GRAFTING *and* BUDDING

By W. P. Duruz

Federal Cooperative Extension Service
Oregon State College, Corvallis

Extension Bulletin 528

September 1939
Revised May 1948

Summary

Graftage is the operation of inserting a scion into a stock so that they will form a union and grow together. The essential points are to bring the cambium layers of the stock and scion together, bind them firmly in place, and prevent drying out until they have grown together.

The reasons for graftage are:

- Many fruit and ornamental plants do not come true to variety from seed, and do not otherwise propagate easily.
- Some varieties on certain rootstocks may be made more productive, more hardy to low temperature, more vigorous, or resistant to disease or insect injury, or they may be accommodated to adverse soils.
- As varieties become unpopular or undesirable, they may be changed to new and better sorts. Furthermore, several varieties or species, if desired, may be placed on a single stock.
- Repairing of injuries and changing of root system may be accomplished by certain kinds of grafting.

Theoretically, plants that are closely related botanically are capable of being intergrafted. Thus, plants of the same species usually, but not always, can be grafted successfully. There is no general rule, except that based on experience with particular combinations.

The time for grafting is generally in the early spring. Scion wood for this operation, however, must be taken while it is dormant, kept cool, and not allowed to dry out. Scions grow out after grafting, producing new tops the same season. Budding, on the other hand, is usually done in the summer, buds being taken from mature wood of the current season's growth and inserted in the stock. They unite and new tops are produced the following season.

The methods of grafting and budding are easily learned and as easily practiced, with satisfactory and profitable results.

Grafting *and* Budding

By W. P. Duruz

Professor of Horticulture, Oregon State College

Introduction

GRAFTING was already an ancient art at the time of the early Greeks and Romans. Virgil, in his *Georgics,* written about 35 B. C., describes cleft grafting as follows: "The knotless stocks are cut and the passage cloven deep into the solid wood with wedges; then the fertile scions are inserted, and in a short time, a huge tree shoots up to heaven with prosperous boughs, and admires its new leaves and fruits not its own."

The art of graftage is defined as the operation of inserting a part of one plant into or upon another so that they will form a union and grow together. Graftage thus includes grafting and budding. *Grafting* properly refers to the use of a scion (cion), which is a short piece of stem bearing one or more buds. *Budding* refers to the use of a single bud attached to a part of the stem.

In grafting and budding, the important point is to bring the cambium layer, or growing tissue, of the scion to meet the same tissue of the stock. The cambium is a very thin layer of cells found between the bark and the sapwood; it produces new wood and bark cells that carry plant foods. It can be seen only under the microscope, but its position can be determined by peeling the bark, the cambium being the tissue that pulls apart. Part of the cambium cells remain on the surface of the sapwood and part remain on the bark when it is peeled.

After the scion and stock have been joined together, care must be taken to prevent drying out of the cut surfaces while the union is being completed. In grafting, some covering material, such as grafting wax, is applied. In budding, tying down of the peeled bark is usually enough.

Graftage is always a secondary operation. The stock (rootstock or understock) must be first grown from seed, cuttings, layers, or other means, and later grafted or budded to the desired variety. Theoretically, plants that are closely related botanically are capable of being grafted. But this is by no means a sure guide.

Experience finally determines the limits of grafting. (See page 29 for chart showing grafting affinities.) For example, apples and pears are closely related but they do not intergraft satisfactorily.

Hawthorne and pear, which are somewhat more distantly related, can be grafted one to the other successfully. Pear can be grafted on quince, while the apple is seldom if ever propagated on the quince, and the quince does not grow well on either the apple or the pear.

Apples are successfully grown only on apple stock, either standard or dwarf. The peach can be grown on the plum and vice versa. The apricot can be grafted on the peach, plum, or prune, but is not satisfactory on the almond. The sweet cherry can be grafted on the sour cherry, but will not graft onto any of the other stone fruits, even though they are closely related botanically.

The best measure of the success of the graft union is the thriftiness of the resultant growth. To be successful, the two parts must unite firmly, but the union must not impede the activity of the whole plant, or seriously check the growth of either stock or scion and result in any impairment of functions. As the graft union increases in age, it generally becomes stronger, although there are some exceptions.

Purposes

The reasons for grafting and budding are:

- To perpetuate a variety.
- To increase the ease and speed of multiplication.
- To produce some radical change in the nature, habit, adaptation, or disease resistance of stock or scion.

Many fruit plants do not come true from seed so it is necessary to propagate them by grafting or budding. It may be quicker and cheaper to obtain a large number of individuals of a certain variety by means of budding or grafting than by any other means. If a variety becomes unpopular or undesirable, it may be changed to new and more promising production by grafting or budding.

Sometimes the grower desires more than one kind of flower or fruit on a plant; this can be accomplished by budding or grafting as great a number as there is space to accommodate. A variety may be made more productive, more vigorous, or more resistant to injury from cold, or it may be accommodated to adverse soil conditions, by working it to a particular type of rootstock. When it is desired, a dwarf tree may be produced by working it on to a slow growing or dwarfing stock. Repair to injured areas, such as those caused by breakage and rodents, may be accomplished by bridge grafting or inarching. In fact, the entire root system of a tree may be changed to a new root system by inarching seedlings planted at its base. Gradually new roots of the seedlings will nourish the original top, the old root system eventually becoming secondary. Examples of the latter

case are French pear seedlings inarched to Bartlett pear trees originally on Japanese root; also myrobalan plum seedlings inarched to prunes originally on almond root.

The effects of grafting and budding are indirect, for the union is mechanical and not physiological (Figure 11G). The individual inherent characteristics of the scions or buds are preserved essentially the same as they were on the parent stock from which taken. Any difference of one on the other is probably caused by nutrition or rest-period influence. For example, dwarfing stock causes the scion to grow more slowly, perhaps, because less moisture is supplied. A rootstock with a different rest period may influence the time of maturity, flavor, and color because of advancing or slowing the activity of the top. On the other hand, according to observations by nurserymen and others, the scion variety may influence the type of root system of the stock.

Season

Grafting

The usual time for grafting is in the early spring (February to March). Winter or late fall grafting can be done, but is not so successful. Scion wood should be taken in the dormant season, selecting healthy, mature wood of the previous season's growth about the diameter of a lead pencil or slightly larger.

The scion wood should be kept dormant and not allowed to become dry. Scion wood is best preserved by burying it in moist, but not wet, moss, shingletow, or sawdust, or by wrapping it in moist burlap or paper, and storing it in a cool place.

Walnut scion wood should be taken in late winter and kept cool in a cellar or in cold storage at 36° to 45° F. until spring (April or May). Scion wood taken from dormant trees may be used at once if the buds are not becoming too active. If the scion buds have begun to swell noticeably, they are usually not satisfactory.

The stock, on the other hand, may be grafted when it is becoming quite active. In fact, for walnut grafting it has been found best to wait until the new shoots on the stock have grown a few inches, before the dormant scion is grafted onto it.

Budding

The season for budding most plants is in the late summer (August to early September). This is desirable because buds of the present season are mature and the bark of the stock can still be slipped. The buds unite during the remainder of the summer and produce their shoots the following spring. Spring (March) budding is done in a few cases—for example, flowering cherry budded high

on mazzard stock. With some roses the bud wood can be kept dormant in cold storage, preferably by dipping in paraffin, until June, and budded in current season's growth. Such buds will grow and produce shoots the same summer.

Bud wood should be taken from the desired strain, well matured, healthy, and cut not long before using. The best propagators cut bud sticks the same day as budding. Bud sticks should be cut as used and must be kept moist at all times, usually with their butt ends in water, so that the buds do not lose their freshness.

Equipment

The tools (Figures 1 and 2) and equipment necessary for grafting and budding may be purchased from nursery supply companies, seed houses, or hardware stores. Of course the grower can make his own tools or use substitute materials he has on hand. He may wish to use a tool carrier, such as a carpenter's apron, or small box strapped to the waist, or carried by hand.

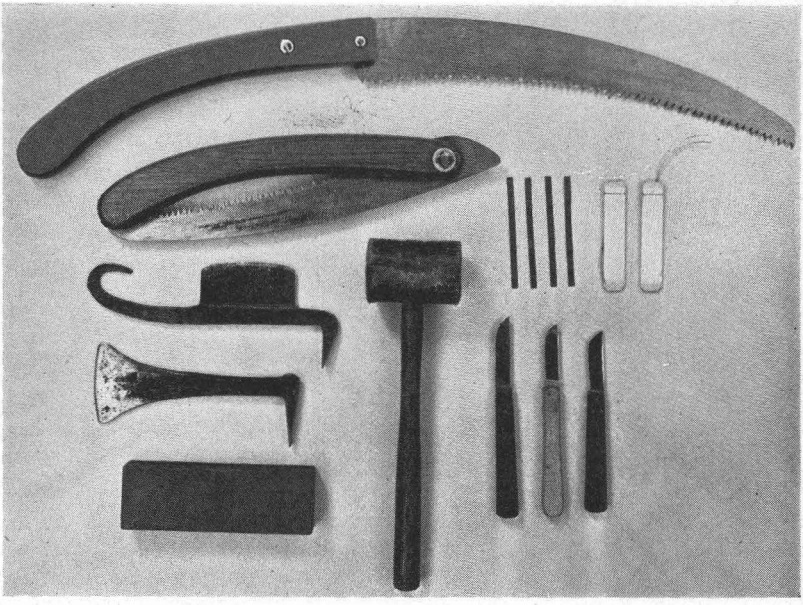
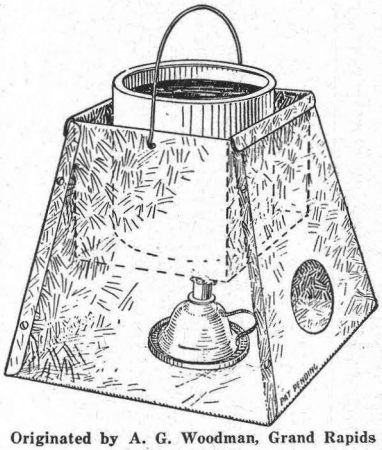


Figure 1. Set of grafting and budding equipment includes pruning saws, clefting chisels, mallet, rubber budding strips, labels, grafting and budding knives, and a whetstone.

Grafting equipment

Tools for grafting include a grafting knife, clefter, mallet, pruning saw, and possibly a hammer and some brads. Some kind of grafting wax or grafting compound will be needed during the grafting season, and should be obtained in advance. Proprietary or homemade compounds may be used (See page 28). These are prepared as either cold or hot waxes. Hot waxes are generally preferred because they fill the cracks and seal the openings more effectively and cover more surface than the cold waxes.



Originated by A. G. Woodman, Grand Rapids

Figure 2. An economical and satisfactory melting pot with container and lamp for warming the wax.

Budding equipment

The tools for budding are few and simple. A round-bladed budding knife for shield or T budding, or other types of knives for special budding, tape, cotton string, raffia, or rubber budding strips for tying the buds, and a whetstone for sharpening the knife, are the essential items. Rubber budding strips are pieces of rubber 3/16 by 3¼ inches that can be stretched to 16 inches in length. Special budding knives for patch and other budding may be used.

Divisions of Graftage*

Scion grafting

Scion grafting is performed on the root, stem, trunk, or scaffold branches (top-working). Bridge grafting is a form of scion grafting that uses a long scion to bridge over a wound. The scion serves as a conductor connecting two healthy regions of the plant. Inarching is a form of bridge grafting in which the lower part of the scion is on its own roots. A sucker or a seedling may be planted beside the tree, the stem is then used as a scion, as in bridge grafting, to carry sap to the upper part of the tree.

* *Grafting and Budding*, by Charles Baltet, translated from the French in 1910, contains more than 180 illustrations of different methods of grafting.

Budding

Buds may be placed in the stem, trunk, or the scaffold branches as they are in scion grafting. The difference between budding and scion grafting is that in budding the buds are generally placed in one- or two-year wood where the bark is not thick. Nursery budding is performed on young stock. Orchard budding is performed on new growth after the large limbs have been severely cut back (dehorned), to produce new shoots at the desired height from the ground.

Types of Grafts

The technique of putting the stock and scion together varies according to the diameter of the stock, character of the wood, conditions of growth, and other factors, including the expertness and preference of the operator.

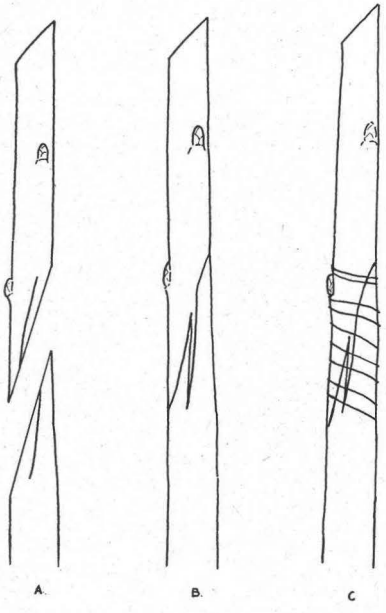


Figure 3. Detailed steps in whip or tongue grafting.
A. Stock and scion prepared with tongues.
B. Stock and scion with cambiums matched together.
C. Union bound in place with string.

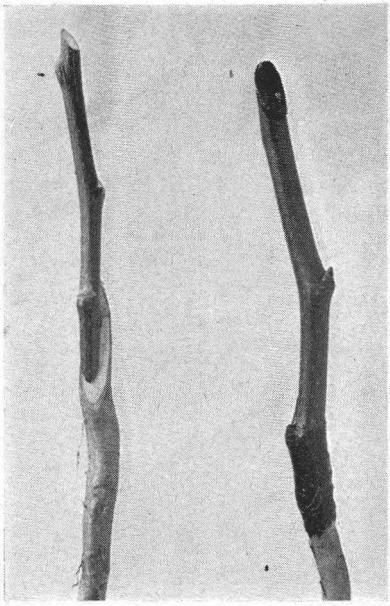


Figure 4. Whip (root) graft. *Left:* Scion in place. *Right:* Scion waxed.

In placing scions, one should try to visualize the future growth so as to determine the new framework. Select upright rather than horizontal scaffold limbs, and those that are suitably placed to produce well-balanced, mechanically strong trees.

Low-hanging, flat, or weak limbs should not be used, except for safety branches or "sap-pullers," that are needed for food manufacture until the new top is sufficiently well developed to take care of the tree. These limbs are later cut off, or if well placed, they too can then be grafted.

Whip or tongue grafting

Whip or tongue grafting is practiced when the stock is relatively small in diameter, and nearly the same as that of the scion. A long sloping cut is made through the scion, then a tongue cut is made midway between the center and upper edge of the exposed surface by drawing the knife vertically and working it across the grain of the wood (Figure 3). The stock is prepared in the same way; then the two pieces are fitted together so that the cambium layers join, at least on one side, if they are unequal in diameter. The union is tied with raffia, string, tape, or rubber budding strips. The cut surfaces are waxed usually as soon as the grafts are made (Figure 4).

This method, when used indoors, is sometimes termed bench or house grafting, where suitable seedlings that have been previously grown are grafted by propagators working at tables or benches.

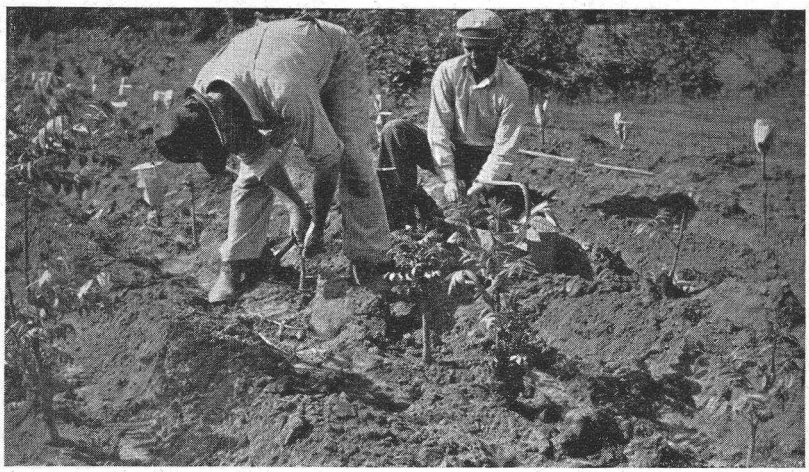


Figure 5. Nursery grafting of black walnuts, using the whip graft. A large butcher knife being used by the grafter for cutting stock and scions smoothly and quickly. After scions are placed they are tied and covered with paper bags for protection.

Completed grafts are tied in bundle, according to variety, and stored in a cool place in moist sand until spring, when they are planted out in the nursery row to grow for a year before being transplanted to a permanent location. By this method also small trees or vines are top-grafted in place (Figure 5). A modification is sometimes em-

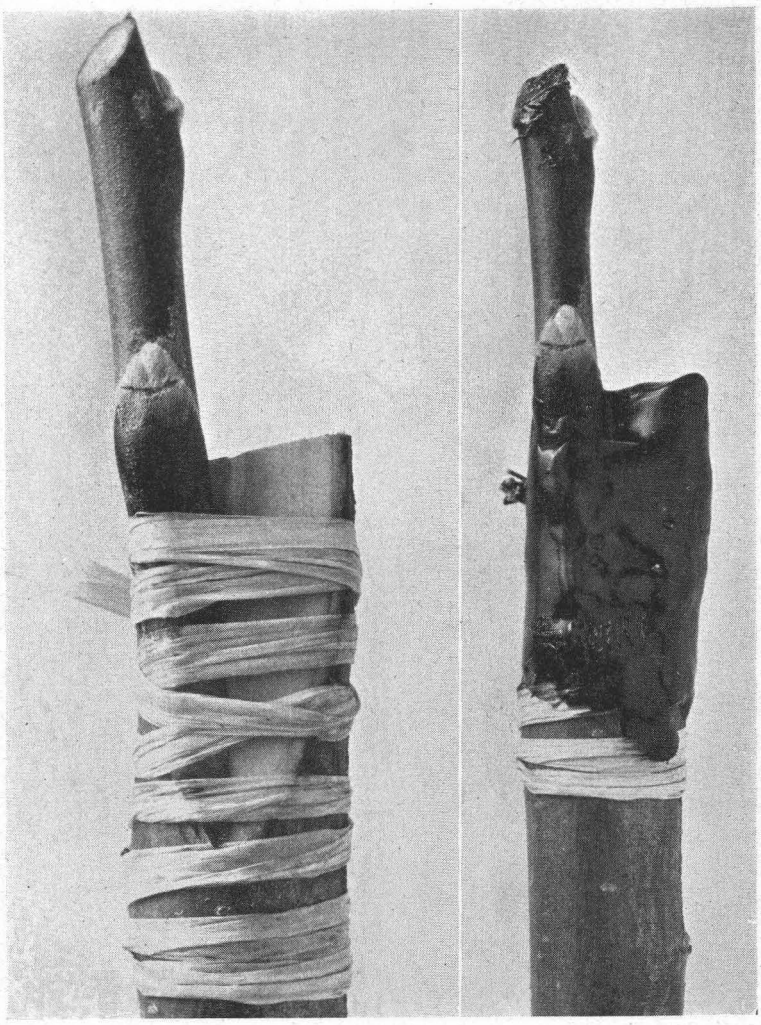


Figure 6. *Left:* Modified whip graft with scion held in place with raffia. *Right:* Scion waxed over. Ties should be cut after graft starts to grow well, to avoid girdling.

ployed where the stock is sawed off at right angles to the grain, followed by a sloping cut, which is then slit to form a tongue. The scion, also cut with a tongue, is inserted so the cambiums match on one side (Figure 6).

Bark grafting

Bark grafting is one of the surest types of grafting and permits less decay than some other types. It can be done, however, only when the bark can be slipped; that is, when the cambium is active. The stock is sawed off at right angles to the grain, then a vertical cut is made with a knife through the bark, extending about an inch and a half down the side of the stock. With the tip of the knife blade the bark is separated from the wood at the junction of the slit and the sawed surface, exposing the cambium next to which the scion will be placed.

The scion is cut with a long, sloping cut, extending from the opposite side of a bud through the scion. A transverse cut is then made halfway through the scion opposite the bud, and a vertical cut is made extending along the middle of the scion. The inner portion at the base of the scion is removed, leaving the remainder with a shoulder and the cambium exposed (Figure 7). A short diagonal cut on the lower outside completes the scion preparation. The scion, inserted at the top of the slit, is gently forced down between the wood and the bark, with its shoulder finally on the top of the stock. The scion needs to be held firmly in place, however, by driving small nails or

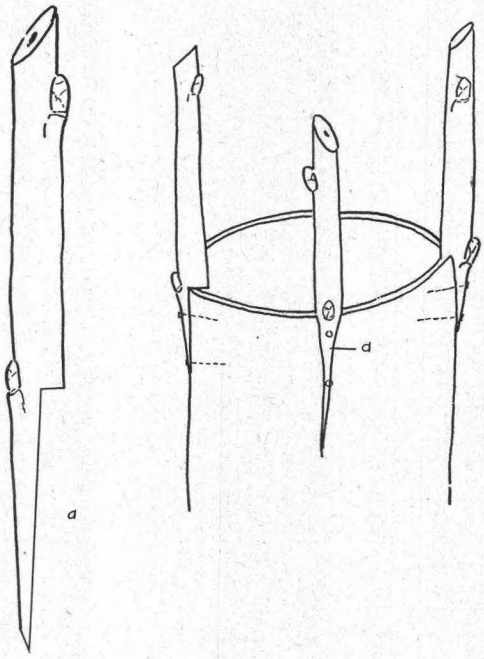


Figure 7. Diagram showing bark grafting with scion (a) showing the vertical, horizontal, and transverse cuts that expose the cambium on three surfaces. The bark on the stock is peeled back after being split, the scion inserted and held in place by two brads driven through the bark and scion.

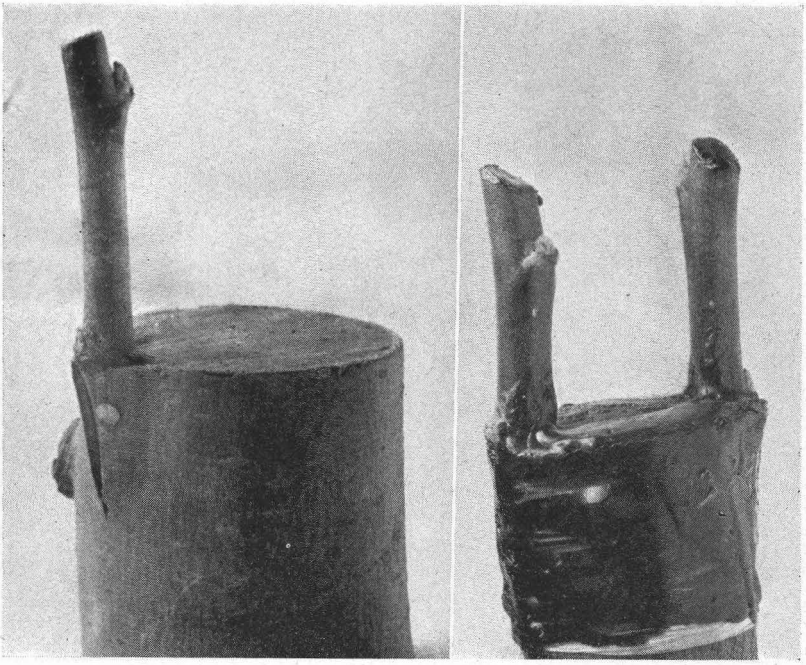


Figure 8. *Left:* Bark graft with scion held in place with brads. *Right:* Bark graft with scions held in place with raffia, and waxed.

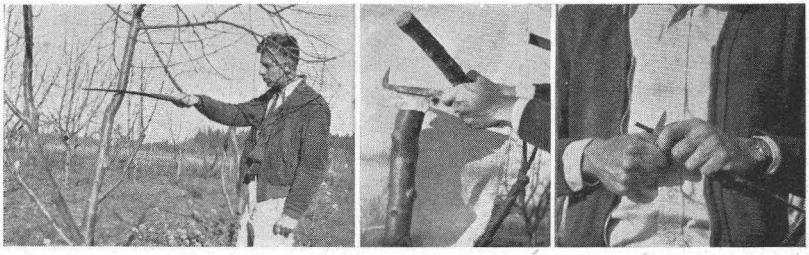


Figure 9. *Left to right:* Sawing off the stock. A smooth place on an upright, vigorous limb is chosen. An undercut is made first and then it is sawed straight across the grain.

Driving the clefting chisel into the stock, using a wooden club.

Cutting the scions. Holding the scion wood and knife firmly near the body, the arms and shoulders are pulled back with a quick motion.

brads through it into the wood, or tying it with string, tape, or raffia (Figure 8). Several such scions may be placed, the number depending on the size of stock. Wax is applied to all the cut surfaces.

Several modifications of this method are in use. If a scion is much larger in proportion to the stock, only the center of the scion, if flat, will touch the wood of the stock, and the edges will not be in contact with the cambium. This can be corrected by using a curved chisel to shape the inside of the scion, making the inner surface concave rather than flat. There are also other methods for inserting the scion, but they are not essentially different from the method above described.

The union resulting from bark grafting is not as strong as some others, and supports should be provided to which the new shoots may be tied as they grow out. The supports should be allowed to remain for several years until the union is sufficiently strong. Each year new wood is formed over the union, adding to its strength.

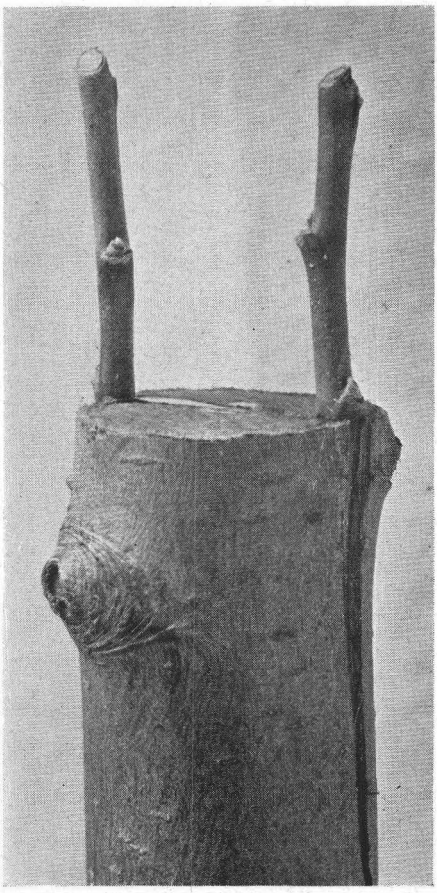


Figure 10. Cleft graft with scions in place.

Cleft grafting

Cleft grafting is the standard method for grafting limbs 1 to 3 inches in diameter. This method has the advantage that it can be done when the bark will not slip, and it results in the formation of a strong union the first year. A limb is chosen that is smooth and free from knots. The stock is sawed off at right angles to the grain (Figure 9). The clefting chisel is placed across the middle of the sawed surface and struck a few sharp blows with a wooden mallet or

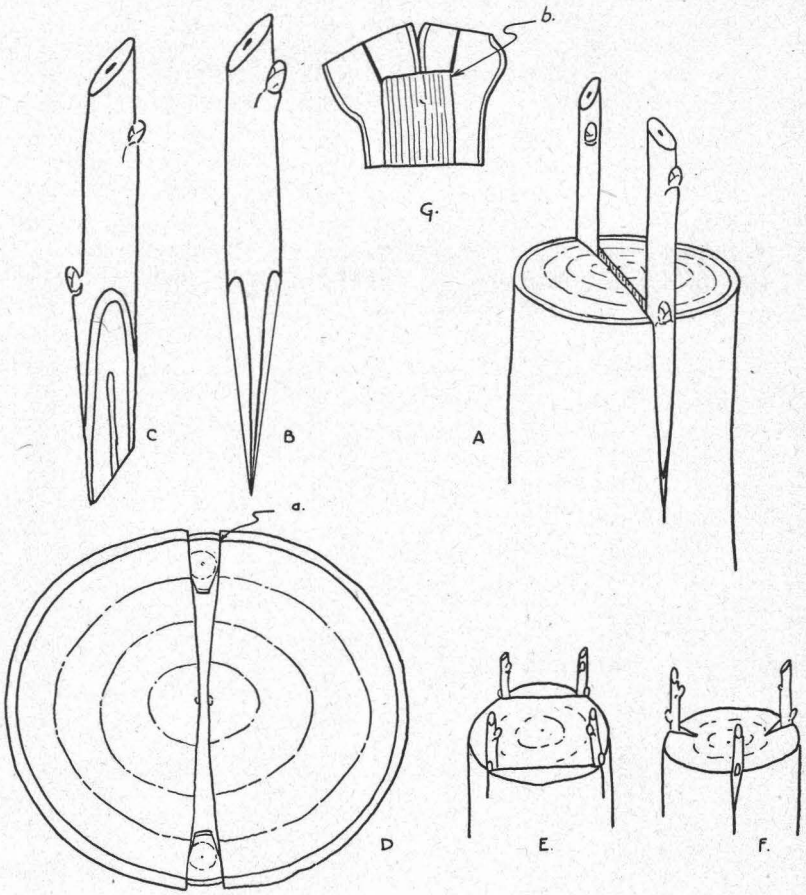


Figure 11. A. Cleft grafting with scions in place.

B. One view of scion showing sloping cut with narrow edge showing.

C. Scion showing broadside view.

D. View from above, showing scions with cambium layers in line as at (a). Note that with large stock the scions are indented in order to have the cambiums meet.

E. Cleft grafting, showing the placement of four scions in two clefts near the outer edges rather than in the center of the stock. In other types one scion is inserted.

F. Saw-kerf grafting using notches for inserting the scions.

G. Diagram of the growth of two scions, one originally at (b). New growth is laid down over the old scions and the old stock, forming a purely mechanical union.

club, driving it into the stock. The chisel is removed and its wedge inserted to hold the split open to receive the scion. The scion is cut to fit by making two cuts sloping downward and inward from a bud. It is inserted at the outer edge of the split so that the cambiums are in line, and is then pushed downward so that the lower bud is about opposite the top of the sawed surface (Figures 10 and 11). Formerly it was advised to slope the scion so that the cambiums would be sure to cross at some point. It is better to align the cambiums because a stronger union results. Two scions are usually placed at opposite edges of the cleft.

After the scions have been placed the wedge is removed. The tension of the stock grips the scions firmly so that in most cases there is no need for binding. With small stock that does not grip the scions securely, binding will be necessary. Wax should be applied over all the cut surfaces, and down the sides of the splits and cracks in the stock.

There are modifications of the cleft method, depending on the size of the stock (Figure 11E and F). For example, stock more than 3 inches in diameter may have two splits made by placing the clefter near the outer edge of the stock and using 4 scions instead of 2. With small stock one scion may be sufficient, similar to the modified whip graft (Figure 6).

Notch grafting

Notch grafting, also called saw-kerf, inlay, and crown grafting, is a variation of cleft grafting. In this method the stock is not split, but a notch or inlay extending down the side is prepared. This is made with two cuts of a saw, the edges being smoothed with a knife. A coarse-bladed saw may be used to make a slanting cut in the stock, at an angle of about 45 degrees. Then the scion is cut to fit the notch, so that the cambiums meet. In this manner several scions may be placed, securing them by means of brads, or string tied around the stock, similar to modified cleft grafting (Figure 11F).

Side grafting

Side grafting is done by inserting scions in the side of a trunk or limb without cutting it off. A slanting cut is made with a grafting knife or special side-grafting chisel, extending into the wood. The scion is prepared with a sloping cut on one or both sides. It is inserted, and pushed or tapped firmly into the opening. The tension of the bark is ordinarily sufficient to hold the scion in place, although tying with raffia or tape may be necessary (Figure 12). Wax is applied over the exposed and cut surfaces.

The old top may or may not be removed above the graft. Some prefer this method because it does not require removal of the limb, but instead adds one. In placing pollenizers, this method may be used. The resulting growth from such a scion may be vigorous, reaching several feet the first season. Side grafting may also be used on small stock by making a sloping, downward cut into the stock just past the center. The scion is inserted and tied to the stock without removal of the original top. Later, the scion grows, the old top is gradually cut off and finally removed.

Veneer grafting

Veneer grafting is similar to side grafting in that a downward diagonal cut is made in the stock, but instead of going to the center, it is merely a surface cut sufficiently deep to expose the cambium. The

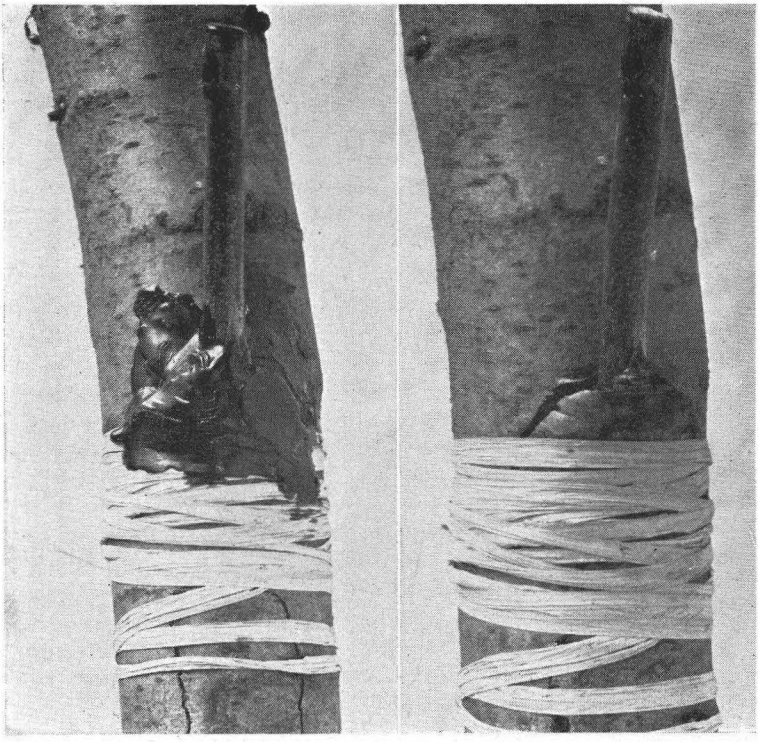


Figure 12. ***Left:*** **Side graft with scion held in place with raffia tied around the stock at the base of the scion.** ***Right:*** **Same side graft, before waxing.**

outer piece is removed and discarded (Figure 13). The scion is cut with the inner surface exposed and the outside bark intact. The scion is fitted onto the stock and tied firmly with the cambiums together. The stock is pruned back after the scion unites, then cut away entirely. This method is employed for greenhouse plants in pots, such as evergreens and other ornamentals. Special grafting cases with bottom heat serve in aiding the union. (See pages 25 and 26 under Grafting Ornamentals.)

Natural grafting

Natural grafting is sometimes found in nature where two trees growing close together intergraft. This type of graft can be performed by intertwining in a straight line two one-year-old twigs growing on the same tree, without any cutting whatever, simply binding them with string or raffia. Two watersprouts suitably located can be intertwined to form either a horizontal or a vertical brace (Figure 14). After a few years the tissues will coalesce and the union will become so complete that it will appear as a single smooth limb, hav-

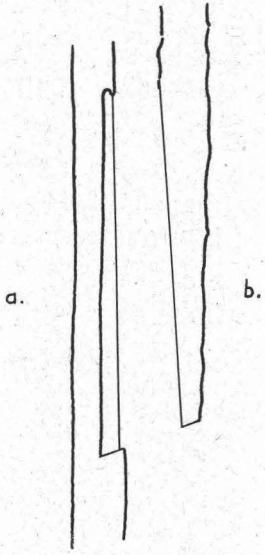


Figure 13. Veneer grafting.
a. Stock with piece removed.
b. Scion with one surface cut to expose the cambium.

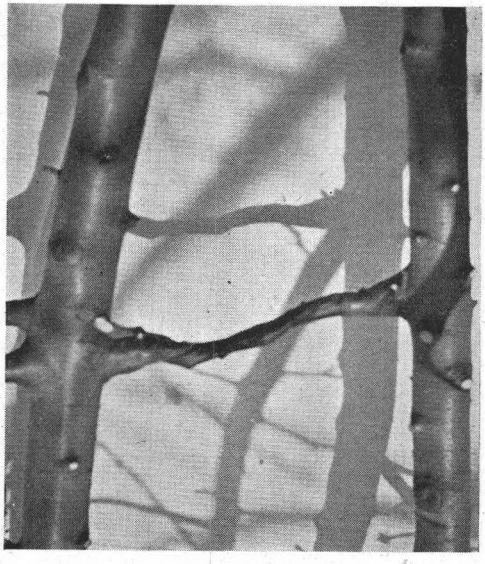


Figure 14. Natural graft on apple tree made from watersprouts twisted together.

Figure 15. Successful bridge grafts and inarches, connecting the roots with the top of the tree, around an injured area.

ing two places of origin (presumably with sap flowing in two directions). The graft becomes increasingly stronger, and in young trees aids in bracing weak forks. With such braces, young apple trees in particular may be easily and cheaply strengthened.

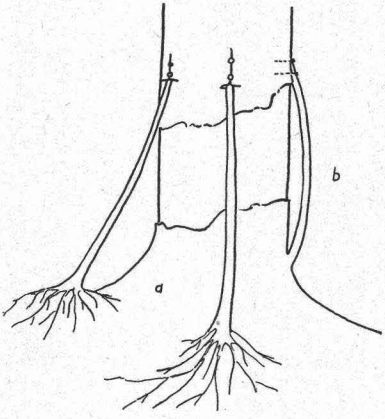


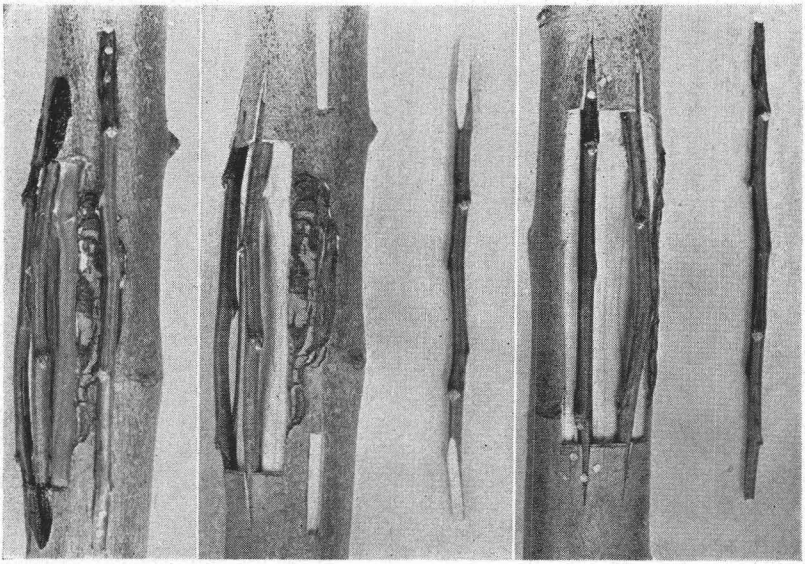
Figure 16. Inarching and bridge grafting.
a. Seedling planted with the tops inarched above an injury.
b. Use of a sucker bridging an injury.

Bridge grafting and inarching

Bridge grafting and inarching are methods of placing scions to carry sap over or around a large wound, such as that caused by mechanical injury, low temperature, sunburn, canker, blight, or rodents (Figure 15). If the cambium has been destroyed extensively, the tree will die before it can be saved unless repair is done quickly. Bridge grafting or inarching will supply conductors or new channels connecting the healthy parts. In a few years the scions will carry on the functions of the original tissues; the plant will enlarge and the entire surface may be grown over so that the scions and trunk appear

as one. This operation should be done early in the spring as soon as the bark will slip. Scions should be dormant and may be from the same or different trees regardless of variety. Bridge grafting differs from inarching in that the scions are cut at both ends, while in inarching the lower end is on its own root (Figure 16).

The wound on the stock should be prepared in advance by removing decayed material and covering with a wound dressing. The healthy tissue above the wound is cut with a T or an inlay, and the bark is peeled to expose the cambium. The scion is cut with a long, sloping cut on its inner surface and, where inserted under the bark, a short cut on the outer surface. This scion is fitted to the stock so as to place their cambiums together, held securely with brads, or string tied around the stock. Next, the scion is bowed slightly and its lower end fastened in an inverted T cut below the injury. Wax



a b c

Figure 17. Bridge grafting.

a. Scion with outer surfaces prepared.

b. Scion cut at both ends, exposing inner surface.

c. Side view of the same scions in place by the inlay and bark-lifting methods, brads being shown holding scions. Ends of scions are waxed over.

is applied over the cut ends (Figure 17). In the case of inarching, only the top of the scion is prepared, the lower end being already in place on its own roots. Several scions may thus be placed around a tree according to its size and the extent of the injury. In changing a root system of a tree, one or more seedlings may be planted and inarched at one operation.

Types of Budding

Shield or T budding

Shield or T budding is the standard method for propagating most nursery plants and occasionally for top-working fruit trees, such as the peach. It is simply and quickly performed, but can be done only when the bark slips—in the spring, summer, or early fall. Bud sticks or shoots of the desired variety are cut just before they are to be used. Leaves are cut off leaving about a half inch of the petiole. The sticks can be kept fresh by placing their butt ends in water. For spring and June budding bud sticks from the previous season may be preserved by keeping them moist and in a cool place.

The stock is trimmed to make a smooth place accessible, preferably on the side protected from the wind or sun. A vertical cut about one inch long is made in the stock, with the knife going just through the bark. Then with the blade slanted, a transverse rolling cut is made at the top of the first cut, forming a T, and the bark, by this motion, is pulled from the wood to expose the cambium.

When taking the bud, the bud stick is held reversed, and the knife blade is started about an inch below the base of a bud and drawn past it, slicing into the wood and coming out about one-half inch above, so as to retain a small oval piece of wood with the bud on it (Figure 19-IA). The oval piece bearing the bud is slipped off the knife blade, with its base into the opened T. Using the point of the blade or the fingers, it is slid along the cambium and pressed into position until the oval piece is all inside the T, where it is tied in place so as to leave the bud exposed.

An expert budder cuts his buds in advance, leaving them partly attached to the bud stick. In actual insertion of the bud, he makes a quick stroke with his knife to remove the bud, and while holding it on the upper part of the knife blade with his thumb, he cuts the T with the point of his knife. He then slips the bud off the blade into the T cut. This method saves lost motion and the budder does not take his eyes from the T. Budders work very fast; some are reliably reported as having put in more than 3,000 buds per day, when the tying was being done by a helper.

The stock also is prepared in advance by being trimmed and obstructions removed, giving the budder easy access to a smooth place on the stock. The stock is sometimes irrigated in advance, especially if the bark is not slipping well.

Tying of the buds must be done without delay, using nurseryman's tape, cotton string, raffia, or a rubber budding strip, the latter being used most extensively at present. In making the tie, a half hitch is made at the bottom, binding around but not over the bud, and catching finally with another half hitch at the top (Figures 18 and 19).

If the budding is done in summer with current season's buds, they unite but remain dormant until the following spring. If dormant buds are used for spring budding they will start to grow and produce shoots during the current season.

As the stock grows, the tie may cause girdling if tape, string, or raffia has been used for tying; the tie, therefore, should be cut on the opposite side from the bud after two or three weeks. Rubber budding strips have the advantage of stretching, thus avoiding girdling, also decompose gradually and save the cutting operation (Figure 20). The original stock should be cut back to the new bud by stages, or at once, in order to give the bud all possible advantage to grow out. Sometimes, as with the rose, the new shoot is cut back to make it produce branches and become more stocky. Generally, no wax is used in budding.

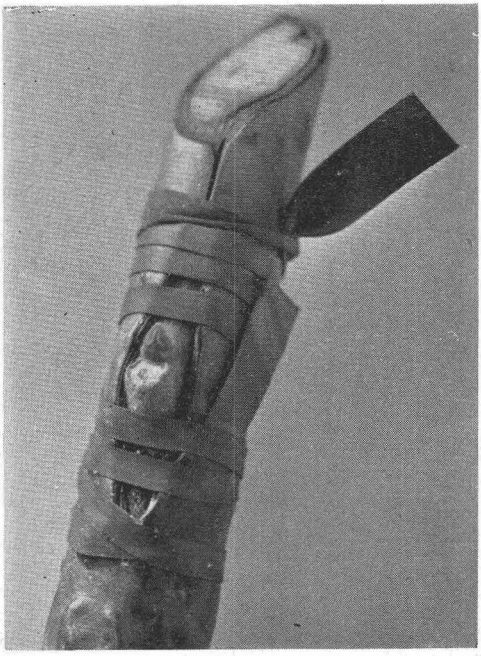


Figure 18. Bud tied in place with rubber budding strip and stock cut back just above the bud.

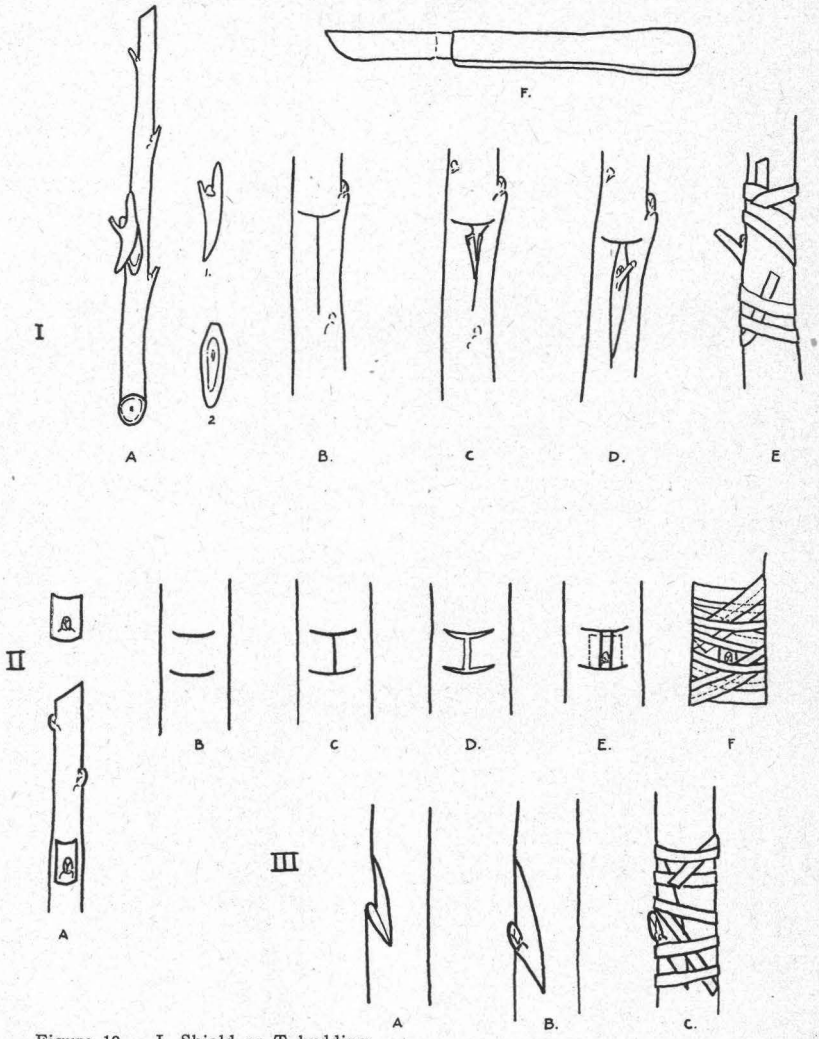


Figure 19. I. Shield or T budding.
A. Buds cut from bud sticks.
1. Side view of buds removed.
2. Surface of buds showing shield.
B. "T" cut on the stock.
C. Cut rolled open, exposing the cambium.
D. Bud slipped into place.
E. Bud held firmly by means of rubber budding strip.
F. Round-bladed budding knife with stationary handle.
II. Modified H bark budding.
A. Bud removed from bud stock.
B. First cut with a double-bladed knife.
C. Two slits connected with a vertical slit.
D. The "door" opened.
E. The bud in place.
F. The bud bound with nurseryman's tape.
III. Chip budding.
A. Stock with chip removed.
B. Bud of same size in place.
C. Bound in place with a rubber budding strip.

Bark budding

Bark budding is especially adapted for trees that have relatively thick bark. This type of budding can be done only during the growing season when a piece of bark can be slipped from the stock, and also from the bud stick, generally in the late spring or early fall. Good results are obtained with spring budding and freshly cut buds. A piece of bark is cut out of the stock and a piece of bark bearing a dormant bud is slipped from a bud stick. Special budding knives are used so that the cuts on the stock and bud stick will match. Working quickly and holding the bud by the edges of the bark, the operator slips it into place on the stock, and binds it with nurseryman's tape or similar material. A light wax is sometimes used to cover the bud in this method. After two or three weeks the binding material should be cut on the opposite side from the bud to prevent girdling of the stock. Gradually the original top is cut back to the bud in order to force it into growth. There are a number of modifications of this method known by the terms: patch, ring, annular, whistle, flute, veneer, H, modified-H, and hinge budding.

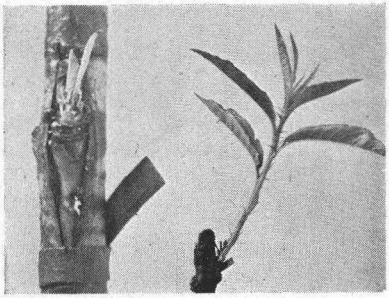


Figure 20. Buds starting to grow. Note that the rubber budding strip has decomposed, releasing the tension. The old top is cut away so new shoot can grow in its place.

Chip budding, or "yema grafting," is used when the bark will not slip easily or while the stock is still dormant. A chip is cut out of the stock and a similar piece of wood bearing a dormant bud is removed from the bud stick and fitted into place, being tied by budding rubber, raffia, string, or tape

Figure 21. Successful grafts the first season after being placed.

(Figure 18). The chip is made by making an oblique downward cut on the stock, about an inch long, and a shorter cut at a sharper angle meeting the first cut at the lower end. Buds of this type are being used on grapevines, where the stock is worked just at the ground level. Immediately after tying, the bud is covered carefully with an inch or two of moist fine soil. The buds unite in two or three weeks but do not grow out until the following spring, when the original top is cut back.

After-treatment of Scions and Buds

In a few weeks after scions have been placed, they should be examined and re-waxed where necessary. As the shoots of the stock and scion appear, those on the stock should be removed and those of the scion that are growing too long or in undesired directions should be pinched or pruned back (Figure 21). If the new shoots of the scion need support, they should be tied to strips of wood, such as lath, nailed

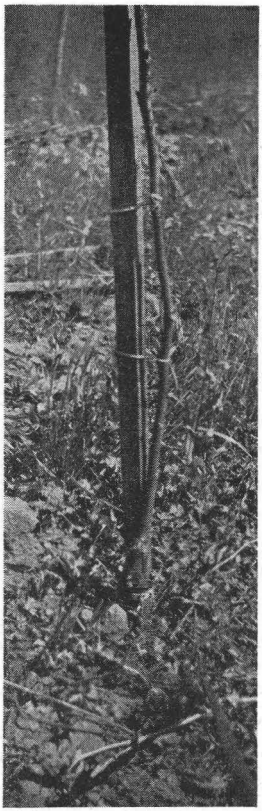


Figure 22. English walnut grafted onto black walnut in the nursery at the soil level. Note a stake is used to hold the new growth straight and erect.

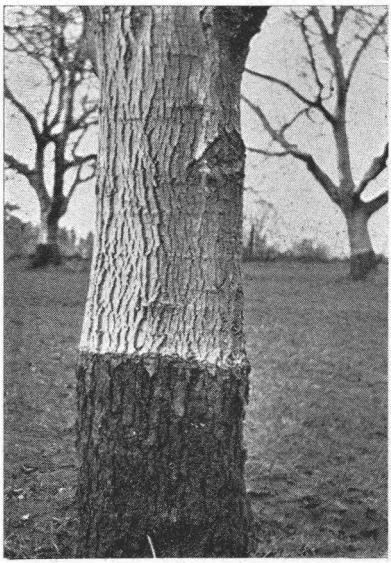


Figure 23. Walnut trees showing perfect graft union of black walnut stock and English walnut top.

to the stock. Frequent attention to these points is necessary in order to obtain good results.

During the following season, the scions that grow too rapidly or in the wrong direction may need to be pruned back. Other limbs on the original stock may require pruning away. In case grafts fail to grow, it may be possible to insert new scions in the same stock, or the watersprouts that grow subsequently may be budded. In the cases of inarches, bridge grafts, and natural grafts, any lateral shoots that appear on them should be rubbed off or pruned away as soon as possible.

After budding, examination should be made in two or three weeks to determine whether the buds are "taking"—that is, alive and uniting to the stock. If not, rebudding may be done at once. Cutting of the binding material may be necessary, especially if it is girdling the stock. Cutting back of the original top soon after budding, by stages or entirely, is necessary to force growth into the bud. As the bud itself starts to grow, it should be favored by elimination of the old top or any competing shoots. In some cases the new shoots from buds require support by being tied to stakes, to make them grow straight (Figures 22 and 23).

Grafting Ornamentals

The following brief review of a talk on *Grafting* by Howard Burton, Hilltop Nurseries, Casstown, Ohio, appeared in Nursery Notes prepared by L. C. Chadwick, Department of Horticulture, Ohio State University, September 1939. "In grafting we have two main elements to deal with: stocks and scions, both of which must be in top condition for maximum results. We like to start with transplanted understock, although in some cases, seedlings that are well rooted are entirely satisfactory. This is especially true of viburnum, beech, Japanese maples, and other deciduous plants and also of *Biota orientalis* grown on light soils, American arborvitae and *Taxus cuspidata*. Junipers as a rule must be transplanted to secure the best root systems. If they are relatively cheap, in which case a large percentage of throw outs is not serious, seedlings may be used. It is, however, poor economy to save doubtful understocks and later throw them out after having given them bench room for a period of weeks.

"It is my belief that many deciduous items should be grown in pots for a year before grafting. I refer here especially to beech, oak, and *Corylus*, although all the other deciduous varieties do very much better if established a season before grafting. Losses are reduced and growth, after grafting, is much greater, the plants often gaining a

year on those from stock not previously established. In evergreens, fir and hemlock understocks should always be established, as otherwise the mortality is entirely too high. Where not established the previous season, deciduous items should be potted early but it is very questionable whether it is not advisable to pot evergreen stocks as late as possible, after heavy frosts or some tolerably heavy freezes. This is a risky procedure but our experience has been that under these conditions they start root growth sooner. As a matter of fact, understocks potted in late winter or early spring will make root growth almost immediately. Union is also more rapid at that season.

"After potting, the stocks should be started at a relatively cool temperature after which the temperature may be raised gradually to force growth. To carry freshly potted material at a high temperature has proven as disastrous as the other extreme of letting the plants freeze in the pots on the bench.

"Evidence of root growth, as seen in the formation of white rootlets, serves as a guide to the proper condition for grafting. There arises the question of scions which should be cut as fresh as possible and during mild weather when the temperature has been above freezing for some time in order to be sure there is no frost in them. More losses are suffered, however, from dried scions than from use of scions cut while in a frozen condition.

"After grafting, the humidity should be maintained at as near a constant saturated condition as is possible. Both domestic and imported peats are used and either is satisfactory if well prepared. A fairly constant heat is desirable. We maintain a relatively constant night bench temperature by use of a thermostatically controlled house temperature. At present we have the thermostat set at 55-60° F. It would be interesting to know what could be accomplished by control of the grafting case temperature directly. Extremely sunny days sometimes raise the temperature of the cases so high that some shading is imperative. Some ventilation of the grafting cases may even be necessary.

"After union is complete in the grafting case the very important process of hardening off begins. The results of too quickly removing the tender graft from the case are seen most quickly in beeches, maples and *Corylus,* magnolias, viburnums and other deciduous varieties, but is none the less fatal to conifers. Usual raising of the sash, with occasional syringings, helps break the shock. When a few days have elapsed the grafts are usually ready to be placed on the open bench but the last cutting back of the understock stem is better done later after the callous material is well hardened and active growth is in progress."

References

Propagation of Horticultural Plants, by Adriance and Brison. McGraw-Hill Book Co., New York, 1939.

Fundamentals of Fruit Production, by Gardner, Bradford, and Hooker. McGraw-Hill Book Co., New York, 1939.

Dwarf Fruits. Leaflet 178, U. S. Dept. Agr., 1939.

Bud-Graft Methods of Propagating Vinifera Grape Varieties on Rootstocks. Leaflet 173, U. S. Dept. Agr., 1939.

Random Notes on Fruit-Tree Rootstocks and Plant Propagation, III. Bulletin 682, New York Agricultural Experiment Station, 1938.

Propagation of Grape Vines. Circular 101, Calif. Agr. Expt. Sta., 1936.

Propagation by Grafting and Budding. Circular 241, Missouri Agr. Exp. Sta., 1942.

Top Grafting Fruit Trees. Ext. Leaflet 117, Mass. State College, 1934.

Influence of the Cion and of an Intermediate Stem Piece Upon the Character and Development of Roots of Young Apple Trees. Technical Bulletin 218, New York Agr. Expt. Station, 1933.

Orchard Grafting. Bulletin 439, Ontario Dept. Agr., Toronto, Canada, 1944.

Propagation of Trees and Shrubs. Farmers' Bulletin 1567, U. S. Dept. Agr. (Rev.), 1945.

Bridge-Graft and Save Trunk-Injured Fruit Trees. Circular 381, Illinois Agr. Expt. Sta., 1931.

A Method of Studying Water Conduction in Plants in Relation to Pruning, Grafting, and Other Horticultural Practices. Bulletin 279, Ore. Agr. Expt. Sta., 1931.

Deciduous Orchards, by W. H. Chandler. Lea & Febiger, Philadelphia, 1928.

Preparation of Grafting Waxes

Grafting waxes consist of materials that will not melt under hot sun, or freeze and crack under low temperatures. Grafting wax should be capable of stretching to a certain extent so as to accommodate the growth of the tree, at least until all wounds are healed.

There are two kinds of waxes; namely, hot and cold (those that are applied in a fluid condition and those that are applied in a paste condition). Some of these waxes are homemade from materials such as beeswax, tallow, or rosin, and others are proprietary compounds with different trade names. Asphaltum and other plastic materials are also in use.

Hot wax made by the following formula and method is recommended: rosin, 5 pounds; beeswax, 1 pound; raw linseed oil, ¼ pint; lampblack or powdered charcoal, ½ pound. Melt the beeswax and rosin over a slow fire in a tin pan or pail. After melting, add the charcoal and oil, stirring to prevent boiling over. This may be poured into a greased pan or into a box lined with greased paper to cool, or may be left in the same bucket to be reheated and poured out into small containers used at the time of grafting. This wax is to be heated and applied with a brush, while just warm enough to flow freely.

Additional formulas for hot wax, known to give good results: a. 2¼ pounds rosin, 2 pounds beeswax, ¾ pound tallow. b. 1 pound mutton tallow, 2 pounds beeswax, 4 pounds rosin. c. 2 pounds rosin, 2 pounds beeswax, ¼ pound tallow, and a little linseed oil. d. 4 pounds asphaltum, 1 pound paraffin.

Cold wax may be prepared as follows: rosin, 4 pounds; beeswax, 2 pounds; tallow or linseed oil, 1 pound. These materials are melted together and the liquid then poured into a vessel of cold water. When the mass becomes cool enough to handle, it should be taken out and pulled like taffy until it becomes tough and has the color of manila paper. In pulling or applying by hand, the hands should be well greased or oiled. The wax may be rolled into balls and stored in waxed paper until ready for use. This wax is then worked again and applied by hand, or it may be melted and applied with a brush.

As a wound dressing, bordeaux paint gives good results if applied after the wound has been cleaned of decayed material and is completely dry. The wound may have to be left open to dry for a month or six weeks before being painted. The paint should be made by slowly stirring *raw* linseed oil *into* a quantity of powdered bordeaux (commercial bordeaux powder) until a smooth paste is formed. This is painted on and brushed out well over the wound, using care not to paint the surrounding bark.

Grafting and Budding Chart*

Affinities of Stock and Scion

Plant	Usual rootstock	May be grafted on	May not satisfactorily be grafted on
Almond (*Prunus communis*)	Bitter almond	Sweet almond Peach Myrobalan	Apricot
Apple (*Pyrus malus*)	Apple	Paradise and Doucin for dwarfing	Pear Quince
Apricot (*Prunus armeniaca*)	Apricot Peach	Peach for light soil Myrobalan for heavy soil	Almond
Cherry (sweet) (*Prunus avium*)	Mazzard (*Prunus avium*)	Mahaleb (*Prunus mahaleb*) Morello for dwarfing	Sour cherry
Cherry (sour) (*Prunus cerasus*)	Mazzard Mahaleb	Morello	Peach Apricot
Grape (*Vitis labrusca*) (*Vitis vinifera*)	Own root	Rupestris St. George for resistance to phylloxera	
†Peach and nectarine (*Prunus persica*)	Peach	Sweet almond Bitter almond	European plum Apricot Myrobalan
Pear (*Pyrus communis*)	French (*Pyrus communis*)	Angers quince for dwarfing Hawthorne *Pyrus calleryana*	Apple
Plum (Japanese) (*Prunus salicina*)	Peach	Myrobalan (*Prunus cerasifera*) Almond	Apricot
Plum (European) and Prune (*Prunus domestica*)	Peach Myrobalan	Almond Marianna	Apricot Japanese plum
Walnut (English) (*Juglans regia*)	Northern California Black (*Juglans hindsii*)	*Juglans regia* *Juglans nigra*	*Juglans californica*

* Grafting is generally an early-spring operation while budding is a summer or early fall operation, when the bark is slipping.

† Peach and nectarine seldom can be grafted satisfactorily but may be easily budded on the indicated stocks.

Chart Showing Methods for Propagating Common Fruits

Fruit	Budding	Grafting	Cuttings	Layers	Suckers and offsets
Almonds	*	1	3	3	3
Apples	1	*	2	2	3
Apricots	*	1	3	3	3
Avocados	*	1	3	3	3
Bananas	3	3	3	3	*
Blackberries, trailing	3	3	2	*	1
Blackberries, upright	3	3	1	3	*
Black raspberries	3	3	2	*	3
Cherries	*	1	3	3	3
Cranberries	3	3	*	1	2
Currants	3	3	*	3	3
Dates	3	3	3	3	*
Figs	2	2	*	1	1
Filberts	2	1	3	*	2
Gooseberries	3	3	1	*	3
Grapes	2	1	*	2	3
Huckleberries	3	3	*	1	2
Kumquats	*	1	2	3	3
Lemons	*	1	2	3	3
Limes	*	1	2	3	3
Loquats	*	1	2	2	3
Mandarins	*	1	2	3	3
Mangos	*	1	2	3	3
Mulberries	1	1	*	3	3
Olives	2	2	*	3	3
Oranges	*	1	2	3	3
Peaches	*	2	3	3	3
Pears	*	*	3	3	3
Pecans	*	1	3	3	3
Persimmons	*	1	2	3	3
Pineapples	3	3	1	3	*
Plums	*	1	3	3	3
Pomegranates	2	2	*	1	1
Pomelos (grapefruit)	*	1	2	3	3
Prunes	*	1	3	3	3
Quinces	1	1	*	2	3
Red raspberries	3	3	1	3	*
Strawberries	3	3	3	*	1
Walnuts	2	*	3	3	3

* The usual method.
1 May be used.
2 Occasionally used.
3 Not practicable.

Chart Showing Behavior of Several Varieties of Plums and Prunes When Top-worked on Other Varieties

Stock \ Scion	Apex	Beauty	Burbank	Burton	California Blue	Climax	Clyman	Diamond	Duarte	Formosa	French	Gaviota	Giant	Grand Duke	Hungarian	Imperial	Kelsey	President	Quackenboss	Robe de Sergeant	Santa Rosa	Satsuma	Standard	Sugar	Tragedy	Wickson
Apex	X	S	S		U	S	U	U	S	S	U	D	U	U	U	U	D	U	U	U	S	S	U	U	U	D
Beauty	S	X	D		U	S	U	U	S	S	U	D	U	U	U	U	D	U	U	U	S	S	U	U	U	D
Burbank	S	S	X	U	U	U	U	U	S	D	U	U	U	U	U	U	U	U	U	U	S	U	U	U	U	D
California Blue	U	U	U		X	U	U	U	S	U	U	S	U	U	U	U	U	U	U	U	U	S	U	U	U	S
Climax	S	S	D		U	X	U	U	S	S	U	S	U	U	U	U	U	U	U	U	S	S	S	U	U	S
Clyman	S	S	S		D	S	X	U	S	S	U	S	U	S	U	U	U	U	U	U	S	S	S	U	U	S
Diamond	S	S	S	S	D	S	S	X	S	S	U	S	U	S	U	U	U	U	U	U	S	S	S	U	U	S
Duarte	S	S	D		D	S	U	U	X	S	U	S	U	U	U	U	U	U	U	U	S	S	S	U	U	S
Formosa	S	S	S	D	U	D	U	U	S	X	S	S	U	U	U	U	U	U	U	U	D	S	S	U	U	D
French	S	S	S	S	D	U	U	U	S	S	X	S	U	X	U	U	U	U	U	U	S	S	S	U	U	S
Gaviota	S	S			U	U	U	U	S	S	U	X	U	X	U	U	D	U	U	U	S	S	S	U	U	S
Giant	S	S	S	S	U	U	S	S	S	S	S	S	X	S	S	S	S	D	S	S	S	S	S	S	S	S
Grand Duke	S	S	S	S	S	S	S	S	S	S	S	S	S	X	S	S	S	D	S	S	S	S	S	S	S	S
Hungarian	S	S	S	S	U	S	S	S	S	S	S	S	S	S	X	S	S	D	S	S	S	S	S	S	S	S
Imperial				S												X										
Kelsey	S	S	D		U	S	U	U	S	S	U	S	U	U	U	U	X	U	U	U	S	S	U	U	U	S
President	S	S	S		U	S	S	S	S	S	S	S	S	S	S	S	S	X	X	X	S	S	U	S	U	S
Quackenboss	S	S	S			S	S	S	S	S	U	S	U	U	U	U	U	U	X	U	S	S	U	U	U	S
Santa Rosa	S	S	S		U	S	U	U	S	S	U	S	U	U	U	U	U	U	U	X	X	U	U	U	U	S
Satsuma	S	S	S		U	S	U	U	S	S	U	S	U	U	U	U	U	U	U	U	S	X	U	U	U	S
Standard	S	S		S					S	S	U	S	S	S	S	S	S	S	S	S	S	S	X	S	S	S
Sugar	S	S	S	S	U	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	X	S	S
Tragedy	S	S	S	S	U	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	X	S
Wickson	S	S		U	U	S	U	U	S	S	U	S	U	S	U	U	D	U	U	U	S	S	U	U	U	X

Explanation of Chart:
S—Satisfactory combination.
U—Unsatisfactory combination.
D—Doubtful combination.
X—Scion on own stock.
* Blank spaces indicate sufficient data not available.

NOTE: The above chart is reproduced from California Agricultural Experiment Station Bulletin 438 *Grafting Affinities with Special Reference to Plums* by Myer J. Heppner and Roy D. McCallum. 1927.

Index

Cooperative Extension Work in Agriculture and Home Economics
Wm. A. Schoenfeld, Director
Oregon State College and United States Department of Agriculture, Cooperating
Printed and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914