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PROPAGATION OF FRUIT PLANTS

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PROPAGATION OF FRUIT PLANTS[1]

C. J. HANSEN[2] AND E. R. EGGERS[3]

THE NUMEROUS METHODS by which plants may be propagated fall into two general classes: by seeds and by vegetative propagation. With the possible exception of a few varieties, fruits do not come true from seed. Consequently, the use of seed for these plants is largely limited to the propagation of rootstocks upon which the desired varieties may be budded or grafted. Vegetative methods involve rooting some part of the parent plant, such as stem, root, or leaf, or placing part of one plant on another in such a way that it will grow. Since a portion of the parent plant is simply growing in a different location, plants propagated by vegetative methods will ordinarily be identical with the one from which the part was obtained.

The various fruits, including nuts, grown in California may be divided into two general groups: temperate zone fruits, principally deciduous, which are grown in both northern and southern California, and subtropical fruits which, though not in all cases limited to southern California, are for the most part best suited to the warmer climate of that part of the state. The first section of this publication will be devoted principally to a discussion of methods of plant propagation and their application to deciduous fruits. The second section will be concerned with subtropical fruits; but since many of the methods of propagation used are the same as those discussed under deciduous fruits, reference should be made to the descriptions in the first section. Many of the subtropical fruits require special treatment, so it has been considered best to discuss each of these fruits under a separate heading.

[1] This publication supersedes Circular 294, *Propagation of Deciduous Fruits*, by J. L. Stahl.

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PROPAGATION OF DECIDUOUS FRUITS[4]

ROOTSTOCKS

The term rootstock, as used in the following discussion, will refer to the plant upon which varieties of fruits are budded or grafted. Although rootstocks are sometimes propagated by some vegetative method—for example, by cuttings or layers—the less expensive method of growing them from seed is almost always used in North America. Many fruit varieties would be propagated by cuttings or layers, hence grown on their own roots, if this could be done economically. At present these methods are applied to such plants as the bush fruits and to the quince, fig, and olive among the tree fruits. In some instances, own-rooted trees would not be used even if they could be produced at a reasonable cost, because other kinds of roots will grow best under certain environmental conditions. The rootstocks in use are summarized below, together with some information as to the source of seed.

Apples.—Rootstocks for apples have been grown to a great extent from "French crab" seed obtained from France and Austria. The "French crab" trees are principally seedlings, the fruit of which is used in France and Austria for cider making. Domestic seed, known as "Vermont crab," is obtained in limited quantities from old seedling orchards in New England. The New York State Agricultural Experiment Station has found seed of commercial varieties such as Ben Davis, Rome Beauty, Whitney, Wealthy, Delicious, and Jonathan to be satisfactory. On the other hand, they believe that seed from Baldwin, Rhode Island Greening, and Gravenstein should be avoided because seedlings from these varieties are inferior. If dwarf apple trees are desired, one should use certain types of Paradise rootstock, which can be propagated by means of layers and root cuttings.

Almonds.—One principal rootstock for the almond is the bitter almond, although sweet almonds are apparently as good. The other important rootstock is the peach. Myrobalan (cherry plum), though sometimes used, does not make a completely satisfactory union with the almond.

Apricots.—The chief rootstocks for the apricot are apricot and peach. Blenheim or Royal apricot seeds, easily obtained from dry-yards and canneries, are commonly used. If nematodes are apt to be present in the soil, the apricot root should be chosen. Myrobalan, though not used so

[4] This first section describing the methods of propagation which are generally applicable to all fruit plants together with the discussion of their use with temperate-zone deciduous fruits was prepared by C. J. Hansen.

extensively as peach and apricot, should probably be preferred on heavy soils that tend to be wet. Apricot trees on Myrobalan root, however, have not been entirely satisfactory; and a small percentage have broken at the graft union as a result of heavy winds.

Cherries.—Mazzard (sweet cherry) and Mahaleb are the common rootstocks for sweet cherries. Trees on Mahaleb root are more resistant to "buckskin" disease and drought than those on Mazzard root. The Mahaleb root, however, is more subject to nematode and gopher injury than the Mazzard.

A sour cherry known as the Stockton Morello has recently been used to some extent for adapting sweet cherries to heavy, shallow, or wet soils. This rootstock is considered to be commercially satisfactory but has a dwarfing influence on the tree and does not make a good union with some varieties. Root suckers, which are produced abundantly, are generally considered the most practicable means of propagation.

Peaches.—The peach is propagated almost entirely on peach seedlings. Although apricot seedlings are occasionally employed in sandy soils to resist nematode injury, the union is not always successful. Seedlings of the Shalil, Bokhara, and Yunnan peaches now under experiment are apparently resistant to nematodes. Being of the same species as the peach varieties grown commercially in California, they should, apparently, make good rootstocks. Whenever commercial varieties of peach and almond have been budded on these seedlings, large nursery trees with perfect unions have resulted.

The wild Chinese peach (*Amygdalus davidiana*), being somewhat resistant to alkali, may be used as a rootstock in alkali spots in an orchard. It is very susceptible, however, to crown gall. Whole orchards should not be planted on alkali land.

Pears.—The French pear is the usual rootstock used. Some of the seed still comes from Europe, but in recent years considerable quantities have been obtained in this country from such varieties as Bartlett and Winter Nelis, which are named varieties of the French pear. Old Home, a blight-resistant French variety, may be used for the framework branches with French pear as the rootstock. In the event of a severe blight infection the resistant framework would still be unaffected, and a new top could be built upon it.

The Japanese pear has proved unsatisfactory in California as a rootstock because of the black-end trouble. Black-end is also produced by *Pyrus ussuriensis,* another Oriental species. *Pyrus calleryana,* likewise Oriental in origin, has not been reported as producing black-end; but most of the orchards on this root are relatively young.

Quince root is used if dwarf trees are desired. Since the Bartlett variety does not make a good union directly with quince, one must double-work with Hardy (Beurre Hardy)—that is, use a short piece of Hardy stem between the quince root and the Bartlett top.

Plums and Prunes.—A principal rootstock for plums and prunes is the Myrobalan (cherry plum). The seeds are obtained from trees growing in California or are imported from Italy by way of France. Peach is the other important rootstock; nearly all varieties do well upon it. Almond has been used to some extent as a rootstock and is satisfactory with many varieties, provided the soil conditions are suitable for the almond. Many varieties do well on apricot root, a fact which is being utilized in soils infested with nematodes, since this root is resistant to the pest.

Walnuts.—Seedlings of the northern California black walnut have in recent times been used almost exclusively as rootstocks, principally because they have proved resistant to oak fungus. Because of the prevalence of the crown-rot disease in some districts, however, some newer plantings are being made with seedlings of the English walnut.

STRATIFICATION AND PLANTING OF SEEDS

When removed from the plant, the seeds of most deciduous fruit trees will ordinarily not germinate even under ideal moisture and temperature conditions. One reason is that the seeds are in a rest, which may be broken by cold. In addition, the seeds of many plants are covered by a stony layer that must be softened before they can germinate. The usual method employed to break the rest and soften the hard coat is to place 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 are allowed to remain in the sand until the latter part of January or February, when they are planted in the nursery. A shorter period of 3 or 4 weeks seems to be sufficient for almonds and apricots; in fact, 24 to 48 hours' soaking in water has sometimes been substituted for stratification in the case of these seeds. The size of the container (fig. 1) used for stratification depends upon the quantity of seed to be treated; it may vary from a small box to a large pit in the ground. 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.

In January or February apricot, almond, peach, and walnut, some-

times cherry, apple, and pear, and often Myrobalan seeds, are planted directly in the nursery row with the intention of budding the resulting seedlings the same year. Usually apple, pear, and cherry seeds, and sometimes Myrobalan seeds, are planted thickly in a seed bed, and the seedlings produced are transplanted to the nursery row the following winter. They are then cut back to an inch or two above the ground level.

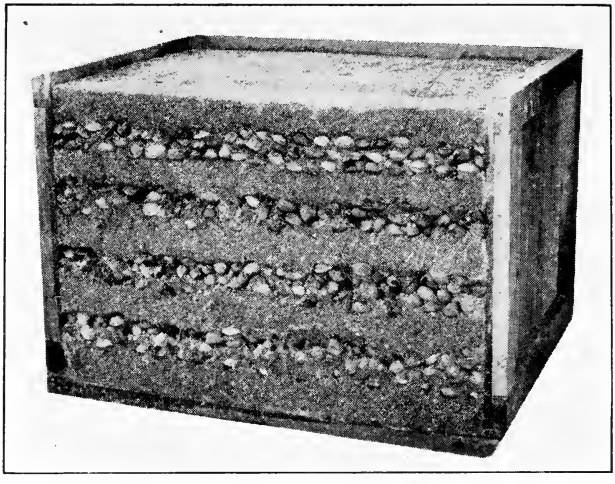


Fig. 1.—Seed stratified in sand; one side of the box removed.

The latter procedure results in a tree with roots one year older than by the first method.

If the seeds are planted directly in the nursery row in the fall, stratification is not necessary. This method is not commonly used, however, because favorable moisture conditions are difficult to maintain in the field, rodents are apt to destroy many of the seeds, and the weeds that grow during the winter may be difficult to remove without disturbing the seeds.

VEGETATIVE METHODS OF PROPAGATION

The principal vegetative methods of propagation utilized for deciduous fruits and discussed in the subsequent pages are as follows: budding, grafting, layering, cuttings, root suckers, and runners. In many cases a plant may be propagated by more than one of these methods. By long experience the nurseryman has ascertained how he can secure the most plants for the least outlay. A fruit grower may, however, in certain instances use a method that would not be practicable on a large scale.

BUDDING

Budding is the operation of placing a single detached bud upon a plant called the stock. This method is used by the nurseryman to propagate nursery plants and sometimes by the grower to change his trees over to another variety—that is, to top-work them. The actual procedure is the same in both cases. If old trees are being top-budded, however, they should be cut back the winter before the budding in order to obtain one-year-old shoots in which to place the buds.

Buds should be taken from the current season's growth of the tree desired. Only leaf buds (wood buds) are used, since flower buds would blossom and die. Leaf buds are usually smaller and sharper-pointed than flower buds. Although single buds are preferred for budding, clusters, including leaf and flower buds are sometimes used.

In nursery practice, buds are usually placed on the north side of the seedlings for protection against the sun. Some propagators, however, in the hot interior valleys of California where summer north winds are common, prefer to bud on the south side of the tree. Another point in favor of placing the bud on the south is that the side opposite the bud is subject to sunburn; if the bud is placed on the south the opposite side will be partially protected. Sunburn is very often followed by the entrance of flat-headed borers.

Budding is usually done as near the ground as it is convenient to work; but in the case of the walnut, the northern California black stock, which is resistant to oak fungus, is often allowed to extend a foot or more above the surface of the ground.

The actual method of placing the bud on the stock has little influence on the success of the budding as long as the cambium of the stock and the bud are joined. The cambium or growing layer is found at the junction of the wood and bark. Of the numerous methods suggested, however, only a few have been sufficiently rapid and easy to be generally used.

Late Summer or Fall Budding.—The time of budding, though usually in July and August, may be continued into September and October until the bark cannot be lifted. The buds are placed in trees resulting from seeds planted in the spring of the same year; or, in the case of apples, pears, cherries, and sometimes Myrobalan plums, the buds are usually placed in trees lined out in the nursery row in the spring. 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) about the time growth starts in the spring following the budding. Usually this cut slopes downward

from the side where the bud is located. All water-sprouts appearing below the bud should be removed at regular intervals.

June Budding.—If advance orders and inquiries indicate that the supply of fall-budded trees will not be sufficient to meet the demand and if the seedling trees have grown sufficiently in the three or four months since planting, June budding may be done in May or the first half of

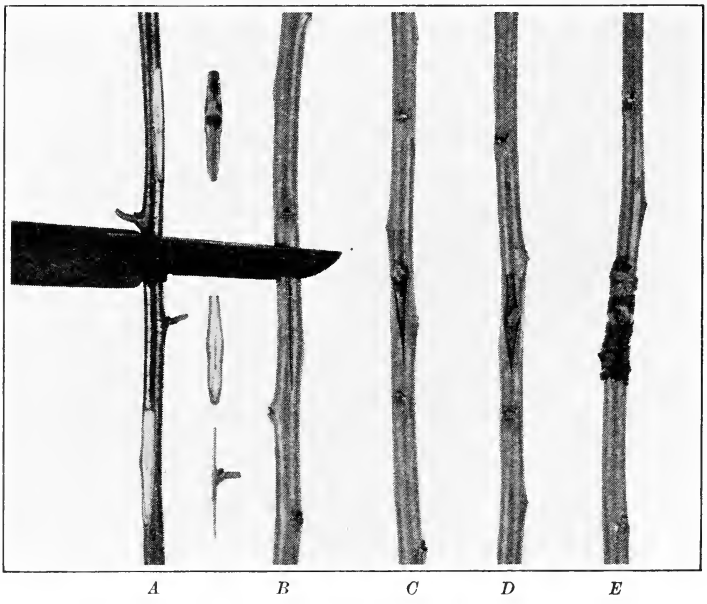


Fig. 2.—T or shield budding: *A*, bud stick with some buds removed (the cuts should be started below the buds); *B*, method of making the crosscut at the top of the vertical slit; *C*, bud partially inserted; *D*, bud in place; *E*, bud tied with a rubber band.

June. In recent years some nurseries have made it a regular practice to propagate a considerable number of trees by June budding.

The usual procedure in this work is to cut the seedling top off 2 to 5 inches above the bud 3 or 4 days after budding. Leave at least one leaf above the bud and several below. It may be necessary to bud as much as 8 inches above the ground in order to save a sufficient number of leaves below the bud. Cut back to the bud 10 to 16 days after budding. Thereafter, whenever shoots other than the buds appear, they should be shortened; and when the buds have grown into shoots 6 to 8 inches high and have plenty of leaves of their own, all other leaves and shoots should be removed. The budwood is collected from the current season's growth, and the wood is usually taken out of the buds. If growing conditions are ideal, a medium-sized tree suitable for planting in the orchard will be

obtained by the time growth stops in the fall; thus a year will be gained. The method described is relatively simple but the nurserymen who developed it state that heavy losses are apt to occur unless the work is carefully done.

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 a rounded point commonly found in budding knives. The leaves have been removed from the bud stick by severing the leaf stem or petiole close to the buds. Beginners often use the leaf stem as a handle to aid in inserting the bud, but expert budders generally hold the bud between the knife blade and the thumb.

The T cut in the stock that is to receive the bud is generally upright, but sometimes an inverted T has been used. Most budders make the vertical cut of the T first. They then make the crosscut and throw open the bark to receive the bud with a single movement. Some propagators, however, make the vertical slit last. In any case the bud is inserted into the T far enough so that its top does not project above the crosscut of the T. Although materials such as raffia and string have been used to tie the bud, they have been practically replaced by rubber bands, which do not have to be cut to prevent constriction of the stem. The rubber bands stretch as the tree grows and after a few weeks rot and fall off. Raffia or string, if used, should be cut in 10 days to 2 weeks. In any case, start wrapping at the top of the T and work down in order to prevent the bud from being forced upward.

With some plants better results have been reported when the wood has been removed from the bud; but in the case of deciduous fruits this is done only when June budding is practiced and in the few instances when T budding is used for walnuts.

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, removed from the seedling, is replaced with a similar patch including the bud desired. The piece of bark containing the bud is slid rather than pulled from the bud stick so that the small core of wood in the bud itself will be retained. Most propagators believe this to be a necessary precaution. The method and some of the special tools are illustrated in figure 3. As a good fit at the top and bottom of the patch is necessary, most tools used have two parallel knives to make the horizontal cuts. Some tools have vertical knives in addition; but if these are not present, an ordinary knife may be used, since a per-

fect fit at the sides is not essential. If the bark of the stock is thicker than that of the budwood, it may be necessary to pare down the stock bark 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 so com-

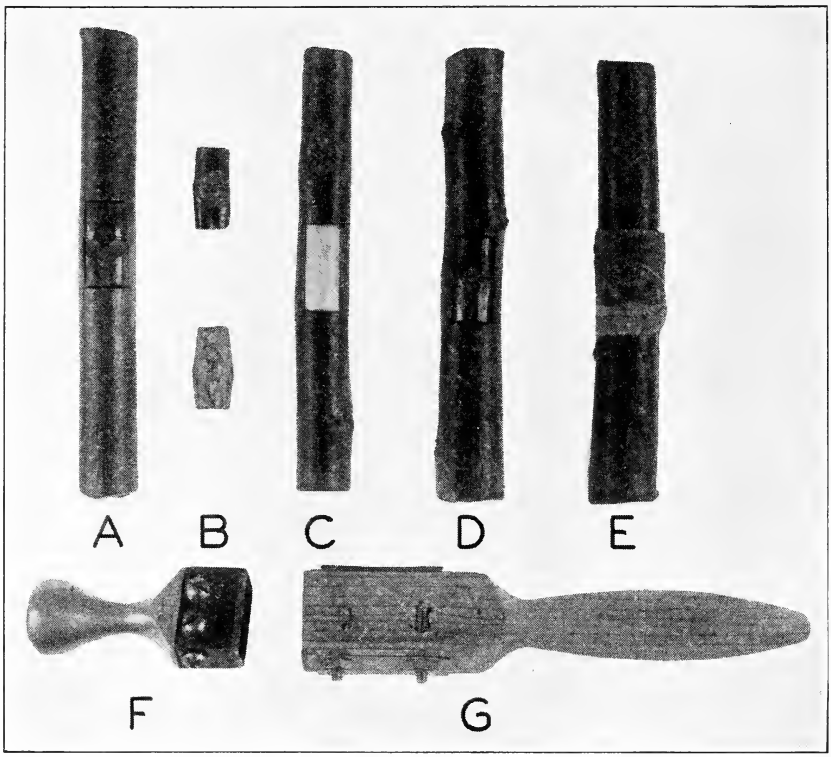


Fig. 3.—Patch or flute budding: *A*, bud stick with the patch cut but not removed; *B*, patches with buds, removed from the bud stick; *C*, patch of bark removed to receive the bud; *D*, bud in place; *E*, bud wrapped; *F*, patch-budding tool with four blades; *G*, patch-budding tool with two parallel blades.

monly used because they are less effective in preventing drying out. Waxed cloth, budding tape, and string should be cut in 2 or 3 weeks.

The bases of the leaves of trees commonly T-budded are not large and consequently do not interfere with the wrapping of the bud. Walnut and pecan leaf bases, on the other hand, are rather large and, unless carefully pared down, make wrapping rather difficult. Many propagators cut the leaves off the budwood, except for short stubs, a few weeks before the budding is to be done. By the time the bud sticks are to be used, the short stub of the leaf petiole or stalk has dropped off or may be easily removed.

The usual recommendation 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 in the case of walnuts because of the pithy nature of the stems and the rather large branches or seedlings sometimes budded. Losses from this cause are practically eliminated if the cut surface is waxed over.

Most nurserymen whip-graft the seedlings whose buds fail to unite, during the winter after the budding.

A *B* *C* *D*

Fig. 4.—Chip budding: *A*, stock with a chip of wood and bark removed; *B*, bud removed from the bud stick—the first cut is made completely through the bud stick below the bud; *C*, bud in place; *D*, bud tied with raffia.

Ring or annular budding is the same as patch budding except that the bark is removed entirely around the stem. This method is slower and has no particular advantage over patch budding.

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 may have to 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, in the form of 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, if care is not taken the patch may buckle slightly and not touch the stock under the bud.

Chip Budding.—Because the bark of grapes does not separate readily from the wood at any time in the season when good buds can be secured, chip budding (sometimes called "Yema grafting") is preferred to T budding or patch budding for grapes. Phylloxera-resistant rootstock rootings are planted in the vineyard in the spring and are budded in August or early September. For good results, the buds must be taken from canes sufficiently mature so that the color has changed from green to yellow or light brown. Figure 4 illustrates how a chip of wood and bark is removed from the stock and replaced with a similar chip carrying a single bud of the desired variety. The removal of the bud from the bud stick is facilitated by making the first cut at the base of the chip completely through the bud stick and at an angle of about 45 degrees. The buds are placed at about the ground level and are covered immediately with about 3 inches of moist soil. Raffia is preferred for tying because it will rot when covered with soil and does not have to be removed. Rubber bands used underground do not rot so readily as when exposed to the air and sun. The top of the rootstock is not removed until the following spring.

Chip budding is seldom used for deciduous fruits other than grapes.

GRAFTING

Grafting differs from budding, which is actually a type of grafting, only in that a short section of a one-year-old twig, called the scion, is placed upon the stock instead of a single bud.

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. The actual methods used will be discussed under these five headings.

ROOT GRAFTING

This method consists in grafting a scion 4 to 6 inches long on a whole root or a portion of a root. California nurserymen bud instead of root-graft, but the method has been used extensively in the colder parts of the United States in propagating apples and to some extent pears. 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.

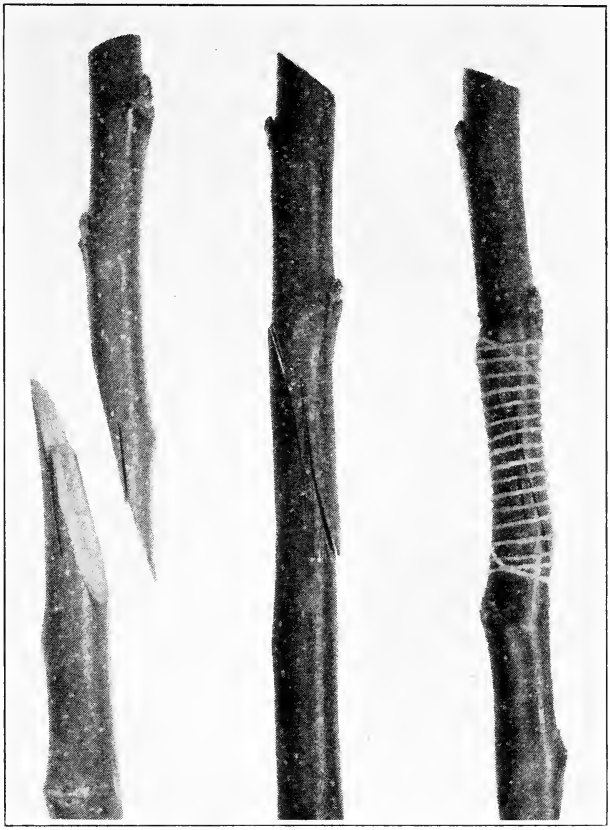


Fig. 5.—Whip or tongue grafting: *A*, stock and scion prepared; *B*, parts fitted together; *C*, wrapped with waxed light twine. For top-working, where the graft union is above the ground, thorough waxing is necessary. If the stock and scion are not exactly the same size, the cambiums cannot be matched on both sides. They are therefore fitted together in such a way that the cambiums of the stock and scion come together on one side.

Whip or Tongue Grafting.—At the base of the scion and the top of the stock, sloping cuts approximately 1½ inches long are made (fig. 5). Then on each of these cut surfaces, starting at a point about one-third from the tip, a reverse cut about ½ inch deep is made. This second cut should not be with the grain of the wood but should tend to be parallel with the first cut. The two pieces are then fitted together and wrapped.

Number 18 knitting cotton, dipped in melted grafting wax, or some similar light twine, is generally used as a wrapping material. Figure 5*C* illustrates a whip graft correctly wrapped for top-working. If root grafts are wrapped in this manner, enlargements often appear at the union which 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 a type of adhesive tape manufactured under the name of "nurseryman's tape" has been found to be better than string for piece-root grafts of apple. The edges of the tape are overlapped slightly so that the graft union is completely covered. Apple-root grafts are now ready to plant, but pear-root grafts are usually waxed over. If the work is done in the winter when the nursery is too wet to cultivate, it will be necessary to store the grafts in cool, moist sand, moss, or some similar material until early spring. Stored grafts will callus and should be handled carefully or 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.

Waxing of the graft is necessary when the whip graft is used in top-working young trees.

CROWN GRAFTING

This method is called crown grafting because the graft is made at the crown of the plant—that is, just below the surface of the ground. Sometimes northern California nurserymen, and usually those in southern California, crown-graft English walnuts instead of using a patch bud. The whip graft (fig. 5) is the method used, but it may have to be slightly modified if the stock is considerably larger than the scion. If the sloping cut on a large stock is made at the same angle as the cut on a small scion, the cut surface of the stock will be considerably longer than that of the scion. This difficulty is eliminated by cutting the stock off squarely and then making 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 that was removed from around the base of the tree is replaced. If the trees are to be planted where oak fungus is present, the graft union should be a foot or more above the surface of the soil, and the resistant northern California black walnut should be used as a rootstock.

Crown grafting is used in changing from one variety of grapes to another. In this case either the cleft graft or the notch graft, as discussed under top-grafting, is used. The graft is made 2 to 6 inches below the ground level and is covered with moist soil, but not waxed.

TOP-GRAFTING

Top-grafting is the usual method of changing from one variety of fruit to another. Top-grafting and top-budding, which has already been mentioned, are generally considered together as top-working. In top-grafting, scions should be placed in branches not larger than 3 or 4 inches in

Fig. 6.—Grafts placed in branches that are too large; it will be practically impossible to prevent wood rot in many of the stubs.

diameter. It is practically impossible to prevent the entrance of wood-rotting fungi into the large cuts shown in figure 6. If large trees are to be top-worked, usually the grafts must be placed high in the tree where reasonably small branches can be found. Such a procedure will be more expensive because more grafts are required. In addition, more branches are left that will have to be kept free of fruiting wood of the original variety. On the other hand, trees that are grafted high in reasonably small branches will usually come into bearing sooner than trees that are grafted close to the ground, and the income from this fruit will more

than offset the original higher cost. The tree shown in figure 7 illustrates a much better procedure than that shown in figure 6. In some instances grafting even higher in the tree than this would be feasible. The long

Fig. 7.—A more desirable practice than that shown in figure 6. The grafts are placed higher in the tree and in smaller branches.

scions shown in figures 6 and 7 made very good growth, but as a general practice they should be somewhat shorter than this because of the possibility 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. Leaving on part of the top is

somewhat more expensive and so is not common. The proper time of year to top-work trees depends mainly on the method used. If top-budding is to be practiced, the usual time will be in late June, as soon as well-matured budwood is available, or in July. Top-budding is usually done earlier in the season than the budding of nursery trees, because under field conditions the trees cannot be kept growing so vigorously as nursery trees, and so later in the season it is impossible to lift the bark. The time of year to top-graft will be discussed under the following methods of grafting.

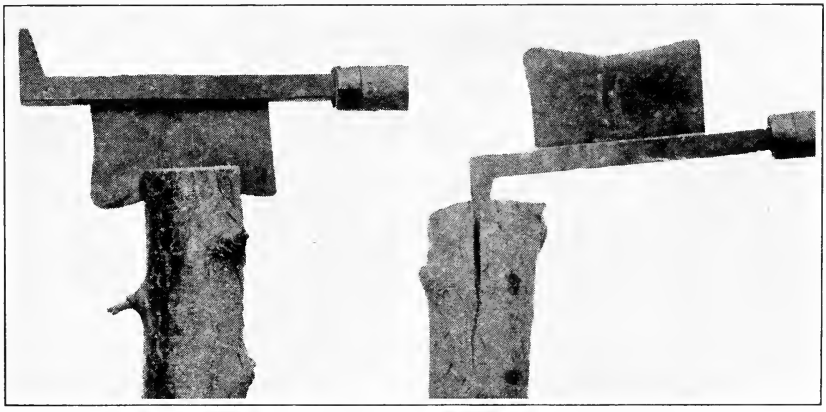


Fig. 8.—Cleft grafting. Left, stock split with grafting tool; right, cleft open, ready for inserting scions.

Cleft Grafting.—This method of top-working trees has probably been used more than all other methods combined. The work 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 not been thorough. On the other hand, most propagators believe that more scions will grow if the work is done before the trees have made much growth. Consequently, most cleft grafting is done in January, February, and March. Although no definite proof is available, many walnut grafters believe they are more successful if the work is delayed until the leaves begin to appear on the black-walnut stock.

The first step in cleft grafting, after the top of the tree has been sawed off, is to split the stock branches down the center (fig. 8). The tool used in splitting may be a special tool with a concave blade designed to cut the bark first and so prevent peeling; or it may be an old kitchen knife. In any case the knife is driven in 1 or 2 inches. It is then removed, and a

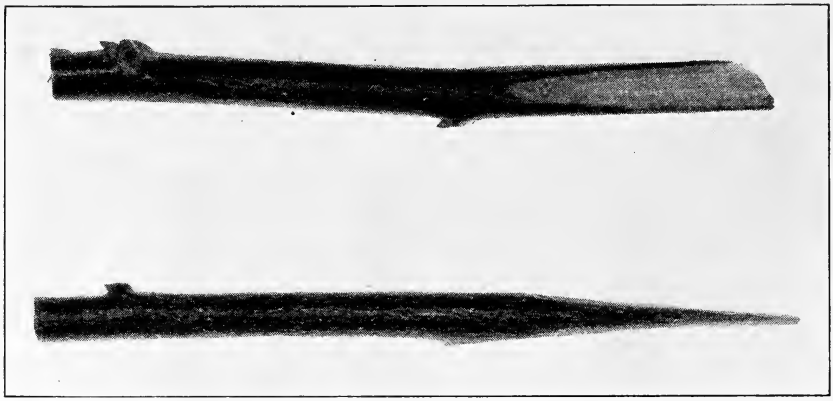
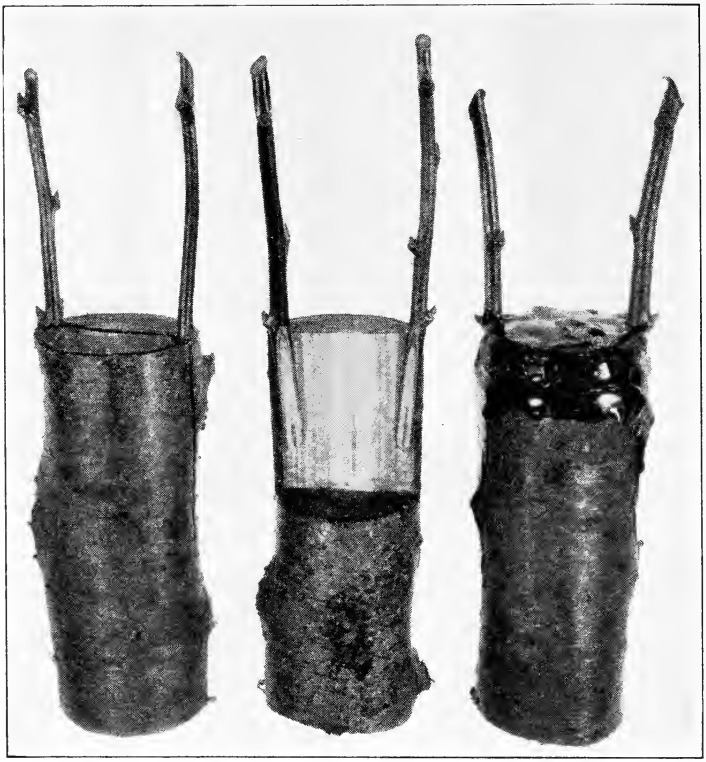


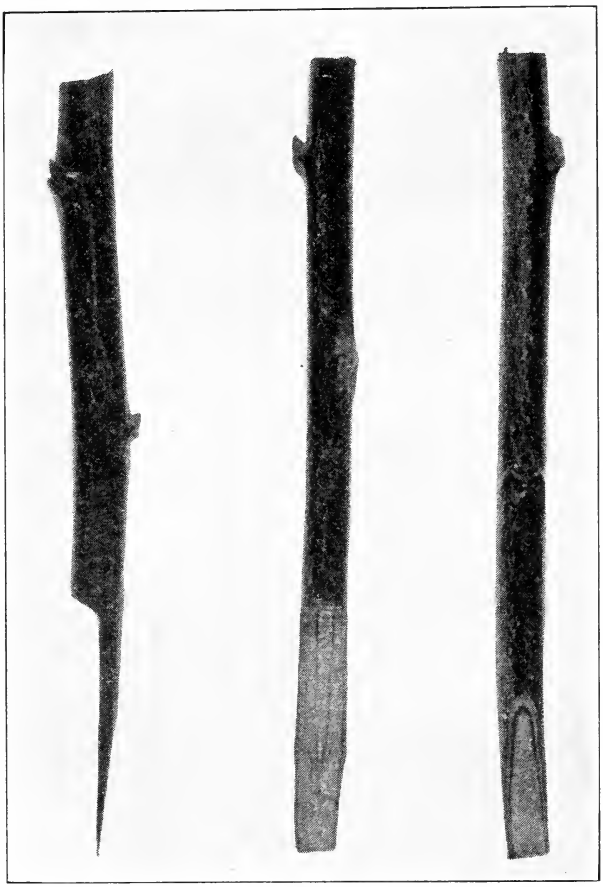
Fig. 9.—Cleft grafting. Two views of a prepared scion. These are cut wedge-shaped at the lower end, with the outer edge slightly thicker than the inner.



A *B* *C*

Fig. 10.—Cleft grafting: *A*, scions in place; *B*, part of the stock removed to show how the cambium of the stock is brought into contact with the cambium of the scion. The scions are slanted outward slightly to make sure that the cambiums touch in at least one place. *C*, Completed graft covered with wax.

narrow wedge driven into the center of the cleft or split to hold it open while the scions are inserted. The wedge is often a part of the tool used for splitting (fig. 8).



A B C

Fig. 11.—Bark grafting. Three views of a prepared scion: *A*, side view; *B*, side of scion that rests against the wood of the stock; *C*, opposite side from *B*. The scions are sometimes cut with little or no shoulder,

Scions 3 or 4 inches long and containing not over 2 or 3 buds (fig. 9) are cut 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 or growing layer of the stock and the cambium on the outer part of the scion. Figure 10*B*, which shows part of the stock cut away, illustrates the proper position of the scions. As this figure shows, the cambium on the inner side of the

scion does not touch the cambium of the stock. Consequently, if 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.

Figure 10*A* shows the wedge removed and the two scions in place. All cut surfaces, including the tops of the scions, are then waxed over. It is

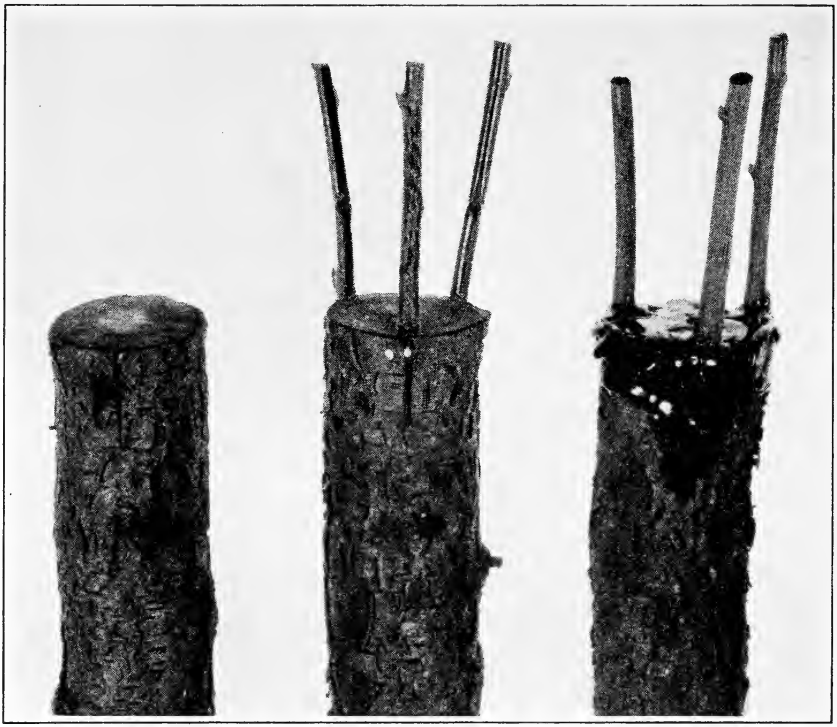


Fig. 12.—Bark grafting. Left, slit made in bark of stock; center, scions nailed in place; right, completed graft covered with wax. If nails are not used, waxed cloth, tape, or string should be wrapped around the stock to hold the scions in place.

possible to place more than two scions in one stock branch by making more than one cleft. If more than two scions seem desirable, however, the bark graft is to be preferred.

Cleft grafting is easily performed and may be done successfully over a rather long period, during the dormant season; but it has a disadvantage in that wood-decay organisms may get into the cleft.

Bark Grafting.—Since the stock is not split in this method of grafting, decay organisms may not 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 as scion wood. Therefore, in most cases, the scion wood must be gathered while still dormant and stored until needed, in sphagnum moss or sand in a cool place.

The scions are generally cut as shown in figure 11, but there are many modifications in the method. Slits are made in the bark (fig. 12), and the scions are inserted and nailed. Exposed surfaces are then waxed over. If the bark of the stock is fairly thick, a thin scion may be forced under the bark without a preliminary slit. If nails are not used, waxed cloth, tape, or string must usually be wrapped around the stock to hold the scions in place. This material should be cut when the tree begins to grow if it shows signs of constricting the stock branch. The side of the scion that rests against the tree is flat if these directions are followed. With average-sized stocks and scions this is not a disadvantage. If the stock is rather small and the scion large, however, the center of the scion will touch the wood of the stock, but the edges of the scion where the cambium is will not touch. This difficulty is easily corrected by making the inner surface of the scion concave with a curved chisel.

Two modifications of the ordinary bark graft discussed above are worthy of mention. In one instance two vertical slits are made in the bark of the stock the width of the scion apart. The strip of bark between the slits is partly raised; and the scion, cut as in figure 11, is pushed beneath it. The sides of the scion lie against the undisturbed bark of the stock. Nails hold the scion in place.

The other method consists of making one slit but raising the bark of the stock on only one side of the slit, so that one side of the scion will rest against the undisturbed bark of the stock. The scion is cut the same as the one shown in figure 11 except that the cut on the back of the scion (fig. 11*C*) is usually not centered but is made on the edge of the scion opposite to the side that rests against the undisturbed bark of the stock. The scion is held in place by nails which are driven through it and the raised flap of bark. The nails are driven in at such an angle that they draw the scion tightly against the undisturbed bark. This method is considered best by many successful walnut grafters.

Saw-kerf or Notch Grafting.—This method has not only the advantage of the cleft graft, in that the work can be done over a considerable period of time, but also the advantage of the bark graft, in that the stock is not split. 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.

A notch (fig. 13) is cut in the side of the stock branch with a knife; or a cut is first made with a saw, and the edges are smoothed with a knife. The scions, cut to fit the notch, are nailed in place, care being taken to match the cambiums of the stock and scion.

A modification of this method is used almost exclusively in some dis-

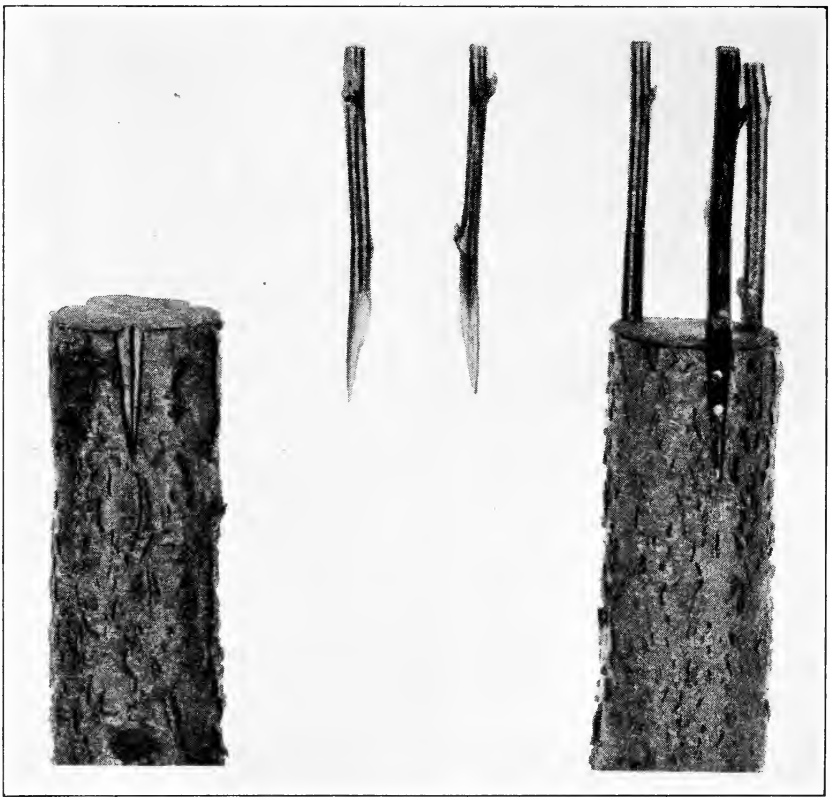


Fig. 13.—Saw-kerf or notch grafting. Left, notch cut; center, two views of a scion cut to fit the notch; right, scions nailed in place. The graft is now covered with wax.

tricts. The notch is made somewhat longer than illustrated, and the top of the notch extends almost to the center of the stock branch. Scions cut to fit this deep notch will be almost the same shape as those used for cleft grafting. If the scions are carefully cut and driven tightly into place, nails will not be needed.

Whip or Tongue Grafting.—This method, already discussed under root grafting, is satisfactory for grafting over young trees whose branches are the same size or slightly larger than the scions. The graft union should be thoroughly waxed.

Side Grafting.—This method is less common than those already discussed. The usual way to make the graft is illustrated in figure 14; but many modifications have been used, including some that require special tools. Although it is possible to side-graft large branches, the method is not ordinarily considered satisfactory for branches more than 1 inch in diameter.

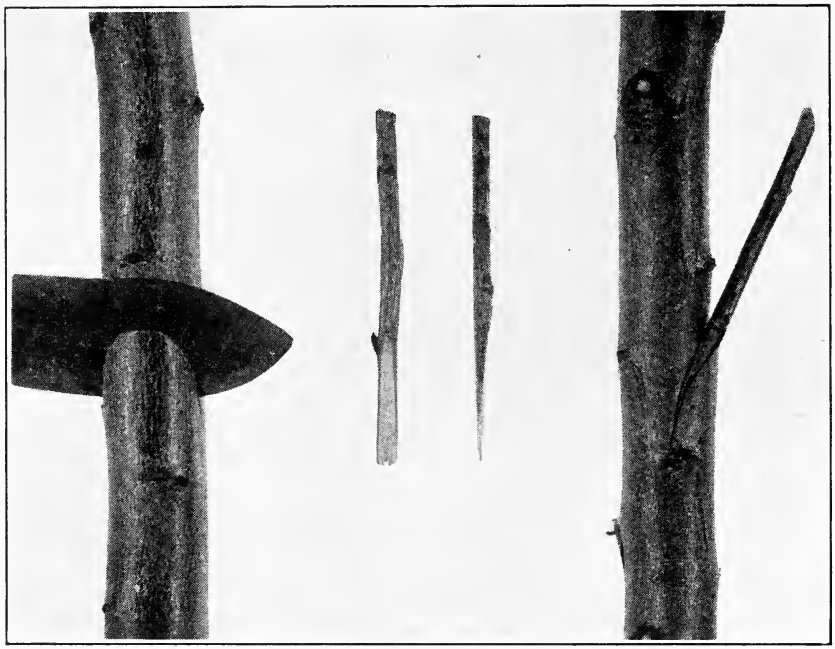


Fig. 14.—Side grafting. Left, oblique cut in the stock; center, two views of a scion; right, scion in place. Nails may be used to hold the scion if necessary. If the top of the grafted branch is to be removed at once, as is usually the case, a cut should be made just above the point of insertion of the scion. All cut surfaces should be waxed.

A chisel or heavy knife is used to make the oblique cut in the stock. The scion is usually cut wedge-shaped as for the cleft graft. The best contact of the cambiums will be obtained if the scion is placed as in figure 14, but the cambiums will touch in at least one place in any case. The stock branch is bent so as to open the cut, and the scion put in place. Although the spring of the wood will usually hold the scion in place, small nails or string are sometimes used. The stock branch is cut off just above the point of insertion of the scion, and all cut surfaces are waxed over.

Some 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.

SUBSEQUENT TREATMENT OF TOP-WORKED TREES

The care of the grafted trees during the first few years following grafting is as important as the grafting operation itself; but this fact is not commonly realized until breakage begins to occur because of heart rot and weak crotches.

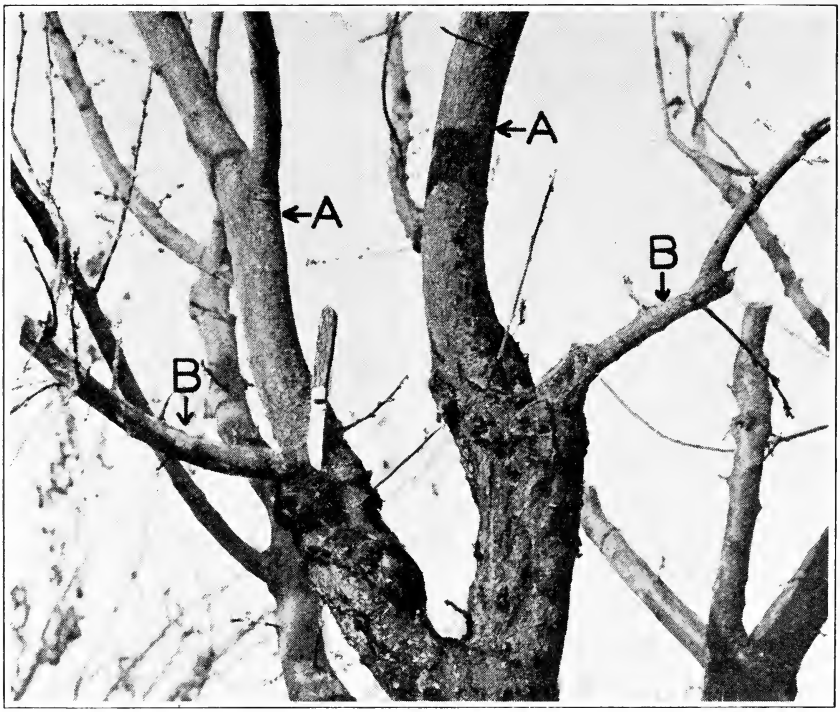


Fig. 15.—Apricot grafts after two seasons' growth. *A*, Graft that is to be saved. This was pruned lightly during the first dormant pruning and has made very good growth. *B*, Graft that is saved temporarily to help heal the stub. This was pruned heavily during the first dormant pruning and has made very little growth. All grafts were approximately the same size at the end of the first season's growth.

As soon as the grafting is completed, the tree should be thoroughly whitewashed to prevent sunburning. From this time until the trees begin growing, nothing further 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 may be prevented either by removing the water-sprouts entirely or by thinning them out and cutting the remaining ones back

severely to keep them from becoming too large. The latter procedure is better because they help protect the tree from sunburn and also help manufacture food for the roots until the grafts become large enough

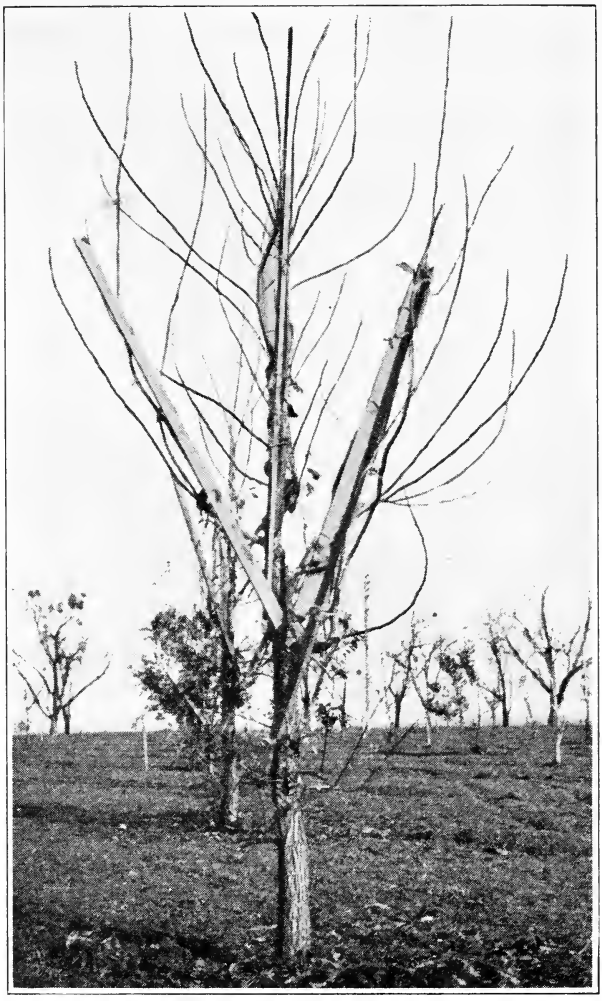


Fig. 16.—One method of supporting young grafts.

to take over that function. If some of the water-sprouts are left on, however, they must be kept under rather close observation to prevent them from becoming too large.

If more than one scion grows on a branch, probably not more than one should be retained permanently, because a weak crotch is apt to be formed. The branches that are to be saved should be pruned as lightly as possible to encourage them to grow rapidly; and those that are to be

removed later should be pruned heavily to prevent them from becoming too large (fig. 15). The suppressed branches helped to heal over the stub and are removed when this purpose is accomplished.

If only one scion grows, the square shoulder on the side of the branch

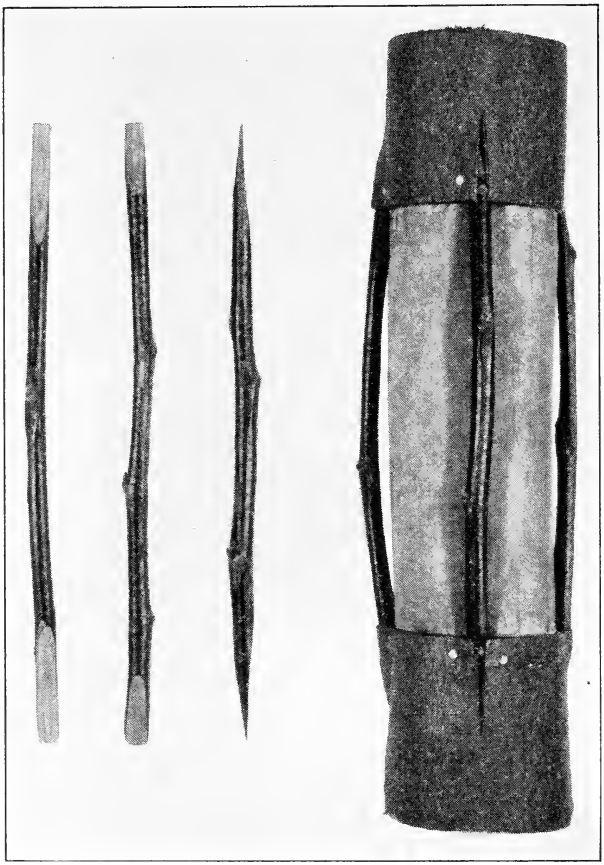


Fig. 17.—Bridge grafting. Left, three views of a prepared scion; right, scions in place. The part of the graft where the scions are inserted under the bark should be waxed over.

opposite the growing scion will die and very likely decay before it is healed over. More rapid healing will take place if a sloping cut is made downward from the side where the scion is growing. The cut surface should be waxed thoroughly.

Often young grafts, especially of walnuts, should be supported with laths or props for a few years (fig. 16). In those instances, however, where the grafts have made a small or moderate amount of growth it may not be necessary to support them or give them any other special

treatment. If grafts of stone fruits such as apricots and plums make extremely rapid growth and if it is considered uneconomical to use supports, the best procedure is to pinch off a few inches at the ends of the grafts after they have made about 18 inches of growth. Later pinching back may also be desirable. This treatment slows down the growth

Fig. 18.—Bridge grafting. This tree, injured by rabbits, was saved by bridge grafting.

enough to allow the succulent shoots to mature somewhat and hence prevents them from breaking or bending. It may also be desirable to thin out some of the shoots to reduce the wind resistance.

BRIDGE GRAFTING

Each year many trees are partly or completely girdled by rodents, pear blight, or mechanical injury. By bridging over the injured area, the tree can often be saved. In the early spring, as soon as the bark of the injured tree will slip, scions are inserted into the live tissue (fig. 17) above and below the wound. It is often necessary to gather the scions while still dormant and store them in moist sphagnum moss or similar material in a cool place in order to have them in a dormant condition when needed. The use of many scions is desirable, but 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 same manner as described under bark grafting. Often the bark of the tree is thick and strong enough to allow the end of the scion to be inserted without a preliminary slit. Another modification is to make two slits in the bark, the width of the scion apart. The strip of bark between the slits is partly raised, and the end of the scion shoved beneath it. In any case, the scions are held in place with nails. If the scions 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. It is also desirable to cover the exposed wood in the girdled area with wax or some of the materials used in covering pruning cuts. All buds that start to grow on the scions should be removed.

Figure 18 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.

INARCHING

Inarching or grafting by approach is a method whereby two plants are made to unite with each other while growing on their own roots. In the case of fruit trees, a young seedling is generally planted beside an older tree and grafted into the trunk (fig. 19). The usual method of making the graft is to remove a strip of bark the width of the seedling trunk and 2 to 6 inches long from the trunk of the larger tree and then to lay the seedling trunk in this slit. Approximately one-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 the end of the seedling is cut wedge-shaped and shoved under the bark at the top of the slit; but this precaution is not considered necessary. The seedling should then be nailed in place, and the cut surface waxed over. It will probably be best to save some of the shoots that appear on the inarches 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.

Inarching may be successfully used to save trees that have had part of their roots killed 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 the blackend trouble, a considerable number of pear orchards on Japanese root-

stock were inarched with French-pear seedlings. The object was to eliminate the Japanese root when the inarches became large enough. A survey of these inarched orchards has shown, however, that many of the

Fig. 19.—Showing two season's growth after inarching.

grafts have not grown and that those which have grown are often so small as to be ineffective. These observations and the possibility of the entrance of decay organisms when the Japanese root is finally severed indicate that inarching is not feasible when used for this purpose.

GRAFTING WAXES

Most grafting waxes consist of 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 prac-

tice 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 very 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 fish glue in a double boiler with just enough water to dissolve it. In another container melt all the other ingredients,

Fig. 20.—Tip layers of blackberry. The arrow points at the tip of a layered cane which will develop into the top of the new plant.

and then allow this mixture to cool down somewhat but still to be in a liquid form. Add the fish glue slowly, with stirring, to the partly cooled wax. If the fish glue is added rapidly while the wax is still very warm, the whole mass will boil over.

If only small amounts of wax are required, it will be more convenient to buy prepared waxes.

In recent years water emulsions of asphalt and similar compounds have appeared under various trade names. They are easily applied cold with a brush and are usually satisfactory.

Waxed cloth and string may be prepared by dipping muslin or other cloth and number 18 knitting cotton or similar string in hot grafting wax.

LAYERING

Layering is the operation of rooting stems while they are still attached to the parent plant. Some of the different types of layering are discussed below.

Simple Layering.—This method consists of laying down a branch and covering part of its length with soil, leaving the tip uncovered. Roots usually form more readily if the buried portion of the branch is girdled or notched. During 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 grapes, but not in the commercial production of deciduous fruits.

Tip Layering.—Trailing blackberries, dewberries, loganberries, youngberries, and black raspberries are commonly propagated by tip layering. The ends of the canes are covered with a shovelful of earth

Fig. 21.—Trench layering. The soil has been removed to show the plant in position. These rooted shoots were produced in one season.

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. 20).

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 with the trunk inclined at an angle of 30° to 45° from the horizontal. During 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 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. In the case of plums, all layered parts should be covered about an inch deep with fine soil just before the buds open. In the early

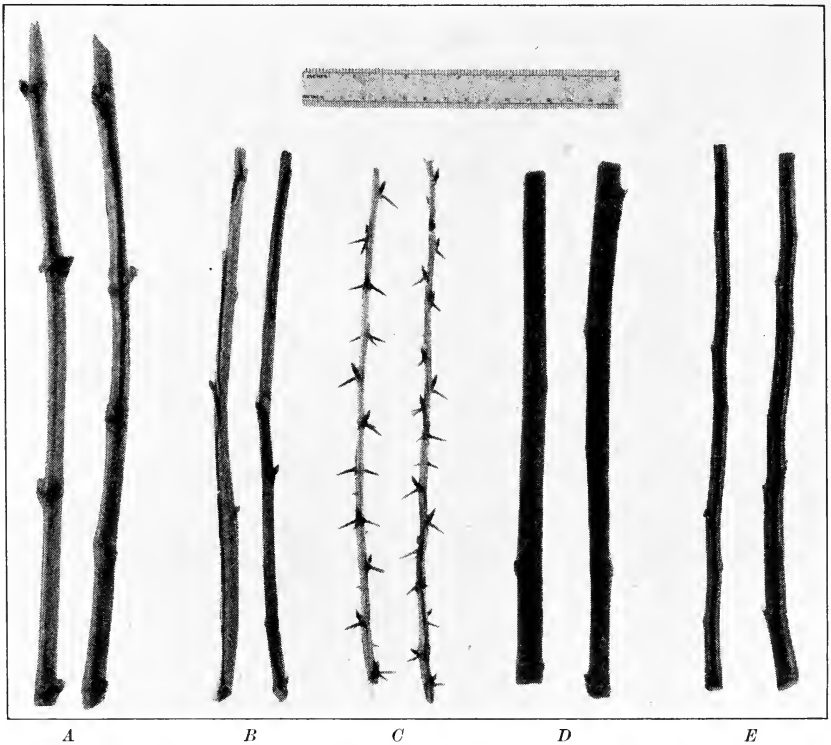


Fig. 22.—Hardwood cuttings: *A*, grape; *B*, currant; *C*, gooseberry; *D*, fig; *E*, quince.

winter, after the shoots have grown one season, the soil is drawn away from the layers, and the rooted shoots (fig. 21) are detached. The old layers are left uncovered until the following spring, when the program of the previous year is repeated.

In the case of filberts, suckers from fairly large trees are usually trench-layered instead of the tops of young trees as discussed above. At present this is the method most generally used for propagating filberts.

The method 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 of budding seedling stocks, it will come into general use only in instances where own-rooted trees can be proved to be better, or certain selected rootstocks superior.

CUTTINGS

Propagation by cuttings consists of placing a piece of the mother plant such as a stem, root, or leaf under conditions favorable for root development. Cuttings are named according to the part of the plant from

Fig. 23.—Left, gooseberry cuttings; right, rooted gooseberry cutting after a year's growth.

which they are taken and the condition of the plant part. Two types of cuttings—hardwood stem cuttings made from dormant stems, and root cuttings—will be discussed.

Hardwood Cuttings.—These cuttings are usually made in the early winter from the previous season's growth or, occasionally, from older

wood. In cold climates they are usually stored in cool, moist sand or moss until spring. In most parts of California the cuttings can be planted out of doors as soon as they are made; but, since the soil may be too wet to cultivate in the winter, cuttings made at this time are often stored until spring. Such fruits as grapes, currants, gooseberries, figs, and quinces

Fig. 24.—Root suckers of red raspberry. *A*, Parent plant; *B*, suckers in different stages of development.

are commonly propagated by this method. Cuttings are usually made from 5 to 14 inches in length. In any case at least two buds should be included. Some typical hardwood cuttings are illustrated in figure 22. If the buds are rather close together on the cutting, the two cuts may be made without attention to the buds. If, however, the buds are far apart, the upper cut should be made a short distance above the upper bud, and the lower cut immediately below the bottom bud. Roots usually form more readily in the vicinity of the nodes or joints where the buds are; so if the lower cut was not made as described, a portion of the lower part of the cutting would probably have no roots. Cutting near the buds keeps the length of cuttings whose buds are far apart within reasonable bounds. Cuttings are generally so planted that only one bud is above the ground level. They are commonly placed 2 or 3 inches apart in the nursery row. Figure 23 shows typical gooseberry cuttings before rooting and a similar rooted cutting after a year's growth.

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 in length and planted in the nursery row. Raspberry and blackberry cuttings are generally planted horizontally 2 or 3 inches deep. Root cuttings of some plants, however, are planted vertically with the top at the ground level. Loose soil is then drawn over them to prevent drying out.

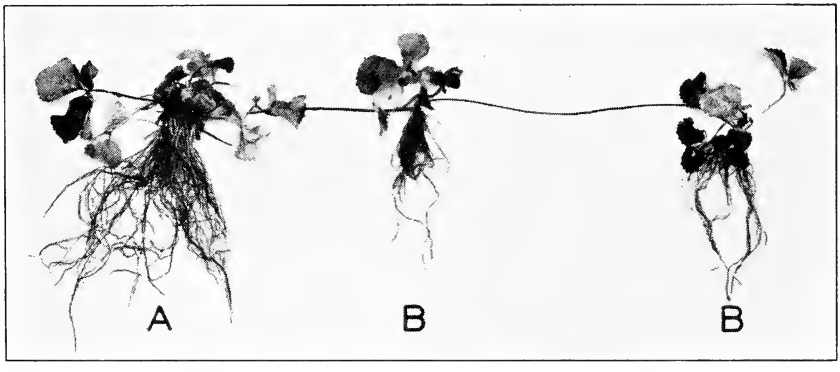


Fig. 25.—Propagation of strawberry plants by runners. *A*, Parent plant; *B*, new plants formed at nodes or joints.

ROOT SUCKERS

Some plants such as red raspberries, upright blackberries, and the Stockton Morello cherry (a rootstock for cherries) are propagated by root suckers. The suckers, together with some roots, are usually removed from the parent plant during the winter (fig. 24).

RUNNERS

This method of propagation is a natural type of layering. The runners of strawberries, which are commonly propagated by this method, root at every other node or joint without assistance (fig. 25). The bud at each rooted node sends out leaves so that a number of new plants are produced.

PROPAGATION OF SUBTROPICAL FRUITS[5]

It is the purpose of this section to briefly describe or summarize the usual methods of propagation and nursery practices employed with the subtropical fruits in California. It is not necessary to present a detailed discussion of each fruit since most of the propagation methods are more or less standardized and are adequately described and illustrated in the section on deciduous fruits to which reference should be made. For a few fruits, however, it has seemed desirable to describe the methods of propagation and nursery practices in some detail. For the others merely a brief summary—the principal rootstocks, standard methods of propagation, special nursery practices and precautions—is presented. For the convenience of the reader the fruits treated are listed in alphabetical order.

With many subtropicals, especially the tender evergreen sorts, a properly prepared seed bed has much to do with success in their propagation. The seed-bed 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 evergreen sorts, the soil in the nursery should be neither too light nor too heavy; fine sandy loams and silt loams ordinarily give the best results. The rows to which the seedlings are transplanted ("lined out") from the seed bed are usually spaced 3 to 4 feet apart and the seedlings 16 to 18 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 economic source is provided by electric heating cable.[6] Adequate leaf surface is important in the rooting of softwood cuttings; usually 3 to 5 leaves should be left per cutting.

AVOCADOS[7]

Rootstocks for Avocados—Seedlings of the Mexican race (*Persea drymifolia*) are commonly used for rootstocks in California. Guatemalan (*P. americana*) and natural Mexican-Guatemalan hybrids are also used to

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

[6] Moses, B. D., and James R. Tavernetti. Electric heat for propagating and growing plants. California Agr. Exp. Sta. Cir. 335:1–20. 1934.

[7] Hodgson, Robert W. The California avocado industry. California Agr. Ext. Cir. 43:12–26. 1934.

a considerable extent. The West Indian race of *P. americana* is not used since it is too subject to frost injury.

Formerly seeds were gathered and planted without regard to source or maturity of the fruit from which they came. This resulted in blocks of nursery seedlings varying considerably in type and vigor, with consequent lack of uniformity and desirability for nursery trees. The present tendency is to select trees or blocks of trees of a certain race or variety, 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, for the seedlings are usually more vigorous and, in the case of some varieties, probably 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 being accumulated for planting. They can be safely stored in a cool place in moist sand or sawdust. Seed should not be allowed to dry out. As a rule nurserymen sprout the seeds prior to planting in the nursery row. For the most efficient use of space and maximum uniformity in the nursery 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 in the nursery row the following March and April.

The seed is planted with the base or large end down and with the apex or pointed end at soil level. A mixture of half soil and half sand, well screened and mixed, makes a good planting medium. To avoid burning of the tips of the seeds they should be covered with an inch or two of clean sand or the bed should be shaded.

Seedlings may be transplanted either bare-root or with the soil attached. If to be lined out with soil attached, they should be placed in the seed bed at approximately 4-inch intervals to permit cutting out a block of soil with each seedling as it is taken up. A slightly more expensive method is to plant the seeds in open-bottom paper pots ($2\times2\times6$ inch is satisfactory for Mexican seeds) purchased or made for that purpose. 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 closer together in the seed bed. Seedlings moved bare-root must have their leaf surface reduced at the time of planting. This is best accomplished by cutting off about two-thirds of each leaf. Irrigation water should follow the planters down the nursery row to prevent drying and each seedling should be shaded with a shingle.

Some nurserymen plant avocado seeds direct in the nursery row. The

Fig. 26.—Desirable budwood of four commercial varieties: (1) Taft; (2) Anaheim; (3) Nabal; (4) Fuerte. (From Ext. Cir. 43.)

seeds must 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. Sunburning of the tips is prevented by applying a layer of sand or sawdust. The nursery must be kept moist by sprinkling until the seeds have sprouted and the seedlings have made some growth after which furrow irrigation may be employed.

Seedlings transplanted in the spring are usually large enough for budding by fall. For best results a seedling should have a minimum diameter of about ½ 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. The buds must be well developed but not too old. In general the best buds are the well-developed buds on suitable wood nearest the terminal. Such wood is hardening and is usually well rounded. The Fuerte variety has good buds over a rather long range whereas the Nabal frequently has a relatively short area of good buds between the too-soft terminal and the older buds that are starting to shell or drop off (fig. 26).

Budwood may be used soon after cutting or 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 using. Clipping the leaves off a budstick a week or 10 days prior to removal from the tree is believed by some to be beneficial. For spring budding the buds should be cut and stored, since the buds are in the best condition before the bark on the nursery seedlings slips properly.

Shield budding is practiced, using a shield an inch or more in length. The bud is wrapped very tightly with the eye exposed. Prepared budding cloth, muslin, rubber bands, or cotton twine are used for wrapping. If a budding cloth is used it should contain a minimum of wax of a high melting point because the avocado bud is very subject to injury by melting wax during hot weather. Some successful avocado propagators use a good grade of untreated bleached muslin for wrapping in preference to other materials.

Avocado seedlings grow rapidly and the wraps may cause constriction; on the other hand the buds are likely to be lost if the wraps are taken off too soon. Therefore, it is best in wrapping to make a minimum number of turns below the bud and a larger number of turns above, where constriction is not so injurious and where tight wrapping is necessary to keep the bark flaps in place. The wraps must be watched closely and, if necessary, unwrapped and retied—loosely below and tightly above the bud.

In from three weeks (in the spring and early summer) to five or six

weeks (in the fall) the seedlings should be partially cut back to force the buds into growth. The wraps should not be disturbed for about two weeks after topping. At this time the buds should be examined and if the bark flaps are well healed-in the wraps may ordinarily be taken off. After a week or two, according to the variety, the seedlings may be cut back to within a foot of the bud. The placing of shingles to protect the stocks and buds from sunburn or wind is desirable at this time. Early bud growth can be tied to the stubs. The stubs should be kept free of

Fig. 27.—Modified cleft graft. Left, the narrow wedge of wood ready for removal. Right, scions in place with all cut surfaces thoroughly sealed. (From Ext. Cir. 43.)

sprouts with the exception of enough growth near the top to keep them from dying-back.

About the time the bud growths are ready for the second tie, the stakes should be placed. Most avocado nurserymen use 1×1 inch redwood stakes 5 feet or more long. 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") should be done after the bud growths have reached a height of 2 to 3 feet.

Top-working Avocado Trees.—Avocado trees may be top-worked at any time, although the winter and spring months are probably best. In selecting scion wood for grafting, large scions are preferable. The wood should be well matured and must have two or three good plump buds or a ring of nodal buds. In many cases both may be had on the same scion. With the exception of the side graft, described later, short scions are used in avocado grafting.

The trees are top-worked in several ways. The modification of the saw-kerf graft with the scions driven in place is commonly employed. Nails are not necessary when this method is used. Other systems of top-graft-

Fig. 28.—Avocado tree side-grafted using two scions. Left, shows the triangular patch of bark removed and the scion in place and waxed. Right, the proper position for a scion with respect to the trunk. (From Ext. Cir. 43.)

ing used are the split cleft graft and a modification of it in which the cleft is made by sawing out a narrow wedge of wood (fig. 27). Any of these methods may be used on the large limbs or on the main trunk.

In top-working, "nurse" limbs are apparently not as important as with other fruits and the tendency is to cut the tree off a few feet above the ground and insert the scions in the trunk. After waxing-in, the

scions are protected with a perforated paper bag and the trunk is shaded with burlap or whitewashed. If the trunk is unsound or the bud union poor it is desirable to cut the tree off below the bud union, in which case the scions may be at ground level. If for any reason the grafts fail, a second trunk section can be cut off and the tree regrafted, or the sprouts that will have arisen may be shield-budded. Occasionally propagators bud into large limbs in preference to grafting.

At the season of the year when the bark is slipping, a bark graft or a special type of side graft may be used; with the side graft it is not necessary to cut off the top of the tree—an advantage at times. It is necessary, however, to have a rather flat surface for side grafting, and for this reason a trunk or limb under 4 inches in diameter should not be top-worked by this method.

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 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. 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. 28).

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

CITRUS FRUITS

Rootstocks for Citrus Fruits.—The citrus rootstock situation has undergone considerable change during the last few years. Until comparatively recently a high percentage of citrus trees were propagated on the sour or bitter-orange rootstock. At the present time the sweet-orange rootstock is gaining in favor and some interest is being shown in grapefruit as a rootstock. Rough-lemon and trifoliate-orange rootstocks are used to a limited extent only.

The sweet orange is congenial with all the commercial varieties of

citrus fruits grown in California and in general produces large, thrifty trees. It is subject to gum disease, however, under certain conditions.

The sour orange is resistant to gum disease but is not so congenial as the sweet stock, which is evidenced in a slightly dwarfing tendency. It seems definitely not compatible with the major strain of Eureka lemon propagated during the past decade and a half and is not recommended for the Satsuma mandarin.

Little is known of the grapefruit stock and its reactions. It appears to exhibit more variation than either the sweet or sour-orange rootstocks. The present indications are that it is hardy, congenial, and produces a good root system.

The Rough lemon is the most vigorous of all citrus rootstocks and is disease resistant. It appears to lower the quality of oranges and mandarins, however, and cannot be generally recommended. It may prove to be a good stock for lemons.

The trifoliate orange is a dwarfing stock which stimulates early production; but the trees are slow growing, generally small, and may be short-lived. It is apparently most useful as a rootstock for mandarin varieties.

Nursery Methods with Citrus Fruits.—Until recently a high percentage of the sour-orange seed used by California nurserymen was brought in from Florida where it was harvested from wild orange trees. This practice naturally resulted in wide variation in vigor in the resulting seedlings. The present trend is toward the selection and propagation of superior sour-orange trees for seed parents. Sweet-orange seed has generally been obtained from California seedling trees. More care in the selection of parent sweet-orange trees is also 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 at which time 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 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 seed bed. 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 following spring the seedlings are pulled and lined out in the nursery row. The seed bed 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 out. 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 chopping them back to about 8 inches in length. The roots must be kept moist prior to 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 a long spade. Irrigation water should follow the planters down the row. After planting, the nursery should be gone over, and all seedlings that missed being shortened by the original chopping should be cut back about one-half with pruning shears.

The young seedlings will be large enough to bud 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 $\frac{3}{8}$ inch should be attained before the seedling is budded. For nursery propagation well-rounded budsticks from one or two-year-old growth 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 fall or spring. Fall budding in October or November, allowing the buds to remain dormant until spring, is the preferred practice. In the spring the seedlings are either topped or lopped to force the buds into growth. In topping, which is the common practice, 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 which time the wound is covered with wax or pruning compound.

Citrus trees may be propagated by cuttings.[8] Several species root readily in propagation frames equipped with bottom heat and in which the humidity is kept high.

Top-working Citrus Trees.—Citrus trees may be top-worked by budding or grafting though the latter is rarely employed in California. For fall work top-budding into the old bark is preferable. The main limbs are thinned in July or August leaving three or four scaffold limbs. This pruning will tend to "set" the bark. In August or September the bark

[8] Halma, F. F. The propagation of citrus by cuttings. Hilgardia 6(5):130–156. 1931.

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 the back of a knife blade. The wraps are left on from four to five 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 use the same procedure as for fall budding; the wraps need not be left on as long, however. A bark graft, holding the scions 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 should be used in top-working and the use of cured wood is advisable. A variety of materials has been used for wrapping citrus buds; for nursery work rubber bands and waxed cloth are preferred, and in top-budding waxed cloth is used almost exclusively.

All exposed portions of the tree should be whitewashed immediately after budding or grafting. Nurse limbs are 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.

DATES

Date varieties can be propagated only by means of suckers or offshoots. Seed propagation, which has been used in the past, 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 are suckers that 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 prior to 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 the spring. Large offshoots are preferable where available; a 20-pound offshoot is considered the minimum size desirable. The offshoot is balled, severed from the parent palm by means of a broad-bladed, long-handled chisel driven with a sledge hammer, and moved to its permanent location. Special care is required to prevent injury of the parent palm and breaking of the ball of the offshoot.

FIGS[9]

Rootstocks for Figs.—Since the fig roots readily from hardwood cuttings and trees propagated in this manner are commercially satisfactory, rootstocks are not commonly employed. Because of its sensitivity to nematode root-knot infestation, however, a rootstock resistant to this trouble would be valuable and would undoubtedly be extensively used. In this case hardwood cuttings of the resistant stock would first be rooted and the rooted cuttings then shield-budded in the nursery row.

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 preferred is ½ to ¾ inch in diameter, well seasoned, and with short internodes. The cuttings are made 8 to 12 inches long (fig 22*D*), 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 at or 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 during the dormant season is the usual practice. After waxing-in the scions, the grafted stubs should 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, using two vertical slits, is the method most used. The stubs should be wrapped to keep the bark in place.

[9] Condit, Ira J. Fig culture in California. California Agr. Ext. Cir. 77:22–23, 36–39. 1933.

Where top-budding 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 must be used. After the buds have healed-in the budded shoots or branches are cut back to force the buds into growth.

OLIVES

Rootstocks for Olives.—The olive is propagated by three methods: softwood cuttings, hardwood cuttings, and budding or grafting nursery seedlings.[10] The method last mentioned is now used very little owing to the fact that rooted-cutting trees have proved to be entirely satisfactory.

Nursery Methods with Olives.—Where a large number of trees are required, soft wood 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.

For the amateur or where only a limited number of plants are required, hardwood cuttings are most satisfactory. They are made 14 to 16 inches long from wood ¾ to 1½ inches in diameter.

Top-working Olives.—Olive trees are easily top-worked by either patch or shield budding or grafting, using either a cleft graft or a bark graft. 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

[10] Bioletti, F. T., and F. C. H. Flossfeder. Growing and grafting olive seedlings: Part II, Grafting olive seedlings. California Agr. Exp. Sta. Bul. 268:322–326. 1916. (Out of print.)

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 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 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[11]

Rootstocks for Persimmons.—The *lotus* persimmon (*Diospyros lotus*) is most commonly used as rootstock for the Oriental persimmon in California. It is easily propagated, is moderately drought resistant, and produces a fibrous root system that is easily handled in transplanting. It is, however, very susceptible to crown gall and where the soil is infected with the crown-gall organism the use of this stock cannot be recommended.

The Japanese, or Oriental, persimmon (*Diospyros kaki*) itself makes a good bud union and is somewhat resistant to crown gall. It is not as resistant to excessive soil moisture as the *lotus* and *virginiana* stocks and because of its long taproot with few fibrous laterals requires special care in transplanting.

The *virginiana* (*Diospyros virginiana*) rootstock has a fibrous root system and is resistant to excessive soil moisture for which reason it is

[11] Ryerson, K. A. Culture of the oriental persimmon in California. California Agr. Exp. Sta. Bul. 416:34–42. (Revised 1933 by R. W. Hodgson.)

best adapted to low or poorly drained areas. It suckers badly, however, and is somewhat difficult to propagate. Trees on this rootstock come into bloom later, and thus occasionally avoid late spring frosts.

Nursery Methods with Persimmons.—Persimmon seeds are usually stratified in sand in the fall and 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. After grafting all exposed surfaces should be sealed and the scions entirely covered with fine soil. Bench grafting is occasionally practiced.

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

Top-working Persimmons.—The persimmon tree is readily top-worked using a bark graft or a cleft graft.

POMEGRANATES[12]

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 by layering.

SANTA BARBARA SOFT-SHELL VARIETIES OF PERSIAN OR ENGLISH WALNUTS[13]

Rootstocks for the Walnut.—For a discussion of rootstocks for the walnut see the section on rootstocks for deciduous fruits, page 6.

Nursery Methods with Walnuts.—Walnut seeds are either planted direct in the nursery row to a depth of 4 to 6 inches in January or February or stratified and germinated, and then set out in the nursery row in early spring. Northern California nurserymen usually patch bud in

[12] Hodgson, R. W. The pomegranate. California Agr. Exp. Sta. Bul. 276:176–179. 1917. (Out of print.)

[13] Batchelor, L. D. Walnut culture in California. California Agr. Exp. Sta. Bul. 379:28–30; 32–39. Revised 1936 by L. D. Batchelor and O. Lee Braucher.

the late summer, allowing the buds to remain dormant until spring at which time the seedlings are cut back to force the buds into growth. In southern California the common practice is to crown graft during the dormant season using a modified whip graft. 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 either cleft-grafted or bark-grafted. If young limbs are suitably placed the tree may be top-budded using a patch bud. Top-working of Persian walnut trees is much more difficult than the working-over of black walnut trees and much more follow-up work is necessary for success.

CERTAIN MINOR SUBTROPICAL FRUITS

The Cherimoya.—The seed, planted to a depth of ½ to ¾ inch, germinates readily in a warm soil. The seedlings may be shield-budded or whip-grafted. Budwood should be cut before the buds start to swell in the spring and stored until the bark slips on the seedlings. Cherimoya trees have been top-worked by cleft grafting; other methods of top-working may be as satisfactory, however.

The Feijoa.—This fruit is commonly grown as seedlings but it is advisable to use named varieties. 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.

The Guava.—The guavas come relatively true to type from seed and are usually grown as seedlings (see feijoa). They are difficult to propagate from cuttings; layering is sometimes practiced.

The 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 prior to 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. Jujubes require high temperatures so care must be exercised not to move the seed out in the open too early since 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 using a whip or cleft graft and 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.

The 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 beds prior to lining out in nursery rows. The seedlings are usually large enough to bud in 18 months. They are shield-budded in October and November using well-matured wood, and cut back to force the buds the following January. Seedlings may also be whip or cleft-grafted in the nursery row. Large trees are top-worked by cleft grafting.

The 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.

The 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 prior to planting. The seedlings are shield-budded in the late spring and early summer using well-matured budwood. Sapote trees are easily top-worked using a bark, saw-kerf, or cleft graft.

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