. The cambium, or growing layer, is found between the wood and the bark.

Late-summer or Fall Budding in the Nursery.—Budding, though usually done in July and August, may be continued into September and October until the bark cannot be lifted. The budwood is collected from the current season's growth at the time the work is done, but may be stored a short while if kept cool and moist. The buds are placed in trees which have grown from seeds planted in the spring of the same year; or, with apples, pears, cherries, and sometimes myrobalan plums, the buds are placed in trees lined out in the nursery row in the spring. About the time growth starts in the spring after the budding, the top of the seedling rootstock is cut back to about ½ inch above the bud (that is, immediately above the crosscut of the T, or the top of the patch). Usually this cut slopes downward from the side where the bud is located. All water sprouts appearing below the bud should be removed. The trees are dug in the winter after the buds have grown one season.

Trees thus produced will have either two- or three-year-old roots and one-year-old tops. They are called, however, one-year-old, or yearling, trees; the age of the roots is not considered. Two-year-old deciduous fruit trees (that is, trees with two-year-old tops) are not usually offered for sale in California.

Late-summer or fall budding is the most important method used for deciduous fruit trees, although in recent years June budding has been used considerably to propagate some kinds of fruits.

June Budding in the Nursery.—If advance orders and inquiries indicate that the supply of fall-budded trees will not meet the demand and if the seedling trees have grown sufficiently in the 3 or 4 months since planting, June budding may be done in May or in the first half of June. Lately some nurseries have made it a regular practice to propagate a considerable number of trees by this method.

The usual procedure is to cut the seedling top off 2 to 5 inches above the bud 3 or 4 days after budding. At least one leaf should be left above the bud, and several below. It may be necessary to bud as much as 8 inches above the ground in order to have a sufficient number of leaves below the bud. These rootstock leaves help to manufacture food for the tree until the leaves produced by the bud are large enough to take over this function. A cut should be made back to the bud 10 to 16 days after budding. Thereafter, any shoots other than those from the bud should be shortened; and when the bud has grown into shoots 6 to 8 inches high and has enough leaves of its own, all other leaves and shoots should be removed. The budwood is collected from the current season's growth at the time of budding. As a rule, all the wood is removed from the bud shield except a small core in the bud. The easiest way to do this is to make the long cut as in Figure 2, *A*, and then, at the upper end, to make a cut through the bark only, rather than through both bark and wood. The shield may then be removed with a sliding motion, and the wood remains attached to the bud stick. If the shield is pulled rather than slid from the bud stick, the small core of wood may become separated from the bud itself, and the result often is failure. Given ideal growing conditions, a medium-sized tree suitable for the orchard will be obtained by the time growth stops in the fall; and thus a year will be gained. Though the method described is relatively simple, heavy losses are likely to occur unless the work is carefully done.

Seedlings must grow rapidly in order to be large enough for budding in May or in the first half of June. Because the peach best meets this requirement, most June-budded trees offered for sale are on this rootstock. Nurserymen list various varieties of June-budded peaches, nectarines, almonds, apricots, and plums.

Spring Budding in the Nursery.—The work is done early in the spring, as soon as the bark of the stock will slip easily from the wood and allow the buds to be inserted. The work should be completed before the trees have made much new growth. This will usually be in March or April, the time depending on the kind of trees. As a rule, the bud sticks are collected in late winter while dormant and are stored in moist sphagnum moss, peat moss, or sand in a cool place. They can be used for T, or shield, budding without further treatment.

For patch budding, however, the bud sticks must be transferred to a warm location and kept there until the bark will slip from the wood. By this time a few buds will have started to grow. These cannot be used, but others will be in good condition. Bud sticks for patch budding may also be cut directly from the tree at the time of budding, and this practice is thought by many to be the best. When this method is used, bud sticks on which part of the buds have started to grow are cut from the trees. Some buds will be in the right condition; that is, they will still be almost completely dormant, and yet the bark of

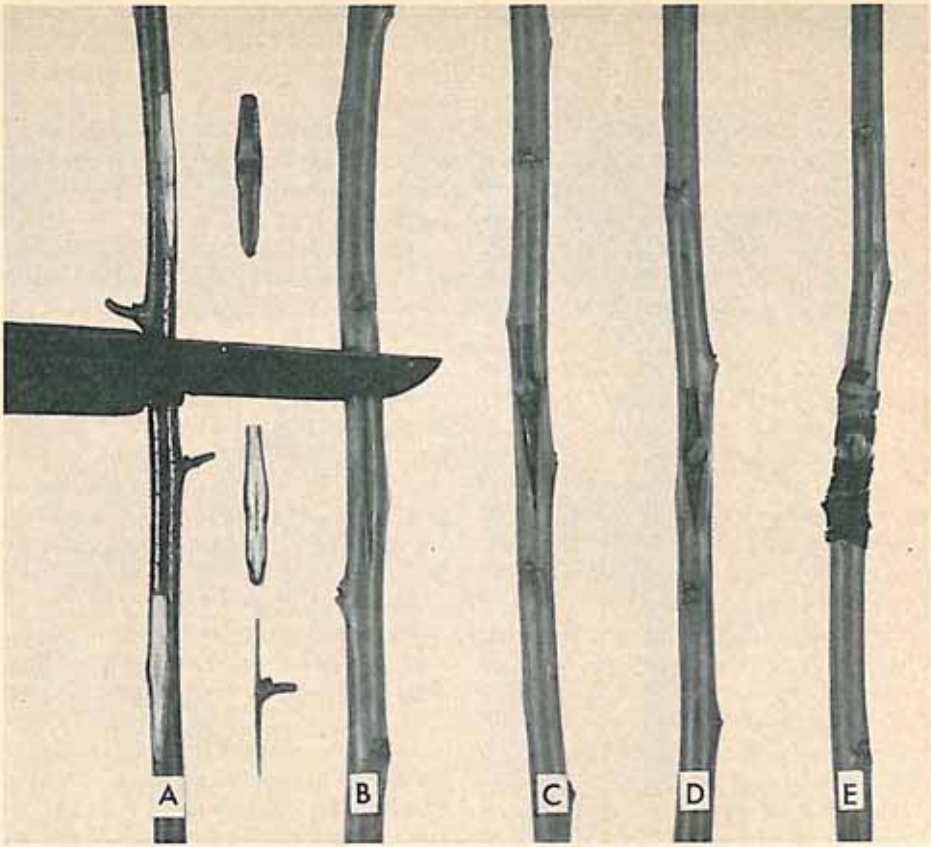


Fig. 2—T, or shield budding: **A**, bud stick with some buds removed (cuts should be started below buds); **B**, making crosscut at top of vertical slit; **C**, bud partly inserted; **D**, bud in place; **E**, bud tied with rubber band.

the patches can be separated from the wood of the bud sticks—a requirement of patch budding.

About 2 weeks after budding, the tops of the stocks are cut off to force the buds into growth. The next winter, after the buds have grown one season, the trees are dug and sold. They are then essentially the same as the one-year-old trees produced by late-summer or fall budding.

This method is usually less satisfactory than late-summer or fall budding and should be used only for trees that were not successfully budded during the fall, or in some other special cases.

Selection of Budwood.—Buds for late-summer or fall budding and June budding should be taken from the current season's growth of the specified tree at the time of budding; but for work in the spring, dormant branches are usually selected and stored until needed. Although it is probably best to choose bud sticks that have leaf buds (wood buds) only, many propagators use clusters containing both leaf and flower (fruit) buds. One must not use flower buds exclusively, since these would blossom and die. In plums, apricots, peaches, and walnuts, a leaf bud usually occurs at each node or joint, either alone or associated with one or more flower buds. A single flower bud is found on the bud sticks of these species occasionally, but not often enough to

cause the propagator much concern. Leaf buds usually differ from flower buds in being smaller and sharper-pointed. Pear, apple, and almond bud sticks often have, near the apical end, a number of single flower buds (which, in the pear and apple, are really mixed buds, but usually respond like ordinary flower buds). Since, however, the apical end is customarily discarded because of its small size, the danger of using these undesirable buds is minimized.

The sweet cherry is most likely to cause trouble because its flower buds are located on the basal part of the shoots (fig. 3), a part which the propagator is likely to use if he does not know the position of the buds. The matter is further complicated by the fact that cherry flower buds are essentially the same, in size and shape, as the leaf buds.

In all the fruit-tree species discussed above, more leaf buds will generally be found on the most vigorous shoots. The danger of using flower buds can be greatly reduced by avoiding the shorter, less vigorous type of growth.

Position of the Buds in Nursery Practice.—Budding is usually done as near the ground as one can conveniently work; but the northern California black walnut stock, which is resistant to oak root fungus, is often allowed to extend a foot or more above the surface of the ground.

Buds are usually placed on the north side of the seedlings for protection against the sun. In the hot interior valleys of California, however, where summer north winds are common, some propagators prefer to bud on the south side of the tree, to prevent drying out of the bud, even though this practice may increase the possibility that the growing bud may be broken off by the wind. There is another point in favor of the south side: the side where the bud is growing is less subject to sunburn. Therefore, if the bud is on the south, the opposite, easily sunburned side, will be at least partly in the shade. Not only is sunburn in itself serious, but the damage caused by it is often followed by the entrance of flat-headed borers.

T, or Shield, Budding.—This is the method most commonly used for deciduous fruits, except the walnut, pecan, and grape.

A bud with some bark and a thin layer of wood is sliced from the bud stick with a sharp knife and placed beneath the bark of the stock as illustrated in Figure 2. The blade shown has the rounded point commonly found in budding knives. The leaves have been removed from the bud stick by severing the leaf stems, or petioles, about ¼ inch from the buds. Beginners often use the leaf stem as a handle to aid in inserting the bud, but experts generally hold the bud between the knife blade and the thumb.

The details so far discussed refer particularly to late-summer or fall budding. They also apply to spring and June budding, except that no petioles are present on the bud sticks used for spring budding, because the sticks are collected in winter, when the leaves are not on the trees. In June budding, the wood is usually removed from the buds by some method such as the one described on page 10.

The T cut in the stock that will receive the bud is generally upright, though sometimes an inverted T has been used. Most budders make the vertical cut of the T first. Then, with a single movement, they make the crosscut and throw open the bark to receive the bud. Some, however, make the vertical slit last. By whatever method the T is cut, the bud is inserted far enough so that its top does not project above the crosscut of the T. The vertical slit should not be longer than necessary to accommodate the bud. If it is too long, the lower part of the shield may not be adequately covered. Although raffia and string have been used to tie the bud, such materials have been practically replaced by rubber bands, which need not be cut to avoid constricting the stem. The rubber

Fig. 3—Sweet-cherry shoots, showing basal position of flower buds. The lower few inches of cherry bud sticks should be discarded. Less vigorous shoots have more flower buds, and more vigorous shoots, fewer flower buds. The danger of using flower buds can be greatly reduced by avoiding the shorter, less vigorous type of growth.

bands stretch as the tree grows, and after a few weeks they rot and fall off. Raffia or string, if used, should be cut in 10 days to 2 weeks. Wrapping should begin at the top of the T and should proceed downward so that the bud will not be forced upward.

With some plants, better results have been reported when the wood has been removed from the buds, but with deciduous fruits this is done only when June budding is practiced and when (in a few instances) T budding is used for walnuts and persimmons.

Patch, or Flute, Budding.—This type of budding is commonly used in propagating thick-barked trees, such as the walnut and pecan. A square or rectangular patch of bark is removed from the seedling and replaced with a similar one including the bud desired. This latter patch is slid rather than pulled from the bud stick so that the small core of wood in the bud itself will be retained. Figure 4 illustrates the steps taken in this method. Since a good fit at the top and bottom of the patch is necessary, most tools used have two parallel knives about 1 inch apart for the horizontal cuts. The vertical cuts are made with an ordinary budding knife. The tool (shown right, bottom) may easily be made from a small piece of wood, two safety-razor blades, two bolts, and two metal strips, one to be placed on the outside of each blade to hold it in place. If considerable work is to be done, a stronger knife consisting of two budding knife blades rigidly attached to each other may be preferable. Some tools (top) have vertical knives in addition. If the bark of the stock is thicker than that of the budwood, the stock bark must be pared down so that the patch can be tied firmly in place. The usual wrapping material is waxed cloth or budding tape. String and rubber bands are not recommended because they are less effective in preventing drying out. Waxed cloth, budding tape, or string should usually be cut

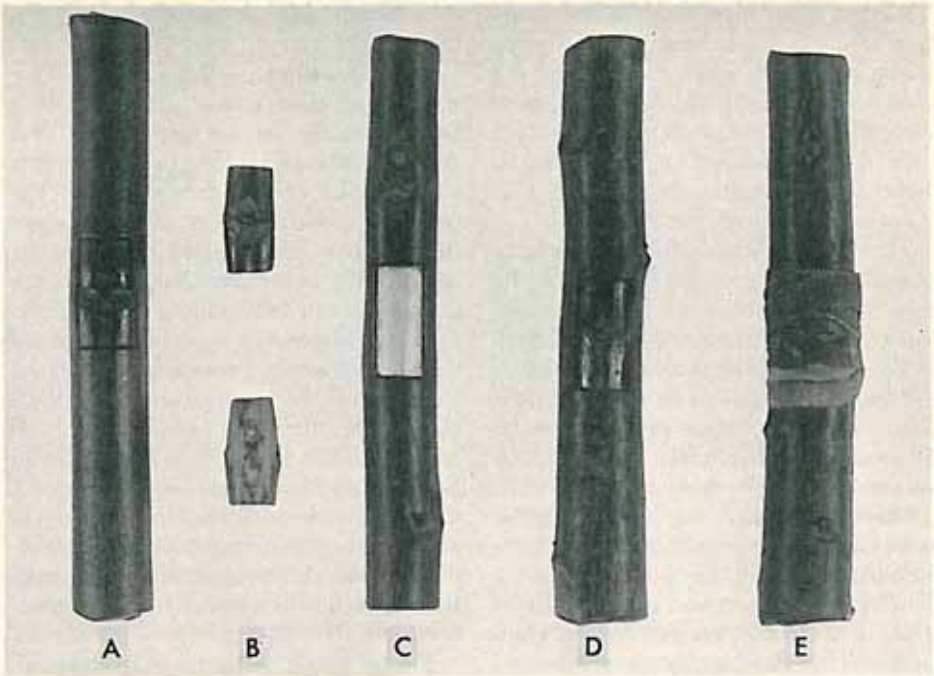


Fig. 4—Opposite page (bottom): budding knife made from small piece of wood, two safety razor blades set parallel, about 1 inch apart, two bolts, and two metal strips, one placed on the outside of each blade to hold it in place. Some tools also have vertical knives, as shown at top of opposite page. Above: patch, or flute, budding. **A**, bud stick with the patch cut but not removed; **B**, patches with buds, removed from the bud stick; **C**, patch of bark removed to receive the bud; **D**, bud in place; **E**, bud wrapped.

in 2 or 3 weeks. If, however, the stock is making such vigorous growth that the wrapping material will cause constriction before the patch is well healed in, the material may be loosened in about 10 days and not cut until after 2 or 3 weeks.

Since the leaf bases of trees commonly T-budded are not large, they do not interfere with wrapping the bud. Walnut and pecan leaf bases, on the other hand, are rather large and make wrapping difficult. Most propagators cut the leaves off the budwood, except for short stubs, 2 or 3 weeks before budding. However, leaves on the terminal ends of bud sticks should be left uncut. By the time the bud sticks are removed from the tree, the short stub of the leaf stem, or petiole, has dropped off or may be easily removed.

With walnuts, the usual procedure of cutting back to about ½ inch above the bud (that is, immediately above the top of the patch) about the time growth starts in the spring may result in a drying out and killing of the bud, because of the pithy nature of the stems and the rather large size of the branches or seedlings sometimes budded. Losses from this cause are practically eliminated, however, if the cut surface is waxed over.

Many nurserymen whip-graft the seedlings whose buds fail to unite. This work is done in the winter after the budding.

Ring, or annular, budding is the same as patch budding except that a complete ring of bark is removed around the stem. This method is slower and has no particular advantage.

Hinge, I, or Modified H, Budding. This method is sometimes used in place of the patch bud when the bark of the stock is considerably thicker than that of the budwood. If the patch bud is used, the bark of the stock must be pared down so that the patch is held firmly in place. This is not necessary with the I bud.

The cut in the stock is made in the form of an I—in other words, like an H on its side. A patch containing a bud (cut as for patch budding) is inserted under the flaps of the I. Wrapping is done as in patch budding. Although this method is reasonably satisfactory, unless care is taken the patch may buckle slightly and not touch the stock under the bud.

Chip Budding.[2]—In budding small grapevines, more consistent results have been obtained with chip budding (fig. 5) than with other common methods. Rootstock rootings that are resistant to phylloxera or root-knot nematode are planted in the vineyard in the spring and are budded the following August in nonirrigated vineyards, September in irrigated ones. For good results, the buds must be taken from mature canes whose bark color has changed to brown. In addition, the stock must be growing actively at the time of budding.

Figure 5 shows how a chip is removed from the stock and replaced with a chip of similar size and shape carrying a bud of the desired variety. To facilitate the removal of the bud from the bud stick, the first cut is made at the base of the chip deep into the stick, at an angle of about 45 degrees. The buds are placed just above the ground level and tied with budding-rubber strips. They are covered immediately with about 6 inches of pulverized soil. The rubber must be cut and removed the following spring, when the tops of the rootstocks are beginning growth. At this time the top of the vine is cut off about ½ inch above the bud union. Chip budding is seldom used for deciduous fruits other than grapes.

Top Budding. — Budding is done mostly by nurserymen to propagate their plants, but also by the fruit grower who wishes to change his trees over to another variety. The only differences from the procedure followed in nursery work are that the buds are inserted higher in the tree, usually in the branches, and that the late-summer or fall budding is often done earlier. This earlier budding in the orchard is generally necessary because the trees cannot be kept growing so vigorously in the field as in the nursery, and so later in the season it is impossible to lift the bark. Late June, as soon as well-matured budwood is available, or July, is an excellent time to top-bud. Spring budding in March or April, although sometimes practiced, is usually less satisfactory.

Fairly large limbs may be budded, though with difficulty. If old trees are to be budded, they are usually cut back the winter before, in order to force out new branches in which to place the buds. It is usually best to top-bud only young trees and to use some method of grafting for the larger branches found in older trees.

GRADES OF NURSERY TREES

The Agricultural Code of California specifies that deciduous fruit and nut trees shall be graded by size. The type of measurement depends on the kind of tree involved. Sometimes the height is used, and sometimes the diameter of the trunk 2 inches above the center of the bud union.

All nut trees except almonds must be graded by height. The grades in terms of feet are as follows: 1 to 2; 2 to 3; 3 to 4; 4 to 6; 6 to 8; and 8 to 10. No tree shall be less than 1 foot high.

Deciduous fruit and almond trees must be graded by diameter of the trunk. It is also permissible to state the approximate height, and this is usually given. The grades are listed below.

[2] For additional information on chip budding and other methods used in propagating grapevines see: Jacob, H. E. Vineyard planting stock. California Agr. Exp. Sta. Cir. 360:1–12. 1944.

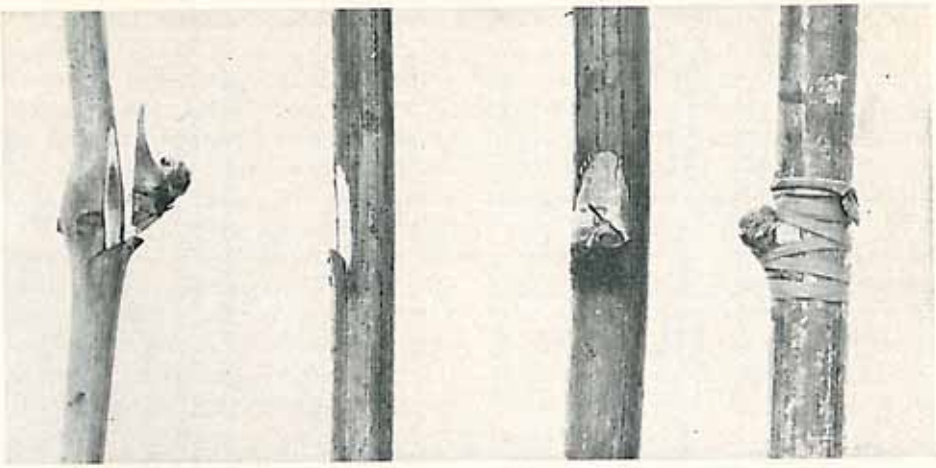


Fig. 5—Steps in chip budding grapes. Left to right: the bud removed from the bud stick; notch made in the stock to receive the bud; the bud in place; and the bud tied and ready to be covered with soil. Chip budding is seldom used for deciduous fruits other than grapes. (From Ext. Cir. 116.)

DIAMETER (inches)	HEIGHT (feet)
¼ to ⅜	2 to 3
⅜ to ½	3 to 4
½ to 11/16	4 to 6
11/16 and up	6 to 8

It is required that these trees shall not be less than ¼ inch in diameter or less than 8 inches in height except that June-budded trees may be as small as 3/16 inch in diameter. June-budded trees under ⅜ inch in diameter may be graded into the additional three following sizes: 3/16 to ¼; ¼ to 5/16; and 5/16 to ⅜.

Grades for other kinds of trees and vines have also been set up by law. The Agricultural Code of California should be consulted for these and for further details concerning the grades discussed above.

GRAFTING

Grafting differs from budding (which is itself a type of grafting) only in that the scion (a short section of a shoot) instead of a single bud, is placed upon the stock. The different kinds of grafting are classified according to the part of the plant upon which the scion is placed and the actual method of putting the scion on the stock. Based on the position of the graft, there are the following five classes: root grafting; crown grafting; top grafting; bridge grafting; and inarching.

As a rule, closely related plants may be grafted one upon the other. Since, however, there are many exceptions, Table 1 has been included to show the combinations possible among the common deciduous fruit-tree species.

Selection of Scion Wood

The selection of suitable scion wood is important. Shoots that are soft, with a large pith (the central, soft portion of the stem, surrounded by the wood), should be discarded in favor of a more solid type of growth. Often the apical third, or even more, of each shoot must be discarded in order to eliminate undesirable scion wood. The precautions just discussed apply particularly to the English, or Persian, walnut. The danger of using flower buds (see budwood selection, p. 11) is much less in grafting than in budding. Since two or three buds should be present on a scion used in grafting, the likelihood of having at least one leaf bud is greater than in budding, where only

TABLE 1—Grafting Affinities of Some Common Deciduous Fruit Tree Species

Scion	Stock											
	Almond	Apple	Apricot	Mahaleb cherry	Mazzard cherry	Stockton Morello cherry	Peach	Pear	Myrobalan plum	Quince	English walnut	Northern California black walnut
Almond	SC	—	US	—	—	—	SC	—	PS	—	—	—
Apple	—	SC	—	—	—	—	—	US	—	US	—	—
Apricot	US	—	SC	—	—	—	SC	—	SC	—	—	—
Cherry	—	—	—	SC	SC	S*	—	—	—	—	—	—
Peach and nectarine	PS	—	PS	—	—	—	SC	—	US	—	—	—
Pear	—	US	—	—	—	—	—	SC	—	SC†	—	—
Plum (Japanese and European)‡	S*	—	S*	—	—	—	SC*	—	SC	—	—	—
Quince	—	US	—	—	—	—	—	US	—	SC	—	—
English walnut	—	—	—	—	—	—	—	—	—	—	SC	SC

— indicates grafts that will not grow, or where growth is very weak and short-lived.
S indicates satisfactory grafting affinity; SC indicates satisfactory and most commonly used in California.
US indicates grafts that will grow for a while, but are unsatisfactory.
PS indicates grafts that are partially satisfactory.

* A few varieties in these combinations do not make satisfactory unions.

† Some pear varieties, such as the Bartlett, do not make good unions with quince, although others, such as the Hardy, do. They are therefore double-worked with Hardy or with some other compatible variety.

‡ In general, many European and Japanese plums may be grafted on European plums. Although many Japanese varieties do well on other Japanese varieties, most European varieties are not successful on Japanese. Peaches, almonds, and apricots may sometimes be grafted on Japanese and European plums with fair success, but as a rule they either fail to grow or grow unsatisfactorily. If plums are to be grafted, consult one of the following references:

Heppner, M. J., and R. D. McCallum. Grafting affinities with special reference to plums. California Agr. Exp. Sta. Bul. 438:1–20. 1927.
Allen, F. W. Plum growing in California. California Agr. Ext. Cir. 34:1–68. 1929.

Although these publications are out of print, copies are usually available for reference in public libraries.

one bud (or cluster of buds) is present. Besides, flower buds can be distinguished from leaf buds more easily at grafting time than at budding. Some care should be exercised, however, to avoid having too many flower buds on scion wood, especially in the cherry.

Most scion wood consists of shoots that have grown for one season. Usually, such one-year-old branches are of a size suitable for grafting and have enough strong leaf buds. Older wood is sometimes employed if satisfactory buds are present; in the fig, two-year-old scion wood is preferable.

Root Grafting

This method consists in grafting a scion 3 to 6 inches long on a whole root or a portion of a root. California nurserymen bud instead of root graft, but the method is used by some nurserymen in the Midwest mainly for the propagation of apples. Either piece-root or whole-root grafts may be used for apples, but whole-root grafts are best for pears. The roots are dug in the fall, and the grafting is done inside during the winter. Since the work is carried on at a table or bench, the term "bench grafting" is sometimes used. The whip, or tongue, graft is commonly used for root grafting.

Whip, or Tongue, Grafting.—At the base of the scion and the top of the stock, sloping cuts 1½ to 2½ inches long are made (fig. 6). The cuts should be adjusted to the size of the branches or roots being grafted; they should be longest on the pieces with the largest diameters. Then on each of these cut surfaces, starting about one third way from the tip, a reverse cut ½ to ⅞ inch deep is made. This second cut should not be with the grain of the wood, but should tend to parallel the first cut. The two pieces are then fitted together and wrapped. Number 18 knitting cotton or some similar light twine, dipped in melted grafting wax, is generally used as a wrapping material. Figure 6 (right) shows a whip graft correctly wrapped for top-working. If root grafts are wrapped in this manner, enlargements often appear at the union and may cause the tree to be thrown out by inspectors. Enlargements of this sort are practically eliminated by wrapping the string in a continuous smooth layer. In recent years nurseryman's tape has proved better than string for piece-root grafts of apple. The edges of this adhesive tape are overlapped slightly so that the graft union is completely covered. At this point, apple-root grafts are ready to plant, but pear-root grafts are usually waxed over except where tape has been used. If

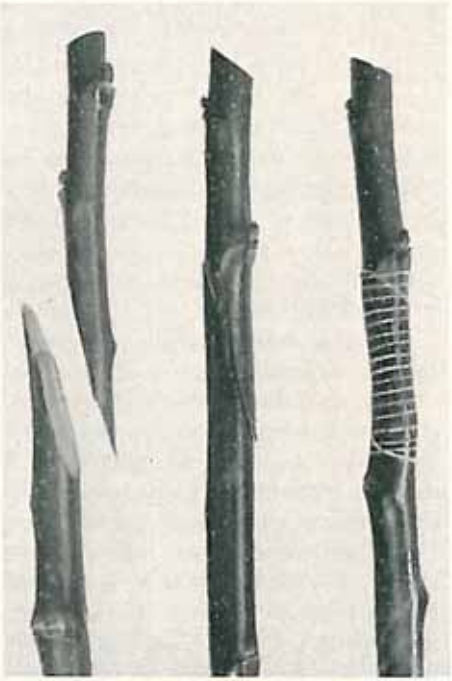


Fig. 6—Whip, or tongue, grafting, left to right: stock and scion prepared; parts fitted together; graft wrapped with waxed light twine. For top-working, where the graft union is above the ground, thorough waxing is necessary. If the stock and scion are not exactly the same size, the cambiums cannot be matched on both sides. They are therefore fitted together in such a way that the cambiums of the stock and the scion come together on one side.

the work is done in winter, when the nursery is too wet to cultivate, the grafts must be stored until early spring in cool, moist sand, moss, or some similar material. Stored grafts will callus, and unless they are carefully handled, the partial union of the stock and scion may be destroyed. The grafts should be planted deep enough so that only the upper bud is aboveground.

When the whip graft is used in topworking young trees, all cut surfaces should be covered with wax, except that with tape the wax is necessary only on the tip of the scion. Tape and the stronger types of string, when used for whip grafting aboveground, must be cut, after the parts have united, to prevent constriction.

Grapes are sometimes whip-grafted onto phylloxera-resistant or root-knot nematode-resistant rootstocks; but cuttings of the rootstock variety, about 10 inches long, are used instead of root pieces.[2]

Crown Grafting

Crown grafting is so called because the graft is made at the crown of the plant—that is, just below the surface of the ground. Sometimes nurserymen in northern California, and usually those in southern, crown-graft English walnuts instead of using a patch bud. The whip graft (fig. 6), the method used, may have to be slightly modified if the stock is considerably larger than the scion. The surface of the sloping cut on a large stock will be longer than that of one made at the same angle on a small scion. To eliminate this difficulty, one may cut the stock off squarely and then make the sloping cut just deep enough to expose a surface equal in length to the cut surface of the scion. After the graft union is tied and waxed, the soil is replaced around the base of the tree, and enough additional fine moist soil is added to cover the entire scion to a depth of 1 or 2 inches. If the trees are to be planted where oak root fungus is present, the graft union should be a foot or more above the soil surface, and the resistant northern California black walnut should be used as a rootstock.

Fig. 7—Glou Morceau pear tree, 55 years old, severely cut back and topworked to Comice. Grafts are in branches that are too large; it will be practically impossible to prevent wood rot in many of the stubs. Compare with Figure 8. Although the long scions made good growth, they are about twice as long as necessary. Shorter scions would be less likely to dry out before union takes place.

[2] For additional information on grape grafting see: Jacob, H. E. Vineyard planting stock. California Agr. Exp. Sta. Cir. 360:1–12. 1944.

Fig. 8—A somewhat smaller tree than the one in Figure 7, but of the same age and variety, in the same orchard. This placing of grafts is more desirable than that shown in Figure 7. The grafts are higher in the tree and are made in smaller branches. The long scions grew well, but they are about twice as long as necessary. Shorter scions would be less likely to dry out before union takes place.

Crown grafting is also practiced in changing from one grape variety to another. In this work either the cleft graft or the notch graft (see top grafting, below) is used. The graft is made 2 to 6 inches below the ground level and is covered with moist soil, but is not waxed.

Late winter or early spring is the usual time to crown-graft.

Top Grafting

Top grafting is the usual method of changing from one variety of fruit to another. This and top budding (already mentioned) are generally considered together as top-working. In top grafting, scions should be placed in branches which are not more than 3 or 4 inches in diameter. It is almost impossible to exclude wood-rotting fungi from such large cuts as those shown in Figure 7. If good-sized trees must be top-worked, usually the grafts are placed high, where the branches are reasonably small. This procedure will be more expensive because it requires more grafts. In addition, it leaves more branches that must be kept free of fruiting wood of the original variety. On the other hand, trees grafted high in reasonably small branches will usually bear sooner than trees grafted close to the ground, and the income from this fruit will more than offset the original expense. The tree in Figure 8 illustrates a much better procedure than that in Figure 7. Sometimes grafting even higher up would be feasible. The long scions shown in Figures 7 and 8 grew very well (figs. 9 and 10), but as a rule, the scions should be somewhat shorter than this because of the danger of their drying out before union takes place.

Sometimes only a part of the branches are grafted at first, and the remaining ones grafted the next year. This procedure is somewhat more expensive but no better than cutting off the entire top at the time of grafting, and is not recommended for deciduous fruits in California. In most evergreen trees, however, nurse limbs should remain until the new tops have become well established.

The proper season to top-graft trees depends on the method used. For example, bark grafting can be done only in the early spring after the bark of the stock has begun to slip. Cleft, saw-kerf, whip, and side grafting, however, may be done over a rather long period beginning in January. Even earlier grafting has been

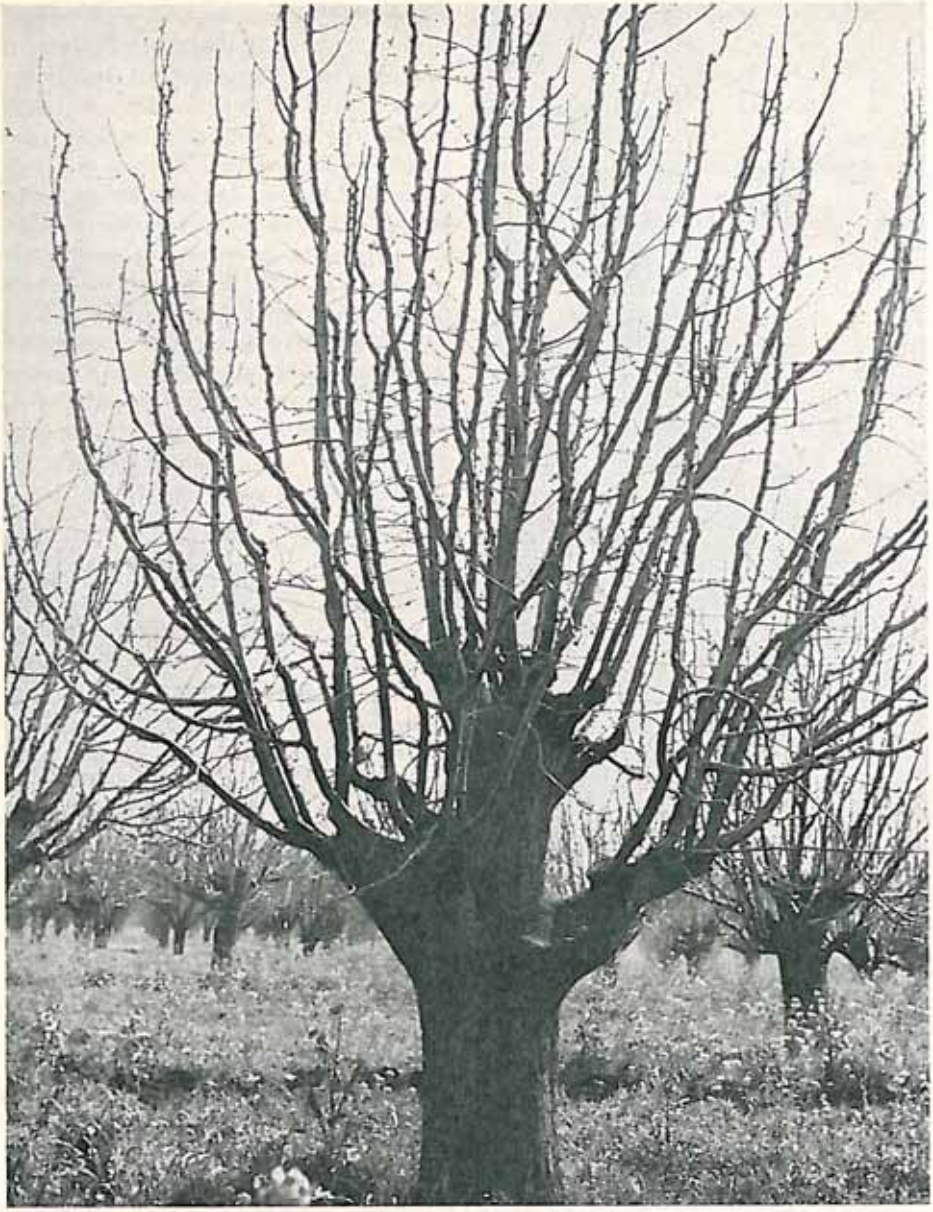


Fig. 9—The tree shown in Figure 7, after six years of growth.

done, but is usually not advisable because of the danger that the scions may dry out.

Cleft Grafting.—This method of top-working trees has been used more, probably, than all others combined. The grafting may be done at any time during the dormant season. If the scions are kept dormant, it may even be continued after the stock has begun to grow. If the work is done very early in the winter, however, there is more opportunity for the scions to dry out, especially if the waxing has

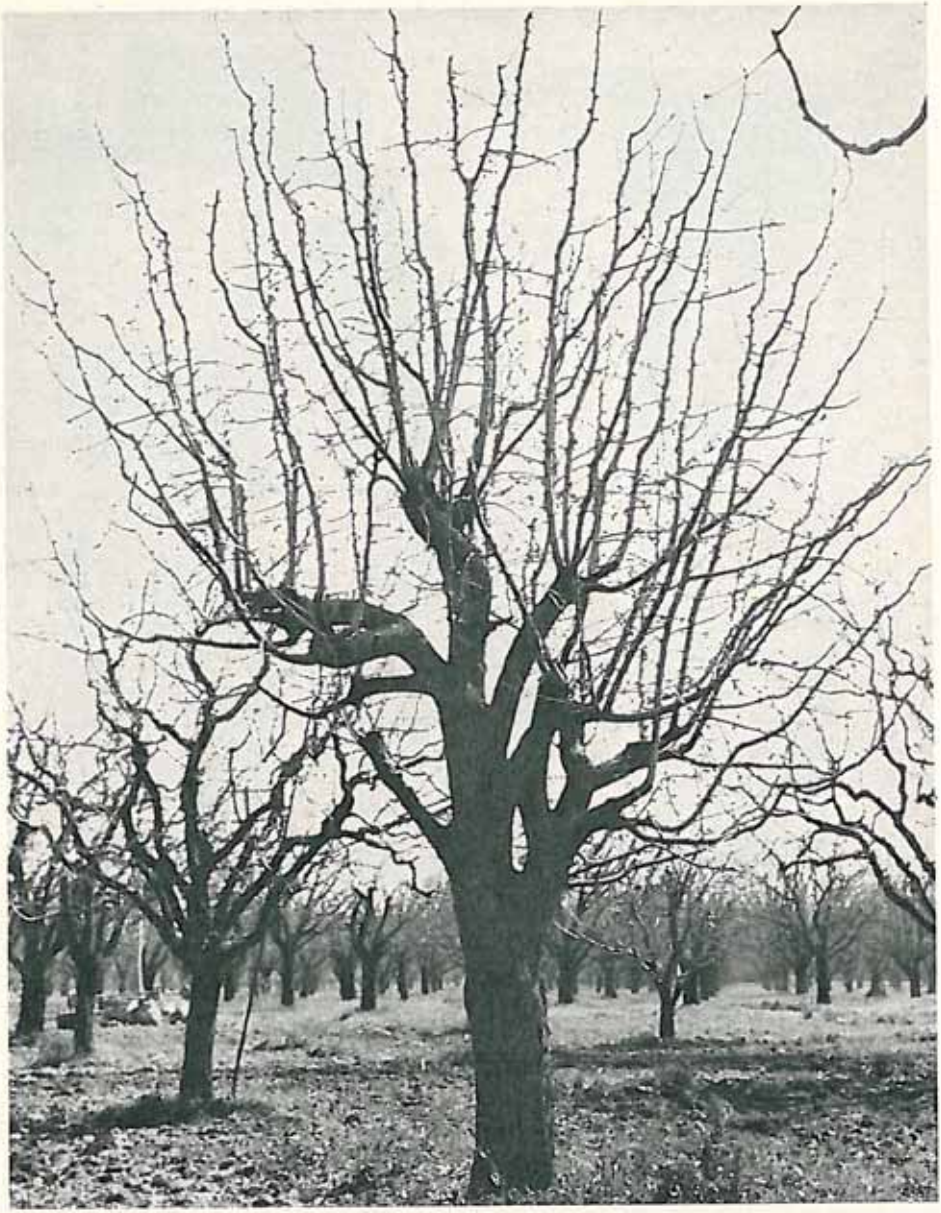


Fig. 10—Tree shown in Figure 8, six years later. Grafting procedure was better than that in Figure 7.

not been thorough. On the other hand, most propagators believe that more scions will grow if the grafts are completed before the trees have made much growth; consequently, most cleft grafting is done in January, February, and March.

In cleft grafting, after the top of the tree has been sawed off, the stock branches are split down the center (fig. 11). The splitting tool may be a special one with a concave blade designed to cut the bark first and so prevent peeling; or it may be

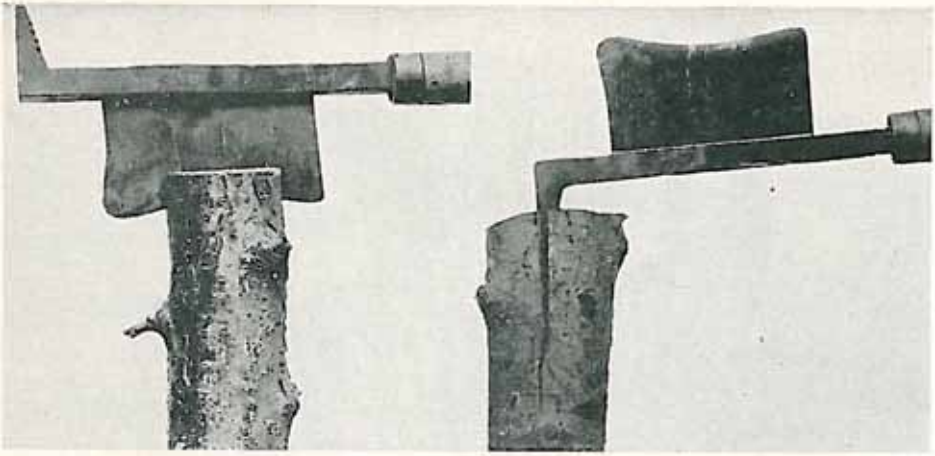


Fig. 11—Cleft grafting: left, stock split with grafting tool; right, cleft is open, ready for scions.

an old kitchen knife. Whatever type of knife is used, it is driven in 1½ to 2 inches. It is then removed, and a narrow wedge driven into the center of the cleft or the split, to hold it open while the scions are inserted. The wedge is often a part of the splitting tool (fig. 11). Some grafters trim the edges of the cleft with a knife, but this procedure is advisable only with difficult species or with unusually rough clefts.

Scions 3 or 4 inches long and containing not over 2 or 3 buds (fig. 12) are usually selected from one-year wood of the variety desired. They are cut wedge-shaped, with the outer edge slightly thicker than the inner. This unequal cutting insures contact between the cambium of the stock and the cambium on the outer part of the scion. Figure 13 (center), showing part of the stock cut away, illustrates the proper position of

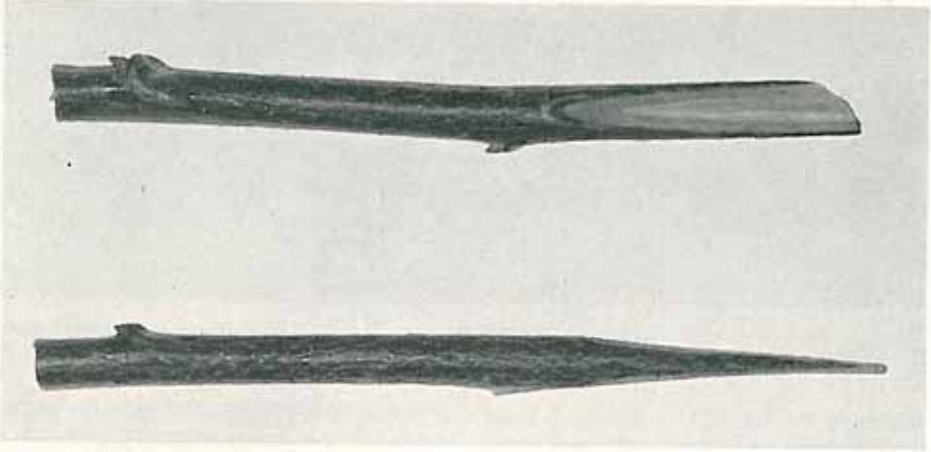


Fig. 12—Cleft grafting: two views of a prepared scion. These are cut wedge-shaped at the lower end (right), with the outer edge slightly thicker than the inner to insure contact of cambiums. The lowest bud should be on the outside edge of the scion, just above the top of the wedge-shaped cut.

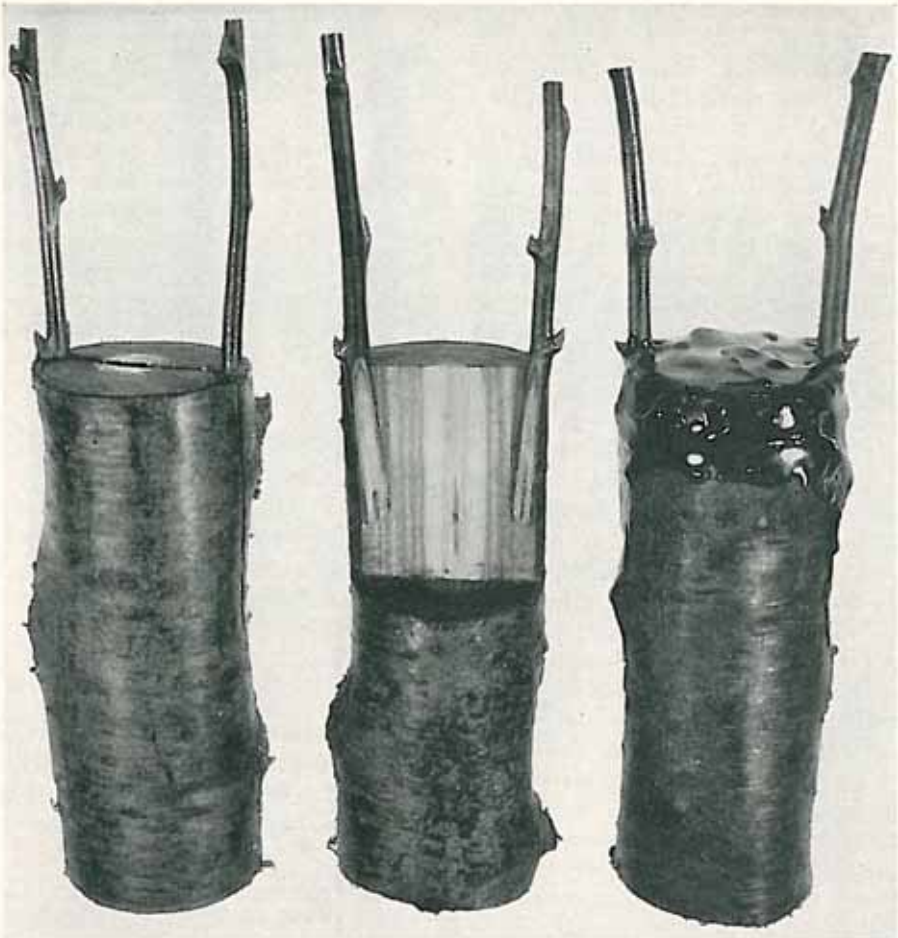


Fig. 13—Cleft grafting: left, scions in place; center, part of stock removed to show how cambium of the stock is brought into contact with cambium of scion. The scions are slanted outward slightly to make sure that the cambiums touch in at least one place; right, completed graft covered with wax.

the scions. As this figure indicates, the cambium on the inner side of the scion does not touch the cambium of the stock. If, therefore, the thick side of the scion were accidentally placed to the inside of the stock, it would hold the cleft open slightly and prevent contact of the cambiums. Scions properly placed in thick-barked branches are not flush with the surface of the stock branch, but are set in a distance almost equal to the thickness of the stock bark.

Figure 13 (left) shows wedge removed and the two scions in place. All cut surfaces, including the tops of the scions, are then waxed over. More than two scions may be placed in one stock branch by making more than one cleft. If more than two scions seem desirable, however, either the bark graft or the saw-kerf graft is to be preferred.

Cleft grafting is easily performed and may be done successfully over a rather long period. It has the disadvantage, how-

ever, that wood-decay organisms may get into the cleft.

Bark Grafting.—Since the stock is not split in this method, decay organisms cannot enter so easily as in cleft grafting. On the other hand, bark grafting is disadvantageous in that it may be done only in the early spring after the bark has begun to slip. By this time the buds are usually opening on the one-year wood that is to be used for scions. Usually, therefore, the scion wood must be gathered while still dormant and stored in a cool place in moist sphagnum moss, peat moss, or sand. It will keep best in cold storage at a temperature of a little above freezing, although a cool cellar or similar location is satisfactory if the storage period is not too long.

Various modifications of bark grafting have been described, but only three of the best will be considered in detail. If the work is carefully done, all three will give satisfactory results, but some are easier than others.

The bark-grafting method illustrated in Figures 14 and 15 will be considered first because it is the type usually described. Although still important, it is gradually being replaced by the other two methods. The scions are usually cut as shown in Figure 14, although slight modifications may be made, especially in the size of the shoulder. When nails are used to hold the scions in place, the only function of the shoulder is to reduce the thickness so that the stock bark will not be pushed out too far when the scions are inserted. When waxed cloth, tape, or string is used to hold the scions, the shoulder perhaps helps to keep them in position. Small scions may be made with little or no shoulder, whereas large ones will require a larger shoulder than illustrated. Care should be taken, however, not to make the scions too thin, or they may be broken off after growth begins. Though a perfectly square shoulder may be made with a fine-toothed saw, the results have been no better than when the

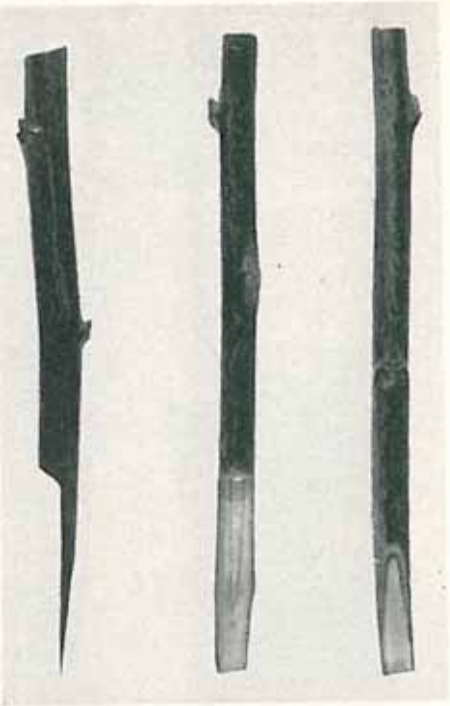


Fig. 14—Bark grafting: three views of a prepared scion. Left, side view; center, side of scion that rests against wood of stock; right, opposite side from center.

scions are cut as in Figure 14. The slit in the bark of the stock (fig. 15) should be just long enough so that the scion can be pushed in place without splitting the bark. The scion is placed in the center of the slit. As a rule, one nail is then driven through it, and one through the bark of the stock on each side of the scion. Usually an additional nail is put through the lower part of the scion. The proper size of the nails depends on the size of the scion wood, but for most deciduous fruits, except walnut, No. 20 flat-headed wire nails $\frac{5}{8}$ or $\frac{3}{4}$ inch long are satisfactory. The large walnut scions usually require No. 19 flat-headed wire nails 1 inch long. As soon as possible after the grafting is completed, all cut surfaces, including the tops of the scions, are waxed over.

The use of nails for bark grafting is

recommended. The scions can, however, be held in place by waxed cloth, tape, or string wrapped around the stock. These materials should be cut if they show signs of constricting the stock branch.

The second method of bark grafting (fig. 16) has been widely used, and nearly always with good results. The scions are more easily nailed in place, and there is less danger of injuring them than when the first method is used. A single slit is made in the bark of the stock, but the bark is raised on only one side of the slit. A scion cut as in Figure 16 is inserted under the raised bark so that one edge will rest against the undisturbed edge of the slit. As in the first method, a shoulder is usually necessary. The scion is held in place by two nails, which pass through it and the raised flap of bark. One or two more nails are driven through the bark into the wood of the stock near the scion, to pull the bark tightly in place. Occasionally the bark that is supposed to be left undisturbed is accidentally loosened. It must then be fastened with a nail or two. The scions are cut, as in Figure 14, except that the cut on the back of the scion (fig. 16, *C*) is not centered, but is made near the edge of the scion opposite the side that rests against the undisturbed bark of the stock. This uneven cutting allows the raised flap of bark to fit more smoothly on top of the scion.

Figure 17 illustrates the third method of bark grafting, which differs in that two slits are made in the stock, the width of the scion apart, instead of one. These slits should be just long enough so that the scion can be pushed into place without splitting the bark. The scions are usually cut, as shown, without a shoulder. The strip of bark between the two slits is raised, and the upper one third to one half is

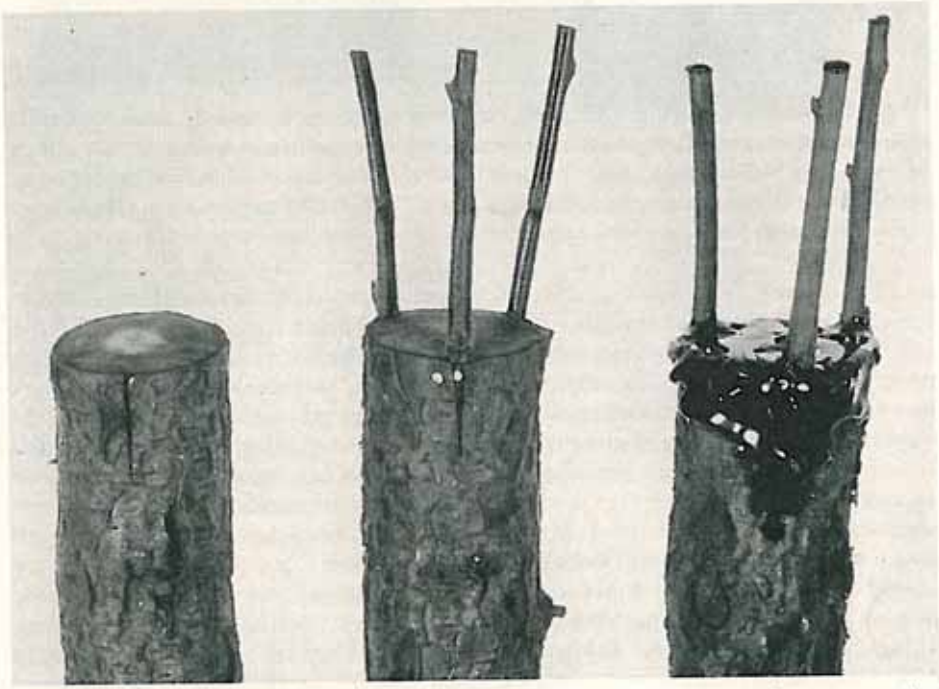


Fig. 15—Bark grafting: left, slit made in bark of the stock; center, the scions nailed in place; right, the completed graft covered with wax. The use of nails is recommended for bark grafting. If nails are not used, waxed cloth, tape, or string should be wrapped around the stock to hold the scions in place.

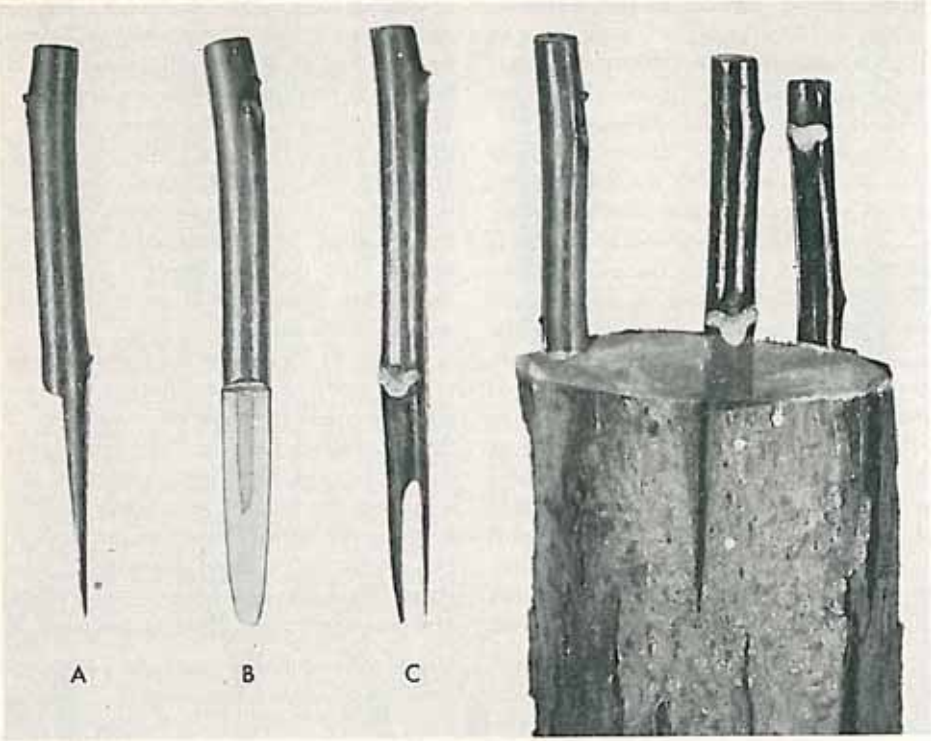


Fig. 16—Modified bark grafting: **A**, side view of scion; **B**, side of scion that rests against wood of stock; **C**, opposite side from **B**. Right, scions in place. This method differs from ordinary bark grafting (figs. 14 and 15) in that the cut on scion **C** is not centered and the bark is raised on only one side of the slit. Wax all exposed cut surfaces thoroughly, including the tops of the scions.

usually removed. The scion is then inserted under the bark far enough so that only a little of the cut surface extends above the top of the stock. Two nails may then be driven into the stock to hold the scion in place, the upper nail directly into the scion, but the lower one first through the strip of bark. The scions for this method can be prepared more rapidly than for the first two methods, since there is no shoulder. However, to make the two slits the proper distance apart requires a little more time than to make a single slit. In the second method of bark grafting, one edge of the scion rests against the undisturbed bark of the stock, whereas in the third method both edges rest against undisturbed bark. According to some, better contact of the cambiums of the stock and scion should be obtained if the bark on the edge of the scion that rests against the undisturbed bark of the stock is trimmed off just enough to expose the cambium. A grafting experiment in which English-walnut scions were placed on black-walnut stock indicated, however, that the extra cut has no effect on the number of scions that grow.

Small scions may sometimes be forced under thick stock bark without a preliminary slit. Usually, however, it is better to use one of the three methods discussed above.

The lower bud on a scion should be on the outside (figs. 16 and 17), only a short distance above the top of the stock.

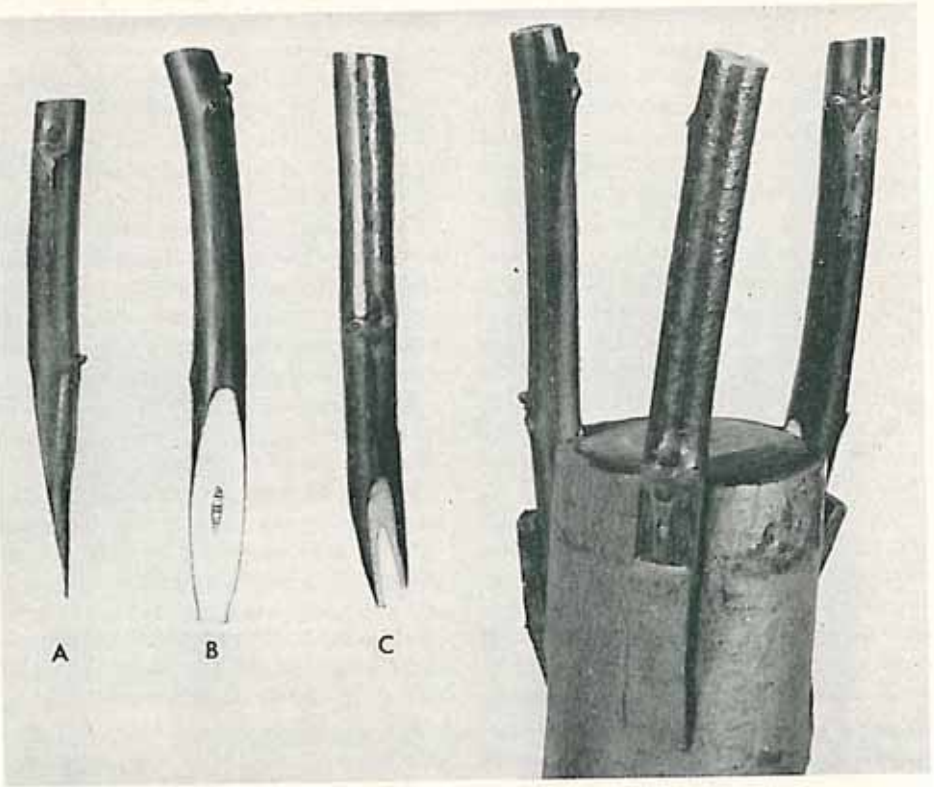


Fig. 17—Modified bark grafting: **A**, side view of scion; **B**, side of scion that rests against wood of stock; **C**, opposite side from **B**; right, scions in place. This method differs from ordinary bark grafting (figs. 14 and 15) in that no shoulder is required on the scions and two slits are made in the stock instead of one. Wax all exposed surfaces thoroughly, including the tops of the scions.

Most bark grafting is done on moderate-sized stock branches. Sometimes, however, the method is adapted to small branches by making the inner surface of the scion concave (with a curved chisel), to fit around a small branch.

Saw-kerf, or Notch, Grafting.—This method has the same advantage as the cleft graft, in that the work can be done over a considerable period. The proper time for grafting is discussed under cleft grafting (p. 22), but most notch grafting is done in January, February, and March. Since the stock is not split, there is less danger from wood-decay organisms than in cleft grafting. In addition, curly-grained stock branches that cannot be split properly for cleft grafting may be notch-grafted. Despite these advantages, notch grafting is less common than cleft and bark grafting because, when properly done, it requires considerable time.

There are two types of notch grafting—deep and shallow. Nails are used to hold the scions in place in the shallow notch but are not necessary for the deep one.

In the first method (fig. 18), a rather deep notch extends approximately to the center of the stock branch. A single cut made with a fine-toothed saw is widened (to fit the scion) with the round knife shown in the photograph. This knife, as used by harness makers, has a blade that

is almost the shape of a half circle; but for grafting it should be cut down to the size illustrated. Most workers find it easier to cut the notch to fit the scion than to cut the scion to fit the notch. As in cleft grafting, the scions are wedge-shaped, with the outer edge slightly thicker than the inner. The cambium on this thicker, outer edge of the scion is brought in contact with cambium of the stock. Since it is difficult to line them up perfectly, it is suggested that the scions be slanted outward slightly to make certain that the cambiums touch in at least one place. The scions must be carefully but firmly driven into position, preferably with a hardwood stick about 1 inch in diameter.

The second method (fig. 19) resembles the first, except that the notch is very shallow. The scions are usually cut as illustrated, with the outer edge considerably thicker than the inner, and are nailed with the flat-headed wire nails used in bark grafting. Again, care should be taken to match the cambiums of the stock and the scion.

Scions properly placed in thick-barked branches will not be flush with the surface of the stock branch, but will be set in a distance almost equal to the thickness of the stock bark.

The round knife suggested for this work gives best results if one side of the blade is ground flat and the other side beveled as usual. If such a tool is not available, an ordinary grafting knife with a moderately large blade may be used.

The lower bud on a scion should be on the outside (fig. 18), only a short distance above the top of the stock.

Whip, or Tongue, Grafting.—This method, discussed under root grafting (p. 19), is satisfactory for grafting over young trees whose branches are the same size as the scions, or slightly larger. As in other methods of top grafting, all cut surfaces, including the scion tips, should be waxed. If tape is used instead of string,

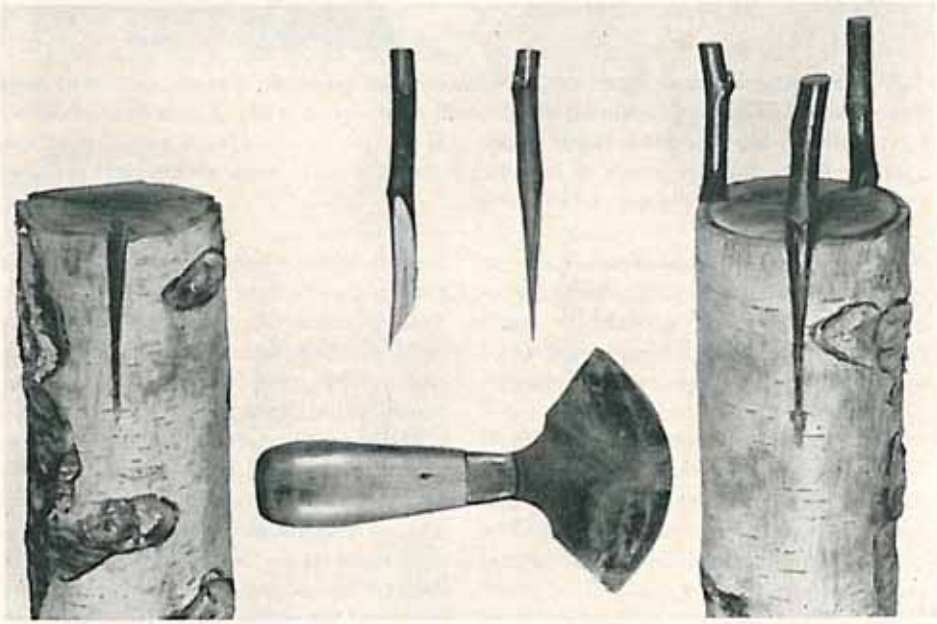


Fig. 18—Saw-kerf, or notch, grafting: left, notches cut; center, two views of a scion; right, scions driven into place. All exposed surfaces, including the tops of the scions, should be thoroughly covered with wax. The round knife is used to enlarge the notches after the single saw cuts have been made.

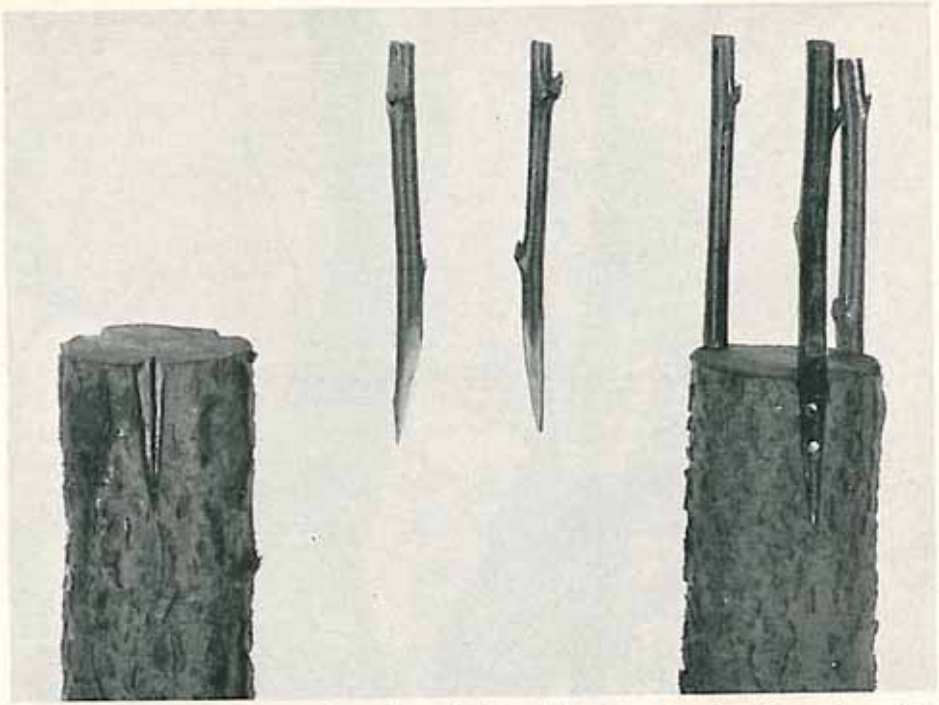


Fig. 19—Saw-kerf, or notch, grafting: left, notch cut; center, two views of a scion; right, scions nailed in place. All exposed surfaces, including the tops of the scions, should be thoroughly covered with wax.

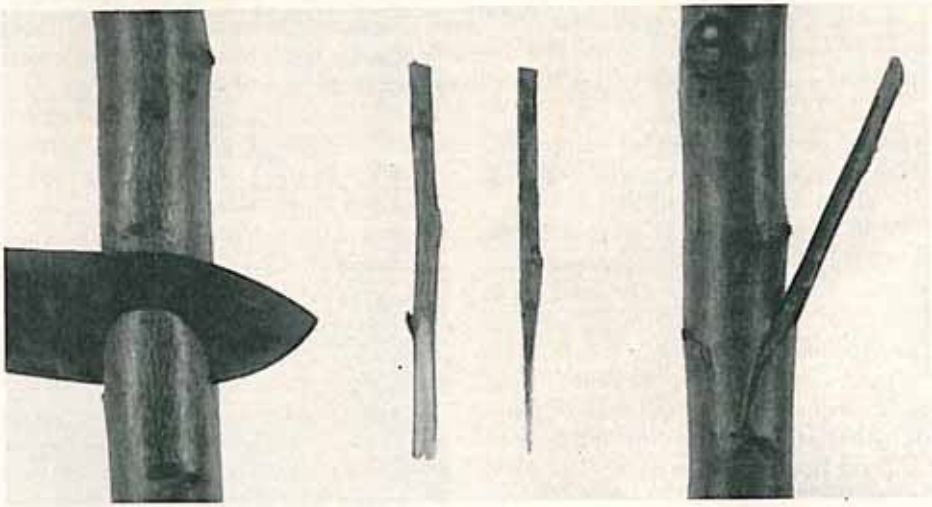


Fig. 20—Side grafting is most useful for branches about 1 inch in diameter. Left, oblique cut in the stock; center, two views of a scion; right, scion in place. Nails may be used to hold the scion if necessary. If the top of the grafted branch is to be removed at once (the usual procedure), a cut should be made just above the point of insertion of the scion. All exposed cut surfaces should be waxed.

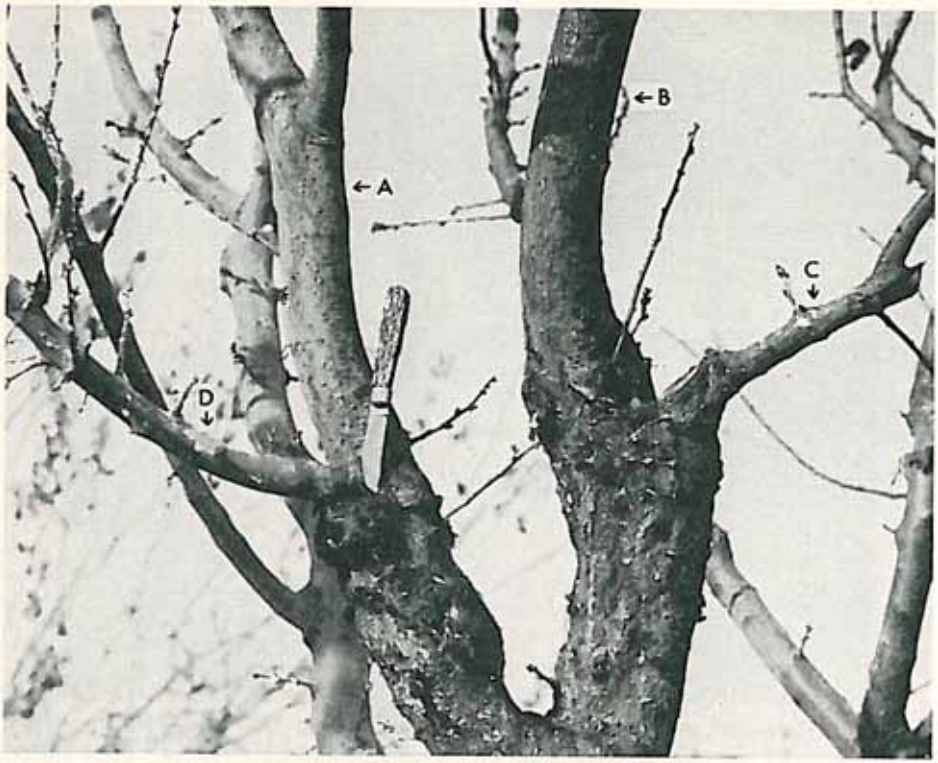


Fig. 21—Apricot grafts after two seasons' growth. **A** and **B** show grafts that are to be saved. These were pruned lightly during the first dormant pruning and have grown very well. **C** and **D** show grafts that were saved temporarily to help heal the stub. These were pruned heavily during the first dormant pruning and have made little growth. All grafts were approximately the same size at the end of the first season's growth.

however, the wax is needed only on the scion tips. The work is usually done in late winter or in early spring.

Side Grafting.—This method is less commonly used than those already discussed. The graft is usually made as in Figure 20, but there are many possible modifications, including some that require special tools. The method is most useful for branches about 1 inch in diameter—that is, too large for satisfactory whip grafting but too small for cleft, bark, or saw-kerf grafting.

The oblique cut in the stock is made with a chisel or a heavy knife. The scion is usually wedge-shaped, as in the cleft graft. For best contact of the cambiums, the scion may be inserted as in Figure 20; but the cambiums will touch in at least one place in any event. The stock branch is bent to open the cut, and the scion is inserted. Although the spring of the wood will usually hold the scion in place, small nails or string can be used. The stock branch is generally cut off just above the point of insertion of the scion, and all cut surfaces are waxed.

Some workers allow side grafts to grow a year before removing the entire tops of the grafted branches, in order to save part of a year's crop while the grafts are growing, but this procedure is rarely successful.

Sometimes a side graft may be placed on the side of a rather large branch if additional branches are desired in that

position. The method of making the graft on large branches varies with the individual worker. Usually, however, a diagonal slit is cut with a chisel or a saw through the bark of the stock and a short way into the wood. The scion is driven into place so that the cambiums touch.

Subsequent Treatment of Top-worked Trees

The care of the tree during the first few years after grafting is as important as the operation itself—a fact not commonly realized until breakage begins to occur because of heart rot and weak crotches.

As soon as the grafting is completed, the tree should be thoroughly whitewashed to help prevent sunburn. Paper bags are sometimes placed over the grafts to protect the scions from the sun, especially if the work is done late in the spring, when warm days are likely to occur. Holes to provide ventilation should be cut in the corners of the bags. From this time until the trees start growing, an occasional inspection and possibly some rewaxing are all that need be done. When growth begins, however, cracks will always appear in the wax and allow decay organisms to enter the wood. Then the grafts must be watched carefully and rewaxed when necessary. If water sprouts appearing below the grafts are allowed to grow without restriction, they will usually choke out the grafts. This trouble may be prevented by removing the water sprouts entirely. A better procedure, however, is to thin them out and cut the remaining ones back severely to keep them reasonably small. They will then help protect the tree from sunburn and also manufacture some food for the roots until the grafts are large enough to take over that function. The water sprouts must not, however, be permitted to become too large.

Fig. 22—Often young grafts need to be supported with laths or strips of wood for a few years.

If more than one scion grows on a branch, probably not more than one should be retained permanently, otherwise a weak crotch is likely to be formed. The branches to be saved should be pruned as lightly as possible, to encourage rapid growth, and those that will later be removed should be pruned heavily, to keep them from becoming too large (fig. 21). The suppressed branches help to heal over the stub and are removed when this purpose is accomplished.

If only one scion grows, the square shoulder on the opposite side of the branch will die and probably decay before healing over. More rapid healing will take place if a sloping cut is made downward and away from the side where the scion is growing. The cut surface should be thoroughly waxed.

Often young grafts, especially of wal-

nuts, need to be supported with laths or strips of wood for a few years (fig. 22). If, however, the grafts have made only a small or a moderate amount of growth, they may not require support or any other special treatment. If grafts of stone fruits, such as apricots and plums, grow extremely fast and the use of supports is considered uneconomical, then the best procedure is to pinch off a few inches at the ends of the grafts after they have grown about 18 inches. Later pinching back may also be desirable. This treatment slows down the growth enough to allow the succulent shoots to mature somewhat and, hence, keeps them from breaking or bending. Some of the shoots may be thinned out, to reduce the wind resistance.

Bridge Grafting

Each year many trees are partly or completely girdled by rodents, pear blight, or mechanical injury. Often the tree can be saved by bridging over the injured area. In the early spring, as soon as the bark of the injured tree will slip, scions are inserted into the live tissue (fig. 23) above and below the wound. Frequently the scions must be gathered while still dormant and stored in moist sphagnum moss, peat moss, or similar material in a cool place in order to be dormant when needed. The use of many scions is desirable, though one every 2 or 3 inches is usually satisfactory. The scions are cut wedge-shaped at both ends, but the cut on one side is only about half as long as that on the opposite side. The wedge-shaped ends are then inserted under the bark so that the longest cut surface is next to the wood of the tree. A slit is made in the bark of the tree to receive the scion, in the manner described for bark grafting (p. 26). The procedure illustrated resembles the first method of bark grafting, in that the bark of the stock is raised on both sides of the slit. The second method, in which the bark is

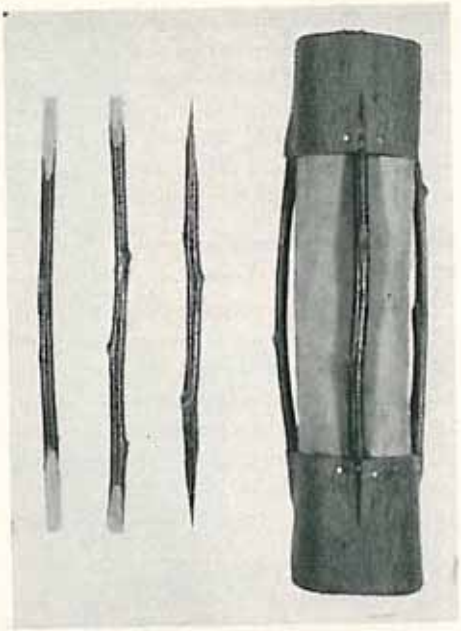


Fig. 23—Bridge grafting: left, three views of a properly prepared scion; right, the scions in place. The part of the graft where the scions are inserted under the bark must be thoroughly waxed over.

Fig. 24—Bridge grafting. This tree, injured by rabbits, was saved by bridge grafting. If suckers or water sprouts appear below the injury, these may be grafted in above, with the same good results.

raised only on one side of the slit, and the third, involving two slits, can also be applied to bridge grafts—in fact, many orchardists prefer the two-slit method. Sometimes the tree has such strong, thick bark that the ends of the scions can be inserted without a preliminary slit. The scions are then nailed in place. If they are made slightly longer than the space to be bridged, they will bow out slightly, and the flat cut surfaces will rest squarely against the wood of the stock. The part of the graft where the scions are inserted under the bark must be waxed over. Preferably, the exposed wood in the girdled area will be covered with wax or some of the materials used on pruning cuts. All buds that start to grow on the scions should be removed.

Figure 24 illustrates how a tree girdled by rabbits was saved by bridge grafting. If suckers or water sprouts appear below the injury, these may be grafted in above, with the same results.

Fig. 25—Two seasons' growth following inarching. A young fruit tree seedling is generally planted beside an older tree and grafted into the trunk.

Inarching

Inarching, or grafting by approach, is a method whereby two plants are made to unite while growing on their own roots. With fruit trees, a young seedling is generally planted beside an older tree and grafted into the trunk (fig. 25). The usual procedure is to remove, from the trunk of the larger tree, a strip of bark as wide as the seedling trunk and 2 to 6 inches long, and then to lay the seedling trunk in this slit. The vertical cuts are best made with the round knife illustrated in Figure 18. About half of the part of the seedling trunk that lies next to the wood of the tree should be cut away to insure contact of the cambiums. Sometimes, in order to make the union more certain, the end of the seedling is cut wedge-shaped as in bark grafting and shoved under the bark at the top of the slit (fig. 17, p. 29). The seedling should then be nailed in place, and the cut surface waxed. Some of the shoots that appear on the inarches should probably be saved for the first growing season, but they must be suppressed by pinching back their tips. After the union is well established, all shoots should be removed. The work described is best done in the early spring as soon as the bark of the injured trees will slip.

Inarching may be successfully used to save trees whose roots have been damaged by pear blight or gophers. If the tree has simply been girdled and the roots are alive below, bridge grafting is the best method.

When it was discovered that the Japanese root produced black-end trouble, many pear orchards on that rootstock were inarched with French pear seedlings. The object was to eliminate the Japanese root when the inarches became large enough. A survey has shown, however, that many of these grafts did not grow, or remained too small. There is also the danger that decay organisms may enter when the Japanese root is finally severed. Inarching, therefore, is not recommended for this purpose.

GRAFTING WAXES

Most grafting waxes are a mixture of resin, beeswax, lampblack, and either linseed oil or tallow. Some combinations of these are soft enough to be applied with the hands, but in California the general practice is to make the wax fairly hard, melt it over a fire, and apply it with a brush. A commonly used wax consists of 4 pounds of resin, 1 pound of beeswax, 1 pint of raw linseed oil or 1 pound of tallow, and 1 ounce of lampblack.

Another satisfactory wax consists of 5 pounds of resin, ¾ pound of beeswax, ½ pint of raw linseed oil, 1 ounce of lampblack, and 1½ ounces of fish glue. Heat the glue in a double boiler with just enough water to dissolve it. Melt all the other ingredients in another container and then allow this mixture to cool somewhat but to remain in a liquid form. Add the glue slowly, while stirring, to the partly cooled wax. If the glue is added rapidly while the wax is still very warm, the whole mass will boil over.

Most grafting waxes contain lampblack or, occasionally, a red pigment. Since these materials give the wax a color different from that of the trees, one can easily determine when the grafts are covered.

If only a small amount of wax is required, it is more convenient to buy a prepared product. In recent years water emulsions of asphalt have appeared under various trade names. They are easily applied cold and are, as a rule, satisfactory. However, they may be washed off if rain occurs before they have thoroughly dried.

Waxed cloth and string may be prepared by dipping muslin or other cloth and No. 18 knitting cotton or similar string in hot grafting wax. The lampblack is usually omitted when the wax is used for this purpose.

LAYERING

Layering is the operation of rooting stems that are still attached to the parent plant.

Simple Layering.—This method consists of laying down a branch and covering part of its length with soil, leaving the tip uncovered. Roots often form more readily if the buried portion of the branch is girdled or notched. In the dormant season the rooted shoot may be severed from the parent plant. This method may be used in propagating small numbers of plants of various shrubs and of grapes, but not in producing most deciduous fruits commercially. However, it is at present the most common way of propagating filberts.

Tip Layering.—The common way to propagate trailing blackberries, dewberries, and black raspberries is by layering. The ends of the canes are covered with a shovelful of earth during the latter part of the summer. The covered portion sends down roots and forms a plant that can be set out the following spring (fig. 26). About 6 inches of the original layered cane is left attached to serve as a handle. This old stem will also act as a marker or guide in cultivating, until the new shoots appear aboveground.

Mound, or Stool, Layering.—Before growth starts in the spring, the mother plants are cut back close to the ground so that the bases of all new shoots may easily be covered with soil. By winter these shoots will have rooted and may be severed from the parent plant. This method is used in propagating gooseberries, currants, quinces, and Paradise apple rootstocks.

Trench Layering.—This method consists in bending over the whole top of the plant and pegging it down in a trench 2 or 3 inches deep. For fruit trees, the usual practice is to plant trees with one-year-old tops in the winter, inclining the trunk at an angle of 30° to 45° from the horizontal. The following winter, after one season's growth, the top is layered. Any branches that cannot be held flat against the bottom of the trench should be removed. In the spring when the new

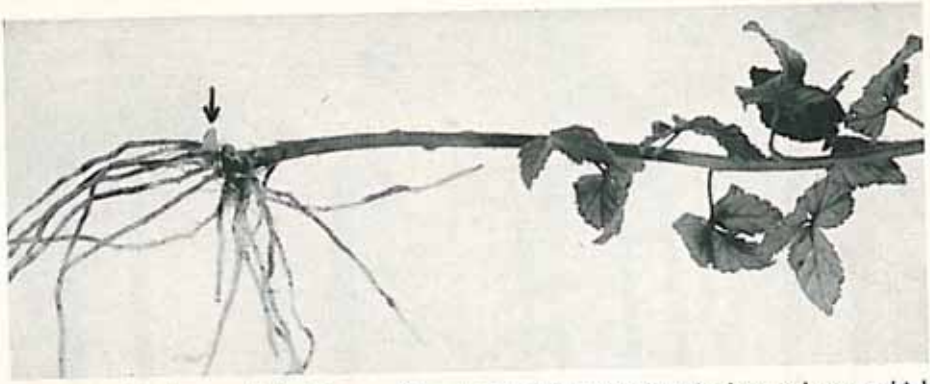


Fig. 26—Tip layers of blackberry. The arrow points to the tip of a layered cane which will develop into the top of the new plant. Ends of canes are covered with earth during latter part of the summer.

Fig. 27—Trench layering. Soil has been removed to show plant in position. These rooted shoots were produced in one season. The whole top of plant is bent over and pegged down in a trench 2 or 3 inches deep.

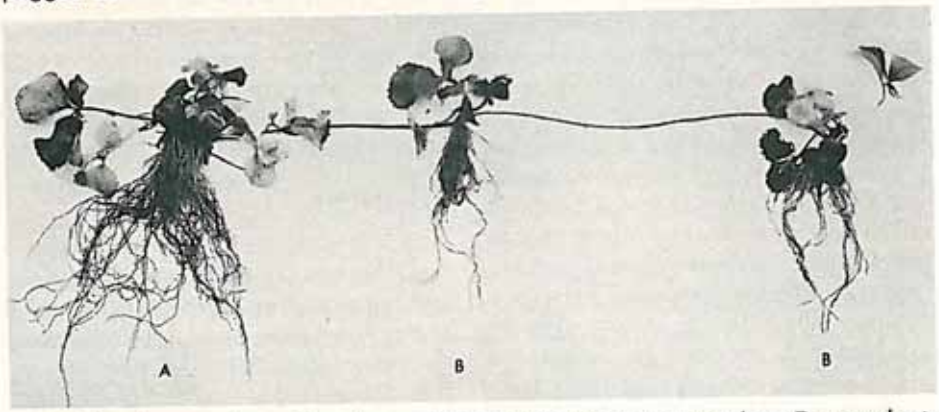


Fig. 28—Propagation of strawberry plants by runners. **A**, parent plant; **B**, new plants formed at nodes, or joints. The new plants that are produced occur only at every other node.

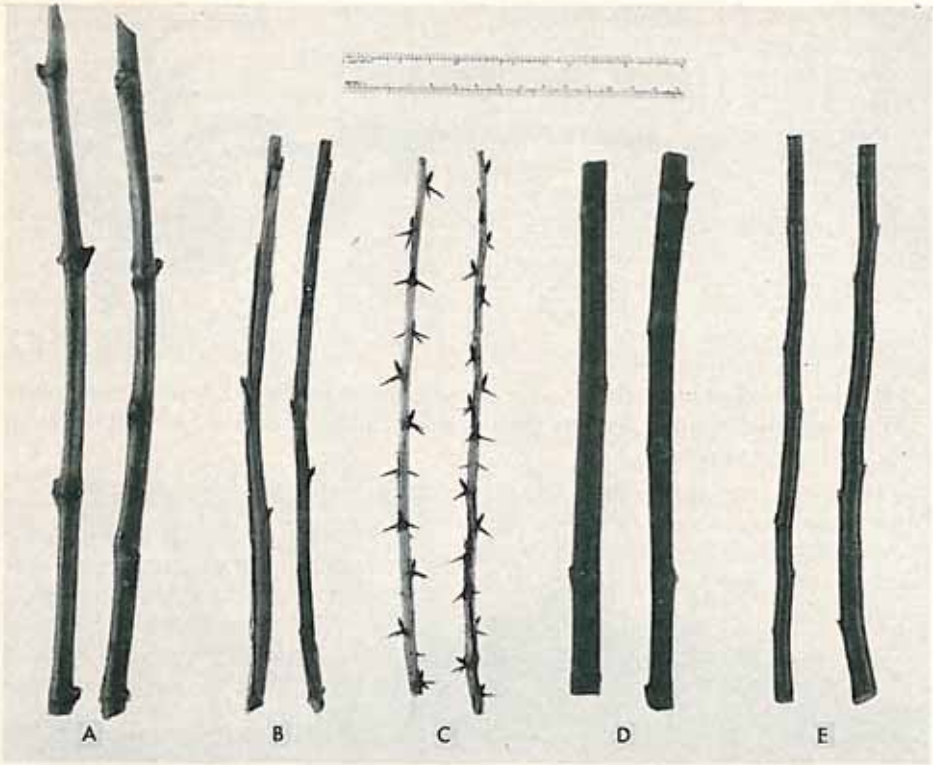


Fig. 29—Typical examples of hardwood cuttings: **A**, grape; **B**, currant; **C**, gooseberry; **D**, fig; **E**, quince.

shoots are about 3 inches tall, fine soil is shoveled around them, and this process is repeated at intervals until the layered top is covered to a depth of about 6 inches. For plums, all layered parts should be covered about an inch deep with fine soil just before the buds open. In the early winter, after the shoots have grown one season, the soil is drawn away from the layers, and the rooted shoots (fig. 27) are detached. A few of the shoots fail to root each year, and these may be laid down to supplement the original layered tree. The old layers are left uncovered until the following spring, when the program of the previous year is repeated.

For filberts, suckers from fairly large trees are usually trench-layered, instead of the tops of young trees as discussed above.

Trench layering is fairly satisfactory for apples, pears, cherries, and plums, but many varieties do not root well. Because it will always be more expensive than the present method (the budding of seedling stocks), it will come into general use only where trees on their own roots have proved to be better, or certain selected rootstocks superior.

RUNNERS

This method is a natural type of layering. The runners of strawberries, which are commonly propagated in this way, root at every other node, or joint, without assistance (fig. 28). The bud at each rooted node sends out leaves so that a number of new plants are produced.

Some strawberry varieties, such as the Rockhill, seldom produce runners, and

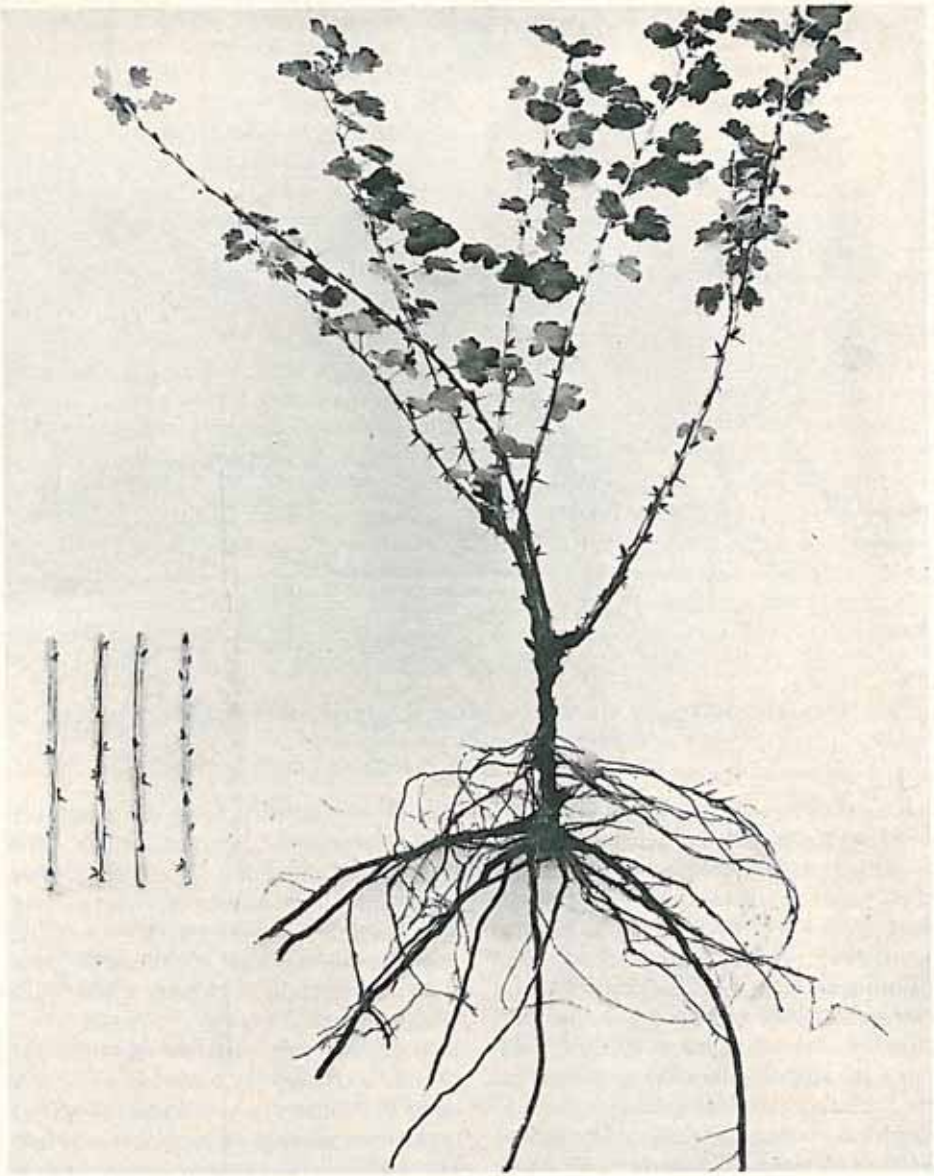


Fig. 30—Left, typical gooseberry cuttings; right, a rooted gooseberry cutting after a year's growth.

are therefore propagated by dividing the crown into two or more plants.

CUTTINGS

Propagation by cuttings consists of placing a piece of the mother plant (a stem, a root, or a leaf) under conditions favorable for root development. Cuttings are named according to the part of the plant from which they are taken and the condition of that part.

Hardwood Cuttings.—These cuttings are usually made in the early winter from the previous season's growth. With

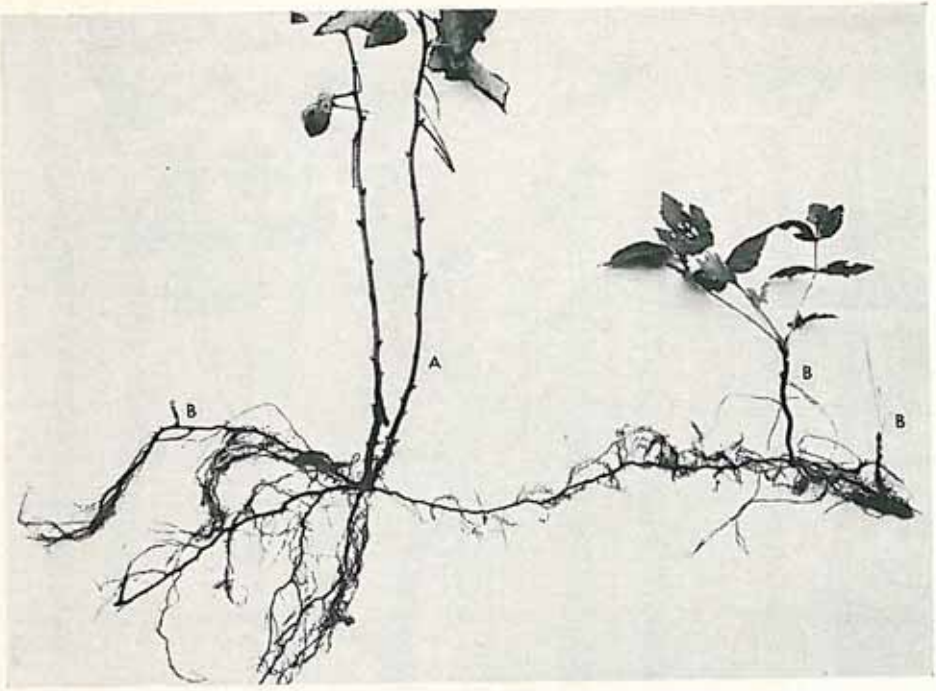


Fig. 31—Suckers of the red raspberry. **A**, parent plant; **B**, suckers in different stages of development.

a few species, such as the fig, however, wood up to two or three years old may be used. In cold climates the cuttings are usually stored until spring in cool, moist sand or in moss. In most parts of California they can be planted out of doors immediately, but if made during the winter when the soil may be too wet to cultivate, they are often put in storage. Such fruits as grapes, currants, gooseberries, figs, quinces, and pomegranates, and certain plum rootstocks, such as Myrobalan 29 and Marianna 2624, are commonly propagated by this method. Cuttings are usually 5 to 16 inches long. At least two buds should always be included. Figure 29 shows some typical examples. If the buds are rather close together on the cutting, pay no attention to them in making the two cuts. If, however, the buds are far apart, the upper cut should be a short distance above the upper bud, and the lower cut immediately below the bottom bud. Roots usually form more readily near the nodes, or joints, where the buds are. If, then, the lower cut were not made as described, the lower end of the cutting would probably have no roots. Cutting near the buds keeps within reasonable bounds the length of cuttings whose buds are far apart. As a rule, cuttings are so planted that only one bud is above the ground level, and are placed 2 or 3 inches apart in the nursery row. Figure 30 shows typical gooseberry cuttings before rooting, and a similar rooted cutting after a year's growth.

Most olive trees sold recently by California nurserymen have been propagated by softwood cuttings. Since this method requires considerable skill and the right kind of propagation beds, hardwood cuttings may be substituted if large numbers of plants are not required. These cuttings are usually 14 to 16 inches in length, and ¾ to 1½ inches in diameter.

Root Cuttings.—Such plants as red raspberries and upright blackberries may be propagated by root cuttings. The roots are cut in pieces 2 to 4 inches long and then placed in the nursery row. Most raspberry and blackberry cuttings are planted horizontally, 2 or 3 inches deep. Root cuttings of some plants, however, are set vertically, with the top at the ground level. Loose soil is then drawn over them to prevent drying out.

Use of "Growth Substances" on Cuttings.—In recent years, such chemicals as indolebutyric and naphthaleneacetic acid have been used considerably, to improve and speed the formation of roots on certain kinds of cuttings. These materials are usually sold in a liquid or powder form. The lower ends of the cuttings are dipped in one of the powders or liquids, or soaked for about 24 hours in one of the diluted liquids.

"Growth substances" have been commercially satisfactory for many kinds of plants that can be grown from cuttings with their leaves attached. Unfortunately they have been generally unsatisfactory for the leafless hardwood cuttings suitable for propagating deciduous fruit plants. Additional materials and improved technics are being discovered daily, however, and perhaps future new methods will permit the propagation of more fruit plants on their own roots and so do away with much of the present nursery budding and grafting.

SUCKERS

Red raspberries, upright blackberries, and the Stockton Morello cherry (a rootstock for cherries), are propagated by suckers. The suckers, together with some roots, are removed from the parent plant during the winter (fig. 31).

Suggested Methods of Propagating the Various Temperate-zone Fruit Plants

Quince, fig, grape, currant, gooseberry, olive, and pomegranate, and certain plum rootstocks, such as Myrobalan 29 and Marianna 2624, are easily propagated by hardwood cuttings. Mound, or stool, layering may also be used for quince, currant, and gooseberry.

Tip layering is the common method for trailing blackberries, dewberries, and black raspberries.

Red raspberries and upright blackberries are usually propagated by suckers or, if these are not plentiful enough, by root cuttings.

The common varieties of strawberries are easily propagated by runners.

Pear, apple, cherry, peach, nectarine, apricot, almond, and plum are, as a rule, budded on seedling rootstocks, using the T, or shield, method. The work is generally done in the late summer or in the fall, but June or spring budding may also be practiced.

Walnut and pecan are budded on seedling rootstocks by the patch or flute method, or they may be crown-grafted.

Fruit trees are top-worked (that is, top grafted or top budded) for various reasons. Sometimes the variety planted may not find a satisfactory market even though the trees are growing well; sometimes seedling trees in orchards or yards may be worked over to established varieties; and sometimes, the home orchardist desires to graft or bud a number of varieties or kinds of fruit on one tree. In all these situations, however, the grower should consult Table 1 (p. 18) to see which combinations are possible. Small branches of pear, cherry, apple, peach, nectarine, apricot, almond, plum, and fig may be budded in the summer by the T, or shield, method. For walnut and pecan, the patch or flute method should be used. Small branches of any common deciduous fruit plant may also be whip- or tongue-

grafted—usually in January, February, or March. For branches about 1 inch in diameter, side grafting is reasonably satisfactory.

The cleft graft, bark graft, and saw-kerf, or notch, graft are suitable for larger branches up to 3 or 4 inches in diameter. All these methods have given good results with apple, pear, cherry, apricot, almond, plum, persimmon, and fig. Each has advantages and disadvantages which should be considered before making a final selection.

Some propagators have successfully cleft- and saw-kerf-grafted walnuts and pecans, but the average worker has better results year after year with the bark graft. The second and third methods of bark grafting as described in this circular are recommended for the walnut and pecan.

One cannot expect good results when grafting old, weak trees or trees whose growth has been seriously hampered by lack of water, nitrogen, or other necessary materials. This statement applies especially to the peach and the nectarine. Young, vigorous peach and nectarine trees may be successfully cleft-, bark-, or saw-kerf-grafted; but old, weak trees will often fail to grow. In general, T, or shield, budding and bark and saw-kerf grafting have given better results with peach and nectarine than cleft grafting.

Simple layering is at present the most common way of propagating filberts, but trench layering is still used to a certain extent.

As previously indicated, grapes are propagated by hardwood cuttings. If, however, there are root-knot nematodes or phylloxera in the soil, the desired grape varieties may be whip-grafted before planting in the nursery or chip-budded in the vineyard on resistant rootstocks.

Bridge grafting and inarching are excellent methods for saving injured apple and pear trees and, to a lesser extent, other species.

See table of contents, page 57, for sections covering each of the methods mentioned above.

II. Subtropical Fruit Plants[4]

THIS SECTION describes or summarizes the usual methods of propagation and nursery practices employed with the subtropical fruits in California. A detailed discussion of each fruit is not necessary since most of the propagation methods are more or less standardized and are adequately described and illustrated in the foregoing section on deciduous fruits. For a few fruits, however, it has seemed desirable to describe in some detail the methods of propagation, and nursery practices. For the other fruits merely a brief summary—the principal rootstocks, standard methods of propagation, special nursery practices and precautions—is presented. For convenience, the fruits are listed in alphabetical order.

A properly prepared seedbed has much to do with the successful propagation of many subtropicals, especially the tender evergreens. The seedbed soil should be light to facilitate drainage and rapid warming up in the spring and after irrigation. It should also be well prepared to promote deep and rapid root growth.

For those subtropicals which are transplanted balled, instead of bare-root—primarily the tender evergreens—the soil in the nursery should be neither too light nor too heavy. Fine sandy loams ordinarily give the best results. The rows to which the seedlings are transplanted ("lined out") from the seedbed are usually spaced 3 to 4 feet apart and the seedlings 10 to 16 inches apart in the row. Where the nursery trees are not balled, the seedlings may be planted closer together in the row.

Beds or propagation frames for the rooting of softwood cuttings should be built relatively airtight and covered with glass sash. Bottom heat is usually advisable; a uniform and economical source is provided by electric heating cable. Adequate leaf surface is important in the rooting of softwood cuttings; usually 3 to 5 leaves per cutting should be left.

Avocados

Rootstocks for Avocados.—Seedlings of the hardier Mexican race (*Persea drymifolia*) are commonly used for rootstocks in California. Guatemalan (*P. americana*) and natural Mexican-Guatemalan hybrids are used to a limited extent. The West Indian race of *P. americana* is used only experimentally since it is subject to frost injury.

The present tendency is to select trees or blocks of trees of the Mexican race, isolated if possible to prevent cross-pollination, and to use these as a source of seed for the seedlings. Some prefer parent trees of the Guatemalan race, as the seedlings are often more vigorous and, in the case of some varieties, may be more compatible.

Nursery Methods with Avocados.—For best results the seeds should be planted soon after removal from the fruit. However, it may be necessary to hold seeds for some weeks as they are accumulated for planting. They can be safely stored in a cool place in dry peat moss, sand, or sawdust. Seed should not

[4] This section was prepared by E. R. Eggers.

be allowed to dry out. As a rule, nurserymen sprout the seeds in beds before planting in the nursery. For the most efficient use of space and maximum uniformity, this system is the best, for it permits culling as the seedlings are lined out in the nursery rows. When using fruit of the Mexican race, which ripens in the fall, the seeds are planted during October, November, and December, and the young seedlings lined out the following March and April.

Germination can be hastened by peeling off the brown seed coats before planting. To facilitate removal of the seed coats, soak the seeds in water for a half hour and then spread them out in the hot sun until they dry. This will cause many of the seed coats to crack. Scarification and mutilation of the seed also hasten germination. The most satisfactory of these treatments consists of cutting off a small piece of the top and bottom portion of the seed. This method has an additional advantage in that the cut at the basal end often reveals defects or decay not apparent on the surface of the uncut seed.

A combination of half soil and half sand, well screened and mixed, makes a good planting medium. Seed is planted with the base, or large end, down. In outdoor beds the tips of the seeds should be covered with ½ to ¾ inch of a light soil mixture or sand. In glasshouses or hotbeds, where the moisture can be maintained, the tips of the seeds may be left exposed. Seedbeds may need shading during hot weather to prevent burning off the young seedlings as they come through.

Seedlings may be transplanted either bare-root or with the soil attached. If they are to be lined out with soil attached, they should be placed in the seedbed at approximately 4-inch intervals to permit cutting out a block of soil with each seedling as it is taken up. Some prefer to plant the seeds in open-bottom paper pots (2 × 2 × 6 inches is satisfactory for Mexican seeds) purchased or made for that purpose. The paper pots must be removed at the time of lining out in the nursery row. Seedlings lined out with a block of soil attached need not be cut back at the time of planting. If the seedlings are to be moved bare-root, they may be planted close together in the seedbed. Seedlings moved bare-root, if quite large, may have their leaf surface reduced at the time of planting. This is best accomplished by cutting off about one half to two thirds of each leaf. Irrigation should immediately follow planting to prevent drying. In late plantings, each seedling should be shaded with a shingle.

Some nurserymen plant avocado seeds direct in the nursery row. The seeds should be selected very carefully because there is little opportunity for culling without wasting space. The method of planting is the same as that used in beds.

Seedlings transplanted in the spring are frequently large enough for budding by fall. For best results a seedling should have a minimum diameter of about ¼ inch. If it has not reached this diameter by fall it will usually be large enough by spring.

Proper selection of the budwood is a major factor in the success or failure of avocado budding.

In general, the best buds are near the terminal ends of completed growth cycles with fully matured, leathery leaves (fig. 32). The Fuerte variety may have suitable buds over a rather long range, whereas many varieties have a relatively short area of good buds at the terminal ends of completed growth cycles.

Budwood may be used soon after cutting. If dormant, it may be packed in moist moss and held in a cool place for several weeks. In either case it should never be allowed to become dry before or while it is used. Clipping the leaves off a bud stick a week or 10 days before it is removed from the tree is believed by some to be beneficial. For spring budding the buds should be cut and stored; they are in the best condition before the bark on the nursery seedlings slips properly.

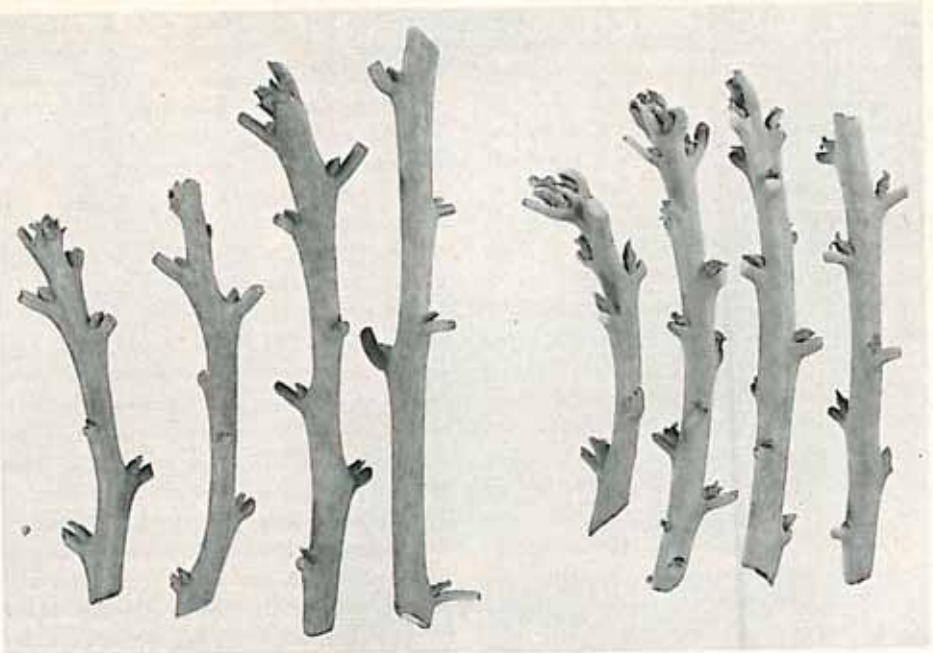


Fig. 32—Avocado bud sticks: left, Fuerte; right, Guatemalan. Proper choice of budwood is very important.

Shield budding (fig. 2, p. 11) is practiced, using a shield about an inch in length. The bud is wrapped very tightly with the eye exposed. Prepared budding cloth, muslin, rubber bands, and pliofilm strips are used for wrapping. If budding cloth is used it should contain wax of a high melting point because the avocado bud is very subject to injury by melting wax during hot weather.

The terminals of the budded seedlings may be nipped off at the time of budding, or within a few weeks following. Young avocado seedlings grow very rapidly during the summer months and if considerable constriction takes place the portion of the tie below the bud should be unwrapped and rewrapped after 3 weeks. In 4 to 6 weeks after budding, depending on the season, the seedlings should be topped to within 8 to 10 inches of the bud or bent over a few inches above the bud. The bent part of the seedlings may be held down with a wire hook made by cutting galvanized wire into 12-to 14-inch lengths and bending one end. If seedlings are topped or bent during hot weather, the stocks should be shaded with a shingle to prevent sunburn. The ties should be removed when constriction becomes apparent. In order to concentrate growth in the buds, young sprouts arising from the remaining portion of the seedling must occasionally be pulled off.

About the time the bud growths are ready for the second tie, the stakes should be placed. Most avocado nurserymen use 1 × ½-inch redwood stakes 4 feet or more in length. Lath may be used if preferred. The buds grow rapidly, and frequent tying is necessary to produce a good straight nursery tree. Stubbing (see "Citrus Fruits," p. 50) should be done after the bud growths have completed a cycle of growth.

Avocado trees are customarily balled out of the nursery and set out in the orchard at the completion of the first or

second growth cycle. At that time they are usually 18 inches to 4 feet in height, depending on the number of growth cycles.

Considerable success has been had in moving *started buds* and *tied-up buds*. The former are buds from ½ to 1 inch in length and the latter run on up to several inches in length tied up to the seedling stubs.

These trees are balled and planted the same as standard nursery trees. The seedling stubs are removed in the orchard after completion of the first growth cycle.

In order to speed up the production of nursery trees and eliminate balling, some nurserymen are producing trees by tip grafting.

This method requires the use of a glasshouse or similar structure in which to maintain a suitable range of temperature and humidity.

Open-bottom paper pots 6 inches to 7 inches in diameter and 12 inches deep are set in greenhouse benches or beds and filled with a good potting soil. Seeds are planted one to a pot when they become available in the fall. The seedlings are often large enough to graft by January or February.

A scion 1 to 1¼ inches long with a single bud taken from terminal growth (fig. 32) is whip grafted (fig. 6, p. 19) near the base of each seedling. The second cut or tongue is frequently not used. The scions are securely tied in place with rubber or pliofilm strips. The tip grafts may be set out in the orchard location at the completion of the first growth cycle—usually about 3 months after grafting.

Top-working Avocado Trees.—Avocado trees may be top-worked at any time, although the spring months are probably best. In selecting scion wood for grafting, large scions are preferable. The wood should be well matured with

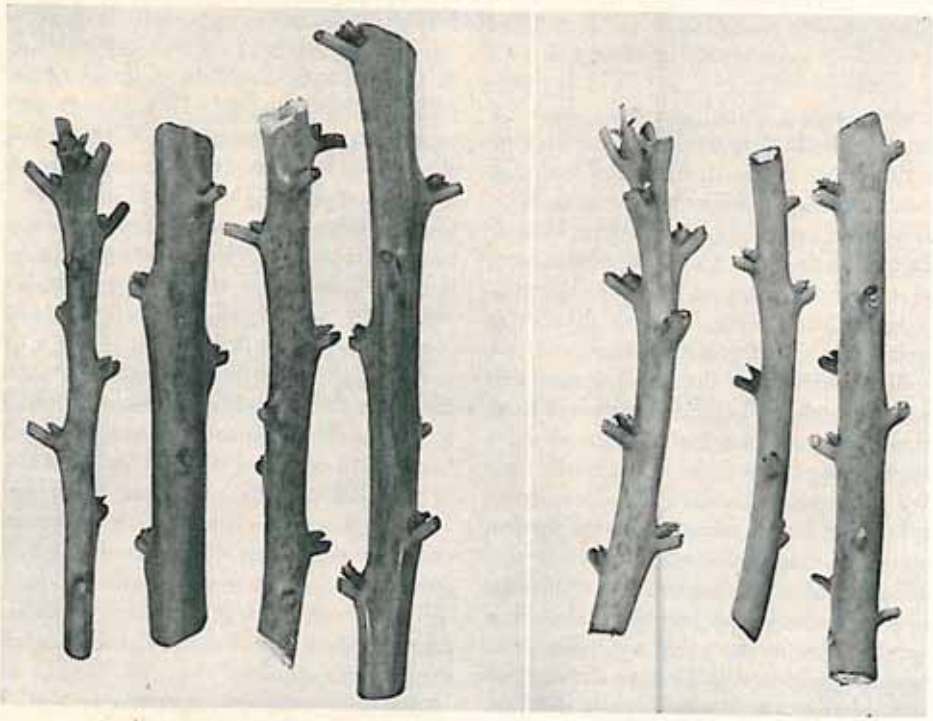


Fig. 33—Avocado scions: left, Fuerte; right, Guatemalan. Wood should be well matured, with plump buds.

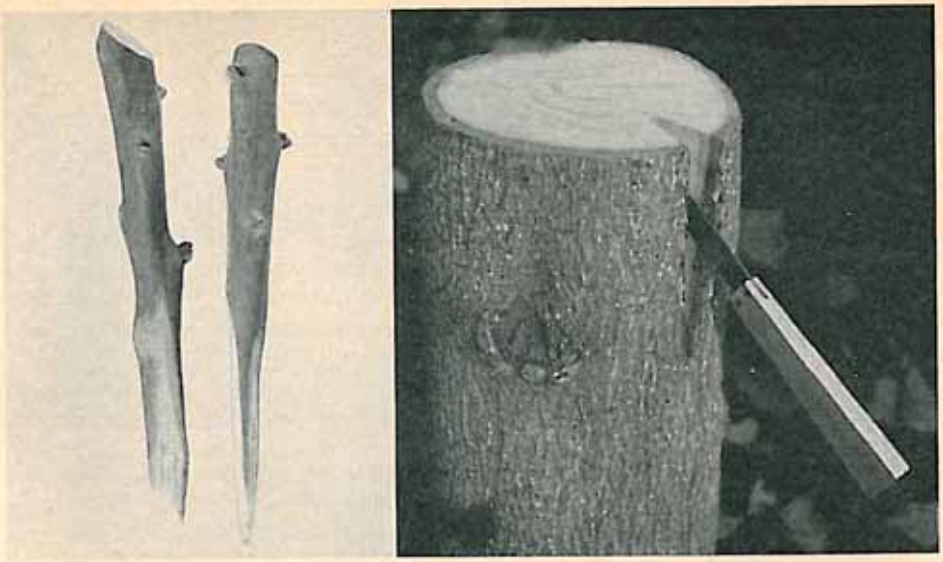


Fig. 34—Saw-kerf, or fit-cleft graft, the method now most often employed for top-working avocado trees. Left, method of beveling scions; right, making the notch; lower right, scion in place with lowest bud on outside. There should be a maximum amount of contact between cambiums of scion and stock. Several scions may be placed on a large trunk. The stub is then wrapped with tape or cord. A saw-kerf or a modified cleft graft may be used in the dormant season when the bark is not slipping.

good, plump buds or a ring of nodal buds (fig. 33). In some cases both may appear on the same scion.

Nurse limbs are apparently not so important with avocados as with other fruit trees. This permits working in the main limbs or the trunk of the tree. If the trunk is unsound or the bud union is poor, the tree may be cut off and grafted below the old bud union. Trees may be worked in a number of different ways, depending on the season and the preference of the operator. During the dormant season when the bark is not slipping, a saw-kerf graft (fig. 18, p. 30, and fig. 34), or a modified cleft graft, in which the cleft is made by sawing out a narrow wedge of wood, may be used.

In placing the scions, care must be exercised to get a maximum amount of contact between the cambial layers of the scion and the stock. After the scions have been securely driven into place, the stub is wrapped with tape or cord. Nails are not necessary to hold the scions in place.

When the bark is slipping, bark grafts are commonly used. They are quick and easy to put in and they take readily. The matrix is prepared by making a single slit if the bark is thin (fig. 35), or two parallel cuts the width of the scion apart

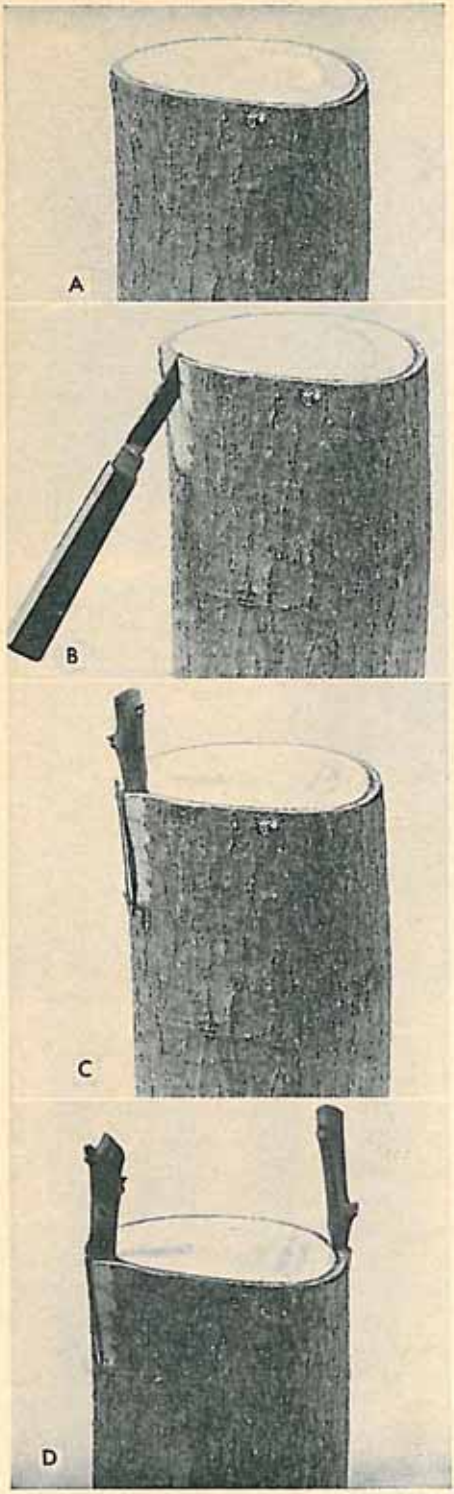


Fig. 35—Steps in making a single-slit bark graft: **A**, stub cleaned and smoothed; **B**, bark thinned and slit made; **C**, scion in place; **D**, grafting complete with the lowest bud on each scion on the outside.

if the bark is thick (fig. 17, p. 29). The scions are cut as illustrated (fig. 36) and are inserted into the matrix. After the scions are inserted they are securely held in place by being wrapped with a heavy string or cord.

The scions should be sealed in as soon as possible by filling all voids with grafting compound and heavily coating all exposed cut surfaces on the stock and scion. The treated surfaces should then be covered with paper and the stub covered with a heavy, perforated paper bag, such as a nail bag that will not collapse when wet (fig. 37, *D*). The trunk should also be wrapped, shaded, or whitewashed to prevent sunburn.

In side grafting, the operator removes enough limbs to permit freedom in working. He then selects suitable positions, preferably in the shade. A triangular patch of bark about 2 inches wide at the

Fig. 36—Method of preparing scions: at left are scions cut for a saw-kerf graft, showing wedge shape; at right are scions cut for a bark graft.

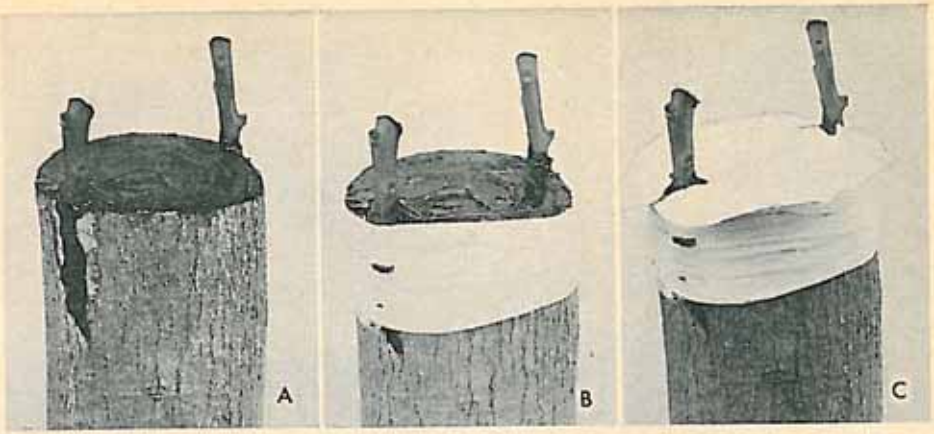
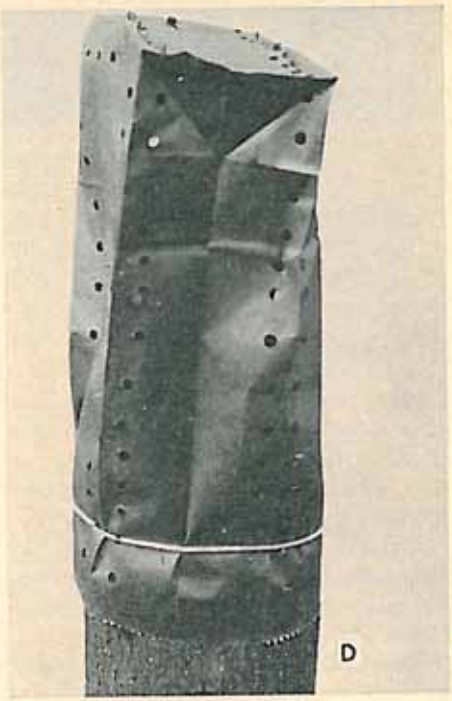


Fig. 37—Steps in sealing in the scions: **A**, waxing; **B**, wrapping the scion in place; **C**, wax covered with paper; **D**, stub covered with a perforated paper bag. The trunk should also be wrapped, shaded, or whitewashed to protect it from sunburn.



base is cut out. Two parallel cuts slightly wider than the scion are made from the base of the triangle down a few inches. The scion is then trimmed with a long flat cut on the side that will rest against the tree and with a slightly concave cut on the side next to the bark. The tongue of bark is pulled away from the trunk, the scion inserted, and the bark flap replaced. Four or five finishing nails are then driven through the bark tongue and the scion into the tree, or the scion may be held by wrapping. All cut surfaces are waxed. As an added protection, a piece of muslin is placed over the bark flap and the base of the scion and waxed in place. More than one scion may be used if the tree is large (fig. 38).

If, after about 6 weeks, the scion is alive or has started growth, the tree should be cut back heavily to force the scion into rapid growth. Nurse limbs that will furnish the most shade for the scion and trunk should be left. After a season or more of growth, the stub may be removed by a long, sloping cut.

Where budding is preferred, the tree may be cut back severely in the late winter, and the new shoots that arise may be summer- or fall-budded. Avocado buds and scions grow rapidly and need support as they grow to prevent breaking out. When more than one scion starts growth on a stub, the strongest and best situated scion should be retained and the remainder cut back but not removed until the graft union is well healed over.

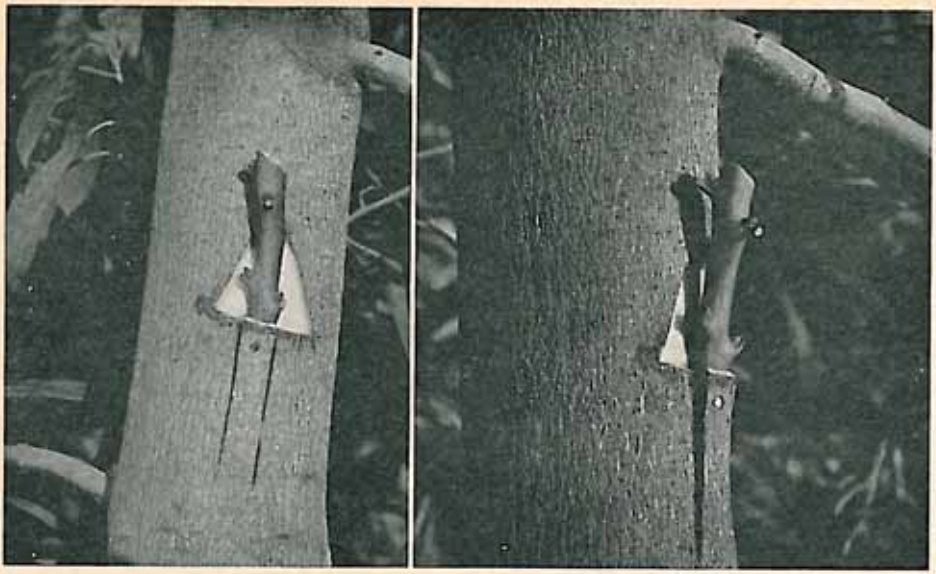


Fig. 38—Side graft: left, front view; right, side view. The scions are held in place by wrapping securely with a heavy cord or by additional nailing. More than one scion may be used if the tree is large. All cut surfaces are waxed. As an added protection, a piece of muslin is placed over the bark flap and the base of the scion is waxed in place. Avocado scions grow rapidly and need support.

Citrus Fruits

Rootstocks for Citrus Fruits.—The selection of the rootstock species depends largely upon the locality in which they are to be planted. For this reason it is advisable to consult the local farm advisor before making a choice.

Sweet orange is congenial with all commercial varieties of citrus fruit grown in California. It is subject to gummosis, however, and requires preventive treatment to control it.

Sour orange has been used, largely because of its resistance to gummosis. However, it is no longer recommended for sweet oranges because it is susceptible to quick decline of oranges. It is also not congenial with certain lemon strains.

Rough lemon seems to be satisfactory for oranges and lemons in some localities. Oranges on this stock tend to be more subject to granulation, however.

Trifoliate orange is used to a limited extent. It is in general a dwarfing stock suitable for oranges and mandarins, under certain conditions.

Other species of citrus, such as tangelo, mandarin, and citrange, are being tested. Information concerning these can be obtained from the farm advisors or from the Citrus Experiment Station, Riverside.

Nursery Methods with Citrus Fruits.—Sweet-orange seed has generally been obtained from California seedling trees. More care in the selection of parent sweet-orange trees is being practiced. Many California nurserymen now record the rootstock parent tree used, as well as the parent tree from which the buds are taken.

Citrus seeds are planted during March and April when the soil is usually warm enough to permit germination and growth. Seed planted too early will rot before germination takes place, or the loss

from damping-off may be high. If the seed is dry, it should be soaked for about 24 hours before planting. Seeds are sown 1 inch apart each way and pressed into a well-prepared seedbed. They are then covered with ½ to 1 inch of sand or of soil and sand. The surface layer should be sand, for it dries out rapidly—an important consideration in controlling the fungi which cause the damping-off disease. The seedbed should be shaded while the young seedlings are coming up or they may be burned off at the soil surface by hot weather.

The following spring the seedlings are pulled and lined out in the nursery row. The seedbed should be thoroughly soaked and, if necessary, the seedlings loosened with a spading fork to prevent breakage of the roots in pulling. At this time all bench-rooted (crooked or bent), diseased, or otherwise inferior plants, are culled. The remaining seedlings are tied into bundles and the tops chopped off to within 7 or 8 inches of the crown. The longer roots should also be shortened by being chopped back to about 8 inches in length. The roots must be kept moist before and during the planting operation. Exposure to the sun or dry air may result in considerable loss. In lining out in the nursery the plants are set in holes made with a dibble or with a long spade. Irrigation should immediately follow the planting. After planting, the nursery should be inspected, and all seedlings that were not shortened by the original chopping should be cut back about one half with pruning shears.

The young seedlings will be large enough to shield-bud (fig. 2, p. 11) in from 6 to 18 months after lining out, the time depending on the variety and the growing conditions. Ordinarily a minimum diameter of about ¼ inch should be attained before the seedling is budded. For nursery propagation, well-rounded bud sticks with well-developed buds should be selected. For spring budding, the budwood must ordinarily be cut and stored, preferably in moist moss, until the bark slips on the nursery seedlings. Citrus seedlings are shield-budded in the summer, fall, or spring.

Waxed cloth, cord, rubber bands, and pliofilm strips may be used to wrap citrus buds.

Spring- and summer-budded seedlings are usually unwrapped in about 3 weeks and are topped or lopped 4 weeks after budding.

Fall budding in October or November, with the buds allowed to remain dormant until spring, is commonly practiced. In the spring the fall-budded seedlings are either topped or lopped to force the buds into growth. In topping, the seedlings are cut off at a point about 6 inches above the bud. In lopping, the seedlings are partly cut through and laid over; after the buds have made some growth, the tops are entirely removed. The growing buds should be staked and tied. Stubbing, or removal of the portion of the seedling above the bud union, is done in the early fall; at this time the wound is covered with wax or pruning compound.

Where bottom heat is available, citrus seed can be planted in the winter in sash-covered beds or boxes and lined out that spring. Satisfactory results have been obtained by covering the seedbed soil with a half inch of well-soaked, shredded sphagnum moss and planting the seed on this. The seeds are then covered with another half inch of sphagnum moss and are thoroughly soaked. Germination is best if the temperature can be kept between 75° and 85° F.

Citrus trees may be propagated by cuttings. Several species root readily in propagation frames equipped with bottom heat, in which the humidity is kept high and the temperature maintained around 75° F.

Top-working Citrus Trees.—Citrus trees may be top-worked by budding or grafting. For fall top budding into the old bark, the main limbs are thinned in July or August with three or four scaffold

limbs left. This pruning will tend to set the bark. In August or September the bark will again slip and the scaffold limbs can be shield-budded. It may be necessary to thin the bark by scraping the area in which the bud is to be placed; this may be done with a knife blade. The wraps are left on from 5 to 8 weeks, until the buds are well healed in. In March or April the budded limbs are cut off several inches above the buds, or at the buds. If cut off 8 to 12 inches above the bud, the stub may be used as a support for the growing bud shoots. If cut at the bud, which is advisable only on small limbs, a long sloping cut should be made which will heal over readily.

Citrus trees may also be top-worked in the spring. For top budding at this time of the year, use the same procedure as for fall budding; the wraps need not be left on so long, however. A bark graft (fig. 15, p. 27, and fig. 35, p. 48), with the scions held in place by wrapping with tape or waxed cloth, is very satisfactory for spring work. All exposed surfaces should be waxed and the grafted stub covered with a perforated paper bag.

Large budwood or scion wood is used in top-working, and for spring work the use of cured wood is advisable. In top budding, waxed budding cloth is used most extensively for wrapping.

Whitewash all exposed portions of the tree immediately after budding or grafting. Nurse limbs are frequently left on top-worked citrus trees until the new tops have become well established. Citrus bud or scion growth is not supported by stakes unless very severe winds are to be expected. Too rapid growth is controlled by pinching out the terminals. Citrus trees may also be worked over by cutting the tree back severely in the spring, and by fall budding the best of the new shoots.

Dates

Date varieties can be propagated only by means of suckers or offshoots. Seed propagation is not satisfactory because it gives rise to a mixture of male and female plants, and the latter are always different from, and nearly always inferior to, the mother plants.

Offshoots arise from axillary buds at or near the base of the palm. For most satisfactory results, offshoots are allowed to develop roots while attached to the parent palm. They may be taken off before rooting and allowed to root in a nursery row. This practice is not generally followed, however, because it requires special handling and care, and the mortality is often high.

Offshoots that arise at or just above the ground level are encouraged to root by mounding soil around the base of the palm. Offshoots arising at some distance up the trunk of the palm are not saved unless they are particularly valuable. They can be induced to root by building a box around the base of each offshoot and filling it with a mixture of equal parts of soil, sand, and well-rotted manure. This mixture must be kept moist throughout the rooting period.

At three or four years of age, an offshoot ordinarily has a well-developed root system and shows signs of maturity, such as blossoming and secondary offshoot development. It is then ready to move to the date garden. The best time for planting is in spring. Large offshoots are preferable where available; a 20-pound offshoot is considered the minimum size desirable. The offshoot is severed from the parent palm by means of a broad-bladed, long-handled chisel driven with a sledge hammer. Special care is required to prevent injury of the parent palm and to insure that the ball of the offshoot is not broken.

Figs

Nursery Methods with Figs.—Hardwood cuttings are made during the dormant season, usually at the time of pruning. Prunings used for this purpose should not be allowed to dry out before being made up into cuttings. The wood

Fig. 39—Either shield buds, as here shown, or patch buds inserted in fig branches up to 3 or 4 inches in diameter are readily forced out and make a good union with the stock. (From Ext. Cir. 77.)

preferred is ½ to ¾ inch in diameter, well seasoned, and with medium-length internodes. The cuttings are made 8 to 12 inches long (fig. 29, *D*, p. 38), using wood up to two and three years old. Tips and soft growth are not satisfactory. The cuttings may be planted direct in the nursery row or may be stored in cool, moist sand, or sandy soil, until conditions are favorable for planting.

Suckers arising below the ground surface frequently root while attached to the parent tree. They may be taken off and planted direct in the orchard, provided the parent tree is on its own root.

Top-working Figs.—Fig trees may be top-worked by either grafting or budding. Cleft grafting is practiced during the dormant season. After waxing-in the scions, the grafted stubs may be covered with perforated paper bags to prevent sunburn and drying of the scions. Bark grafting may be employed after the bark slips in the spring. The modified bark graft (fig. 17, p. 29), using two vertical slits, is the method most often used. The stubs should be wrapped to keep the bark in place. The trunk and main scaffold limbs should be whitewashed.

Where top budding (fig. 39) seems desirable, either of two methods may be followed. If the trees are small, the buds are placed in the main branches; if large, the main branches are cut off to stubs during the dormant season and the shoots which result are shield-budded when of suitable size. If fall budding is practiced, the buds should be cut from growth of the current season; for spring budding, buds from growth of the previous season are used. After the buds have healed in, the budded shoots or branches are cut back to force the buds into growth.

Olives

Nursery Methods with Olives.—Where a large number of trees are required, softwood cuttings are used because they are more plentiful. Softwood cuttings require propagation beds and special skill in handling. They are made of twig terminals that have completed their length growth and become firm. The cuttings are made about 4 inches in length with the basal cut just below a node. The two lower leaves are removed and the remaining leaves are cut back to about half their length. The cuttings are immediately placed in a sand bed where they will ordinarily root in a few weeks under favorable conditions. Bottom heat will materially stimulate rooting. After roots have started, the cuttings are transplanted to the nursery row.

Most nurserymen find hardwood cuttings, when they are available, to be most satisfactory. The cuttings are made 14 to 16 inches long, from wood ¾ to 1½ inches in diameter.

Top-working Olives.—Olive trees are top-worked by patch budding, shield budding, or bark grafting. Special care is required in the follow-up work to make certain that the new top is not composed of a mixture of the old and new varieties.

Pecans

Rootstocks for Pecans.—Seedlings, grown from nuts of either seedling trees or commercial pecan varieties, are used as rootstocks with varying success. Most nurserymen agree that there is apparently little difference in the desirability of named varieties as rootstocks. Seedling pecans are cheaper, have proved generally satisfactory, and are therefore usually used as a source of seed. The maturity of the nuts at the time of harvesting seems to be of major importance in obtaining vigorous seedling stocks.

Nursery Methods with Pecans.—The nuts are harvested in the fall when fully matured. Best results are obtained by stratifying the nuts in boxes or in beds of well-drained, sandy soil. In the early spring they are planted to a depth of 2 or 3 inches, 8 to 12 inches apart in the nursery row. The young seedlings are subject to burn by the hot surface soil and should be shaded with shingles or lath sections.

During the first season, pecan seedlings make a rapid root growth, but very little top growth. By the middle of the second summer, the seedlings are usually large enough to bud, and by fall, large enough to graft.

Most nurserymen bud pecan seedlings during the summer, using a patch bud. Seedlings on which buds fail to take may be whip-grafted during the following winter or early spring.

Top-working Pecans.—Pecan trees are top-worked by budding or by grafting. Top budding is favored by many and trees worked by this method are cut back heavily during the dormant season. The young shoots that arise are patch-budded (fig. 4, p. 15) the following summer. The budded shoots must be gradually cut back to force the buds into growth.

In top grafting, the bark graft is generally employed.

Persimmons

Rootstocks for Persimmons.—The Oriental persimmon (*Diospyros kaki*) makes the best rootstock for the Hachiya variety and seems suitable also for other varieties. This stock makes a good bud or graft union and is somewhat resistant to crown gall. It has a long taproot, however, with few fibrous laterals, and requires special care in transplanting.

Diospyros lotus is the most vigorous rootstock used. It is moderately drought-resistant and produces a fibrous root system that is easily handled in transplanting. It is very susceptible to crown gall and its excessive vigor causes fruit of the Hachiya variety to shed badly, which results in low production. It is not satisfactory for the Fuyu variety.

Nursery Methods with Persimmons.—Persimmon seeds are usually stratified in sand in the fall and are planted in flats or nursery rows in the spring. The seed may be planted direct in field beds made up of half sand and half soil, without stratification. Soaking the seeds in water for 2 or 3 days before planting will tend to hasten germination.

The young seedlings are subject to sunburn, and flats or beds must be shaded during germination. The seedlings should also be shaded when transplanted from flats to the nursery row. Shingles or lath sections are commonly used.

The seedlings are usually large enough to graft at the end of the first growing season. Most nurserymen crown-graft in the field, using either a whip or a modified whip graft (fig. 6, p. 19). After grafting, all exposed surfaces should be sealed and the scions entirely covered with fine soil. Where crown gall is a hazard, considerable infection can be avoided by wrap-

ping the sealed graft union with treated nurseryman's tape and by leaving the grafts open instead of covering them with soil as is usually done. Bench grafting is occasionally practiced.

Seedlings can be fall- or spring-budded by using a shield bud with the wood removed as for June budding.

Top-working Persimmons.—The persimmon tree may be top-worked by using a bark graft or a cleft graft.

Pomegranates

The pomegranate roots readily from hardwood cuttings and this method of propagation is the one commonly used. Hardwood cuttings are normally ready to transplant from the nursery row after one season's growth. Where cutting beds are available, softwood cuttings may be rooted or propagation may be accomplished by layering.

Santa Barbara Soft-shell Varieties of Persian, or English, Walnuts

Rootstocks for the Walnut.—For a discussion of rootstocks for the walnut, see the section on rootstocks for deciduous fruits (pp. 5–9).

Nursery Methods with Walnuts.—Walnut seeds may be either stratified and planted in the nursery row to a depth of 4 to 6 inches in January or February or stratified and set out in nursery rows as they germinate. Northern California nurserymen usually patch-bud in the late summer, allowing the buds to remain dormant until spring, when the seedlings are cut back to force the buds into growth. In southern California the common practice is to crown-graft with a modified whip graft during the dormant season. After tying and waxing, the entire scion is covered with fine, moist soil to a depth of 1 or 2 inches. The nursery trees should be staked and tied as they grow.

Top-working Walnut Trees.—Walnuts are commonly top-grafted. Small trees or limbs may be side-grafted. Large branches are usually bark-grafted or cleft-grafted. If young limbs are suitably placed, the tree may be top-budded with a patch bud.

Certain Minor Subtropical Fruits

Cherimoya.—Seeds may be planted to a depth of ½ to ¾ inch in beds or coldframes in the spring or early summer. In the same or the following spring they are lined out bare-root in nursery rows or they may be transplanted with blocks of soil on the roots after spring growth has started.

The seedlings may be summer- or fall-budded or they may be grafted the following spring. When grafting, dormant scions are cut and inserted about the time the seedlings start their spring growth. If whip-grafted, the union is made aboveground at a point at which the scion and stock are about equal in size (fig. 6, p. 19). If the seedlings are considerably larger than the scion wood, a modified whip graft or a cleft graft may be used. The wraps must be watched and cut before very much constriction takes place.

Cherimoya trees have been top-worked by cleft grafting or whip grafting; other methods of top-working may be satisfactory, however.

Feijoa.—The seeds are sown in flats, in a light soil to a depth of ⅛ inch, and when large enough, are set out in the nursery row. The seedlings may be whip- or cleft-grafted. Large plants may be top-worked by cleft or bark grafting.

Guava.—The guavas come relatively true to type from seed and are usually

grown as seedlings. They are difficult to propagate from cuttings. Layering is sometimes practiced.

Jujube.—The seeds of jujube germinate slowly and for best results should be stratified in sand in a cool place for several months. About a month before planting, which is generally done in the open, the stratified seed should be moved to a warm place; the seed is planted as soon as it begins to crack. As jujubes require high temperatures, care must be exercised not to move the seed out in the open too early or losses may occur if cold weather follows. The seed may be cracked and planted direct in the nursery row without stratification. The seedlings are crown-grafted by using a whip or cleft graft and by covering the scion with soil. Bench grafting is sometimes practiced. In this case the scions are placed on the crown or on the main root of the stock.

Loquat.—Loquat seedlings are commonly used as rootstocks; quince seedlings are occasionally employed for the purpose of dwarfing the trees and bringing them into bearing earlier. Loquat seed should be planted soon after removal from the fruit. If stored, it should not be allowed to dry out. The seed is planted to a depth of about 1 inch in the nursery row or is sprouted in boxes or shaded beds before lining out. The seedlings are usually large enough to bud in 18 months. They may be shield-budded in October and November and cut back to force the buds the following January. Seedlings may also be whip- or cleft-grafted in the spring. Large trees are top-worked by bark or cleft grafting.

Macadamia.—Macadamia seedlings will usually fruit; however, they do not come true to type. Vegetative propagation must be used to reproduce a variety. Under sash with bottom heat, macadamias can be rooted from cuttings. Hardwood cuttings or tip cuttings set in the fall and winter will usually root in 3 to 5 months.

Macadamia seed should be planted soon after harvesting. Warm, moist sand makes a suitable planting medium. The seedlings are ready to line out or to transplant to pots about 2 months after germination. A side tongue graft works fairly satisfactorily in the grafting of nursery seedlings.

Experience in the Hawaiian Islands indicates that a higher percentage of grafts take if scions are conditioned on the tree before cutting. This is done by girdling suitable branches 2 or 3 weeks before the scions are to be cut. This permits an accumulation of starch in the scions before removal from the tree.

A scion two or three nodes in length is side grafted near the base of the seedling (fig. 20, p. 31). The scion must be securely tied in place and waxed. The tip of the seedling is removed at the time of grafting. Subsequent follow-up work is similar to that given budded avocado seedlings.

Natal Plum.—The Natal plum (*Carissa grandiflora*) is grown from seeds (see feijoa) or cuttings. Cuttings placed in the open ground take about a year to root. Softwood cuttings root in a few weeks with bottom heat.

White Sapote.—The seeds of white sapote (*Casimiroa edulis*) should be planted to a depth of about 1 inch soon after removal from the fruit. The seed coat may be left on or taken off before planting. The seedlings are shield-budded in the late spring and early summer with well-matured budwood. Sapote trees are top-worked in the late spring or summer with a bark, saw-kerf, or cleft graft.

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J. Earl Coke, Director, California Agricultural Extension Service.

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