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Agricultural Experiment Station

Plant Propagation

L. R. BRYANT

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Plant Propagation

L. R. BRYANT

PLANT propagation includes all methods whereby plants can be increased in quantity. The methods used may vary considerably and will depend on the plants considered. Plant propagation naturally classifies itself into two general groups: sexual propagation, or propagation by means of seeds and spores; and asexual, or vegetative propagation, where a vegetative part of the parent plant is used for reproductive purposes.

PROPAGATION BY SEED

In nature most species of plants depend on seed propagation. With comparatively few exceptions, plants which may be reproduced by other methods can also be grown from seed. However, this method is not satisfactory if the plants will not come nearly true to type from seed.

Conditions Necessary for Germination

There are four requirements for germination: viable seed, moisture, heat, and oxygen. Needless to say, seeds must be alive. They must be able to germinate.

Most seeds are able to take up moisture, although the rapidity with which they absorb it will vary considerably. Some porous-coated seeds will absorb sufficient moisture in a day, while others which have hard or less porous coats may lie in the ground a year or more. The first step in germination is the absorption of water and the swelling of the seed which accompanies it.

Oxygen is necessary for germination, as germination is a life process.

The last requirement for germination, heat, varies greatly with the type of seed. Seeds may be classified in three groups on their temperature requirements: cool season, or hardy seeds requiring a temperature from 40° to 70° F. for germination; half-hardy, requiring from 60° to 80°; and tropical, or greenhouse seeds, which will not germinate at temperatures below 75° to 90°. The grower must see that the necessary requirements for germination are met.

The simplest method of handling seeds is to prepare the seedbed and plant the seeds in the location where they are to grow and mature a crop. This is the method usually followed with cereal crops, most forage crops, and with many truck,

garden, and ornamental crops. Others may need additional care. For example, the seeds may first be planted in seedbed, cold-frame, hotbed, or greenhouse, and later transplanted to field or garden. Garden crops such as cabbage, tomatoes, cauliflower, and peppers are started in this manner. Many types of tree fruits are grown from seeds first planted in seedbeds and then transplanted to the field, either before or after budding or grafting.

Aids to Germination

Some seeds are difficult to germinate. Some have very hard seed coats, while others may be impervious to air or moisture. With these, some method of treatment to aid or hasten germination is desirable.

One treatment very frequently used is stratification. Stratification is merely placing thin layers of seeds between layers of moist sand or soil in pits or shallow boxes. Then they are covered with soil or a layer of straw or leaves and left exposed to the weather. The object of this treatment is to soften or crack the seed coat without starting germination. Freezing is not always necessary, although it may help crack the seed coat of such seeds as walnuts and hickory nuts. Stratified seed should be protected from rodents. Large, hard-shelled seeds such as peach pits may be planted directly in the field in rows in the fall.

Soaking such seeds as cannas and moonflowers in lukewarm water will soften the seed coats. Scarifying seeds such as clover and alfalfa will give quicker and more complete germination.

In many instances, treated seeds are more difficult to handle than are untreated seeds. Once soaked, seeds should never be allowed to dry out. Swollen seeds should be planted with care and pressed into the soil only lightly.

Time to Plant

The most desirable time to plant seed of a given variety depends on the character of the seed as well as on weather conditions. Hardy types which can stand severe weather may be planted just as soon as frost is out of the ground and the soil can be prepared. Half-hardy plants cannot stand such severe weather and should not be planted before danger from frost is past. Tender plants such as melons, cucumbers, and lima beans should not be sown until the soil has warmed up, about the time the trees are well out in leaf.

Depth to Plant

An important factor in successful seed propagation is the depth at which the seed is planted. Very small seeds should

barely be covered. After sowing them on the surface of a well-prepared plot or seedbed, pressing them into the soil lightly with a board is sufficient. Generally speaking, seeds should not be covered much more than three times their diameter. The character of the soil has a direct bearing on the depth of planting. Seeds should be planted deeper in light, sandy soils than in heavy soils. Weather conditions should also be considered. Spring-sown seeds need not be planted as deep as summer-sown seeds because of temperature and soil moisture differences. Seeds must come in contact with moist soil.

The type of seedling also influences the depth of planting. Bean seedlings, which have a hook-like shoot, have more difficulty in pushing through the soil than do the spear-like corn seedlings.

Indoor Sowing of Seed

Indoor sowing of seed makes it possible to raise tender plants which otherwise could not be grown. Seeds planted indoors are usually planted in "flats," or shallow boxes from 3 to 4 inches deep and of convenient size to handle. A common size measures about 4 by 12 by 15 inches. Larger sizes than this are not practical. Drainage should be provided in flats by holes or cracks in the bottom of the flats or by a layer of broken pots, gravel, or sphagnum moss.

If the number of plants wanted of one kind is small, common flowerpots may be used for seed planting. Here, too, careful attention should be paid to drainage. It may be provided by broken pots, coarse gravel, or stone placed in the bottom of the pot.

Most seeds will germinate satisfactorily in a sandy loam soil. It should be thoroughly worked and screened before it is placed in the pots or flats. The soil is placed in the flat or pot, leveled, and then compacted slightly.

Under most conditions, seeds should be sown in rows. If planted in this way, weeding, watering, and transplanting will be easier.

Small seeds need special attention. They should not be planted deeply. One successful method is to sow the seeds on the surface of the soil and then press them in with a piece of board. The seed flat or pot is then watered through a thin cloth. This will prevent washing the seeds out.

Watering is necessary with all seeds. However, it must not be overdone. The soil should be moist at all times, but it should never be water-logged.

Outdoor Seedbeds

Some plants require considerable care as seedlings, but they do not need to be started before the weather permits outside planting. Under these conditions, an outside seedbed having partial shade is desirable. The soil should be a good, well-drained, sandy loam. The top soil should be fine and level. The seeds are sown and covered as for inside sowing. They should be covered with fine soil to a depth of from two to three times the diameter of the seed. Transplant when the seedling plants begin to crowd each other.

Planting Out of Doors

Most vegetable seeds and many flower seeds can be sown in the place where they are to mature. Soil preparation for planting should consist of thorough plowing or spading to a depth of 6 or 8 inches and working the soil until a good seedbed is obtained. Remove all stones and coarse material. Where the water content of the soil is excessive, the seed may be sown on ridges 3 or 4 inches high. Most seeds of these types are sown in rows or drills. Small lots of seeds are usually sown by hand. All seeds should be sown thinly. If the seedlings are too thick, they should be thinned to the desired spacing.

VEGETATIVE PROPAGATION

Vegetative plant propagation is propagation by means of vegetative parts of plants. Parts used are leaves, buds, stems, and roots. The usefulness of this general class of propagation is based on the ability of single buds to develop into new plants which carry the characteristics of the parent plant.

There are definite reasons for the use of vegetative means in plant increase. Probably the most important is that many plants, especially fruits and ornamentals, will not come true from seed. This makes it necessary to use some vegetative means to reproduce the plants true to type.

The use of materials which stimulate certain plant responses has come into prominence the last few years. Particular interest has been shown by plant propagators in those materials that stimulate root formation. A number of commercial preparations of these plant hormones or "growth substances" are now on the market. Properly handled, good results have been obtained by their use. However, they can not take the place of careful selection of propagating material and of careful workmanship. They must be considered as aids to the rooting of plants and as nothing else. At the present time there is not enough specific information available to justify the use of "growth substances" in

more than an experimental way. To use them successfully requires even greater knowledge of individual plants and their reactions than ever before.

A number of types of vegetative propagation are in common use. These include cuttings, layers, separation and division, and buds and grafts.

Cuttings

The use of cuttings in plant propagation is more common than any of the other vegetative methods. The term "cutting" is the propagator's name for the piece of stem, leaf, or root which, when removed from the parent plant and placed under suitable conditions, will reproduce the parent plant. It is the housewife's "slip." It is a cheap, convenient, and rapid means of increasing a stock of plants wherever it can be used. Cuttings are not successful with fruit trees, but are commonly used for a large number of herbaceous and woody plants.

Cuttings are classified according to the location of the part used and its condition. Thus, there are stem, root, and leaf cuttings according to position, and green-wood or softwood and hardwood cuttings, according to the condition.

Softwood Cuttings

There are a number of distinct advantages to the use of softwood cuttings as a means of propagation. They strike root quickly and can be handled under glass where conditions can be controlled. They provide a very rapid increase in stocks, and

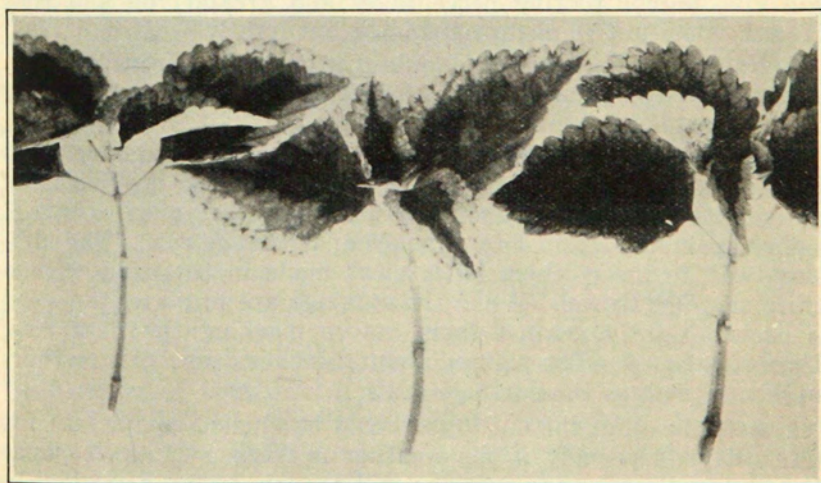


Figure 1.—Softwood cuttings of coleus.

more species can be grown from softwood than hardwood cuttings.

The wood used in making softwood cuttings is either soft, actually growing material such as is used with herbaceous plants, or partially hardened or semi-hard material such as is used for woody plants.

The texture of the material used for soft woods is important with herbaceous plants such as geranium and coleus. The cutting material should be fairly matured and not young, extremely soft material. With woody plants such as privet, spireas, and honeysuckles, the wood should be in a "half-ripe" condition. A simple test for texture is as follows: Bend the shoot sharply. If it breaks off squarely, it is in condition to use, but if it bends or crushes before breaking, it may be either too old or too young.

In making cuttings of any kind, all tools used should be sharp, and all cuts should be clean. Cuttings with ragged ends do not root well. In making softwood cuttings, many propagators use a cutting board and make the cuts against the board.

Softwood cuttings are usually made from 3 to 6 inches long (fig. 1). The lower cut should be made just below a bud or leaf, and the upper one just above a bud or leaf. Ordinarily, two or three buds per cutting are left. However, where propagating material is scarce, one bud per cutting may be sufficient. For single-bud or "one-eye" cuttings, the upper cut is made just above the bud or leaf, and the lower cut 2 or 3 inches below.

It has long been the custom to reduce the leaf area of softwood cuttings when they are made. It is neither necessary nor desirable to trim the foliage on the cuttings severely. Most plants will give higher rooting percentages and greater top and root growth when untrimmed or trimmed but lightly.

Newly made cuttings should be protected from wilting, either by covering them with moist cloth or paper or by dropping them in water as soon as they are made.

The rooting medium most often used is clean, sharp sand fine enough to pack tightly but coarse enough to provide good drainage. The cuttings should be placed in the sand in rows 2 inches apart, and from 1 to 4 inches apart in the row. The simplest way to insert them is in a cut made in the sand with a knife or a flat trowel. When the cuttings are in place, the sand is packed tightly against them before marking the next row. The cuttings should be planted about 2 inches deep. Water thoroughly as soon as the cuttings are set.

After setting, the cuttings should be shaded completely for a few days, especially if the weather is warm. Cloth or paper placed directly over the cuttings will provide suitable shade. In cloudy weather or after the cuttings have become established,

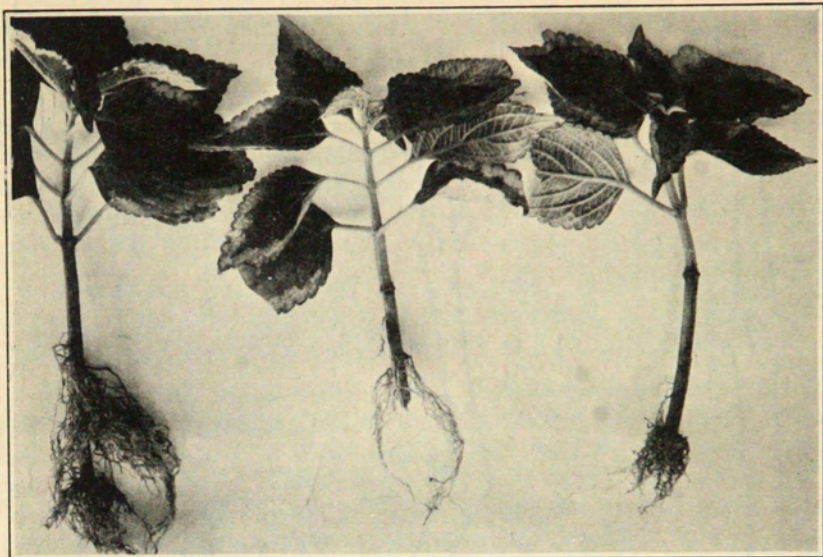


Figure 2.—Rooted coleus cuttings ready to pot.

the amount of shade should be reduced. This can be done by removing the shade except during the hottest part of the day. After 10 to 14 days the shade may be removed completely.

The cuttings should be watered lightly two or three times a day, or more as needed. The sand should always be moist but never wet.

Where only a few cuttings are being grown, they may be kept in pots or jars. If they are grown in quantity, a hotbed with some bottom heat from manure, or a special bench in a greenhouse with bottom heat, is desirable.

The time required for the cuttings to root varies widely. With softwood and herbaceous material, most cuttings will be well rooted in from 3 to 6 weeks, but evergreens and some deciduous shrub and tree cuttings may take several months to root.

Cuttings should not be left in the bench too long. They should be transplanted when the roots are from 1 to 1½ inches long (fig. 2). They may be potted, moved into flats, or even set out in the field.

Leaf Cuttings

Leaf cuttings are used with some thick, fleshy leaved plants. They are most successful with such plants as bryophyllum, begonia, and gloxinia. They may also be used for such leafy plants as cabbage. Begonia leaves may be split or cut into triangular pieces and inserted in the sand. Bryophyllum and Rex begonia leaves are laid flat on the bench and the margins covered with

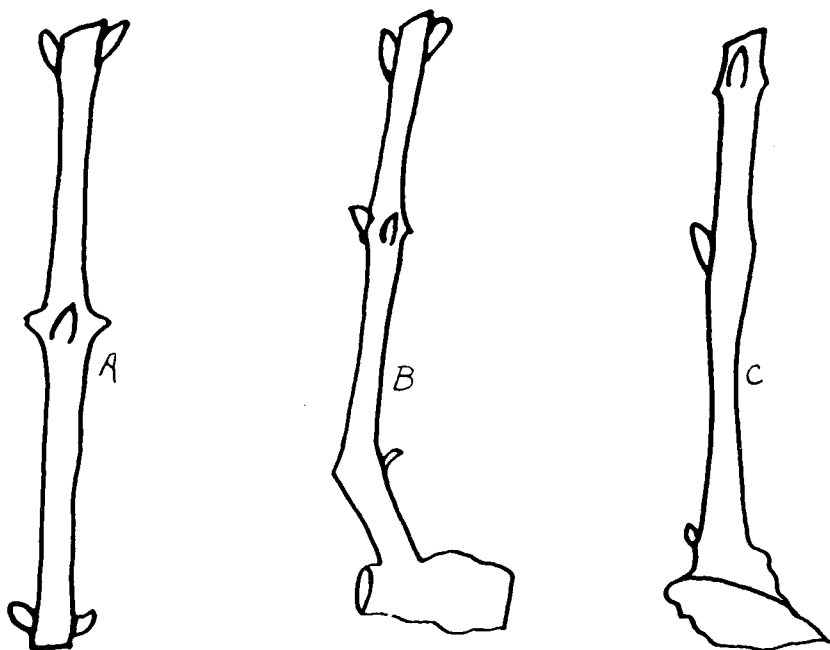


Figure 3.—A hardwood cutting; B, mallet cutting; C, heel cutting.

sand. These plants form roots directly from the leaf. Gloxinias form tubers on the free ends of the petioles, and the new plants are grown from these tubers.

Leaf cuttings are handled in the same manner as are soft-wood cuttings. They can be used for only a few species of plants.

Hardwood Cuttings

Hardwood cuttings are made during the winter of ripe, mature wood which is in a dormant condition. After they are made, they are stored until they can be planted in the open ground in the spring. Hardwood cuttings are used mainly with deciduous, woody plants. Some plants which may be grown from hardwood cuttings are privet, spirea, honeysuckle, tamarix, gooseberry, grape, and quince.

Select 1-year-old wood, one season's growth, of medium size, which has been well ripened. Discard all soft, spongy, or immature wood. Excessively large wood is not as desirable as that of average diameter.

Cutting wood should be obtained in late fall or early winter, after the wood has become well ripened and hardened. There is no objection to getting cutting wood while it is frozen, provided it is thawed out slowly. This slow thawing is best done in a cool room under sawdust, moss, or straw. The cutting wood

should be stored in moist, but not wet, moss or sawdust until needed.

Hardwood cuttings are usually made from 8 to 10 inches long (fig. 3-A). The lower cut is made just below a bud, and the upper cut is made a short distance above a bud. Each cutting should contain at least two buds. Cuttings should be fairly uniform in length to facilitate handling. A cutting box is desirable to give uniformity.

Hardwood cuttings are usually made with hand pruning shears. The type of shears is not important if the blades fit closely and if the shears cut smoothly and are not tiring to use.

After the cuttings are made, they should be tied in convenient-sized bunches, about 3 or 4 inches in diameter, and stored, butts up, in a cool place. They may be stored in sand, moss, or sawdust. Many large growers bury them in a well-drained place out of doors. They should be protected with a covering of straw or leaves. Stored in this manner, the cuttings are in the proper condition to callus.

Variations of this long type of cutting are sometimes used. Mallet and heel cuttings (fig. 3-B, C) contain a small portion of 2-year-old wood at the base of the cuttings. They should be handled like the ordinary hardwood cuttings.

Short cuttings of mature wood which have but one bud are sometimes used where the supply of propagating wood is limited. They do not have the strength nor drought resistance of the larger types, and consequently must be handled more carefully. They must normally be started in a greenhouse or in a hotbed where bottom heat is available and where moisture and temperature can be controlled. In making single-eye cuttings, the upper cut is made a little above a bud and the lower cut about 2 inches below the bud.

Hardwood cuttings are either planted out in the field in rows or in cutting beds. The soil must be in excellent condition in either case. In planting, the cuttings are set deep enough to allow only the top bud to remain above the ground. They are usually set in the field, in rows from 6 to 42 inches apart, depending on the method of cultivation to be used. They are spaced from 1 to 4 inches apart in the row. They may be set in a plowed furrow against the land side of the furrow or in a narrow trench. They must have the soil packed tightly around them. With the exception of currants and gooseberries, which ripen their wood very early in the fall, hardwood cuttings are usually planted in the spring. To obtain the best stands, they should be planted as early as the ground is fit.

Root Cuttings

Some plants may be grown from root cuttings. These include sumac, dahlia, apple, pear, cherry, plum, horseradish, trumpet creeper, and a large number of others. Material for root cuttings ordinarily comes from one of two sources: Entire plants may be removed and all roots pruned off for cuttings, or root pieces may be collected when nursery stock is removed from the field in the fall. Root cuttings may either be made up in the fall or winter and stored in pits in the ground over winter, or the pieces of roots may be stored and cut in the spring before planting. Roots from $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter are the most desirable. They are cut in pieces from 2 to 4 inches long.

Root cuttings are planted in the spring in furrows from 2 to 3 inches deep, and the soil is mounded up over the rows for a couple of inches. This ridge is later raked off when the cuttings have started and made about 1 inch of growth.

When handled in the greenhouse or hotbed, the pieces of root are often cut shorter, from 1 to $1\frac{1}{2}$ inches long. They are often planted as soon as secured, although many propagators believe they obtain better stands if the cuttings are allowed to callus. It is possible to start root cuttings at once, as roots have no absolutely dormant period.

Tuber Cuttings

The best known examples of tuber cuttings are the white or Irish potato and the sweet potato. With the white potato, the tuber is cut into pieces containing one or more eyes or buds. The pieces are often slightly dried before planting. If much disease such as potato scab is present, the tubers should be treated with a disinfectant. The cut tubers are planted directly into the field.

A sweet potato is a true root and will produce shoots from adventitious buds. These shoots are transplanted after they form roots. Sweet potatoes are propagated by burying tubers an inch or two in a hotbed or coldframe quite early in the spring. They should not be placed so close in the bed that they touch each other. In about a month, the young plants may be pulled off and planted. Three or four crops of sprouts may often be obtained from each tuber.

Layerage

Layerage is one of the simplest and surest methods of vegetative plant propagation. It is merely the bringing of shoots or branches into contact with some rooting medium while they are still attached to the parent plant. Propagation by layers requires very little care, as the parts of the plant which are used are still

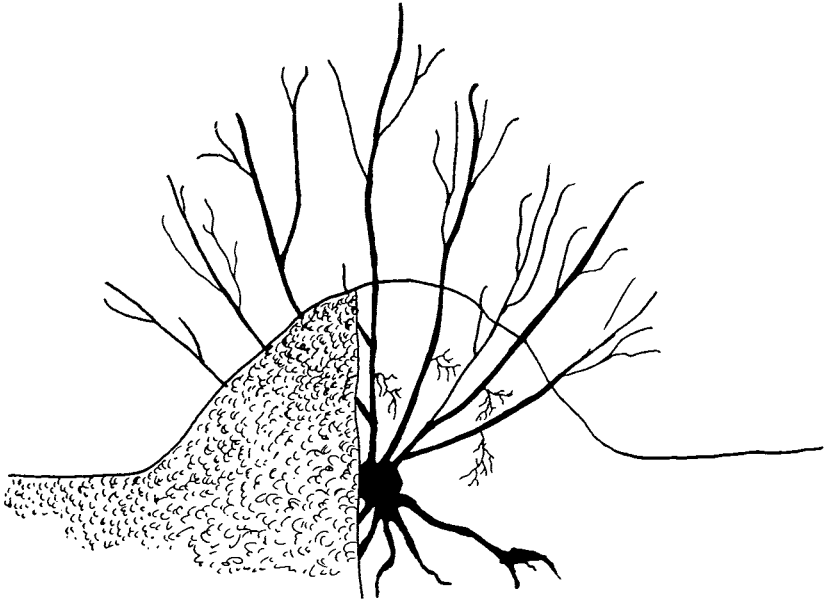


Figure 4.—Mound layering.

receiving nourishment from the parent plant. They are almost certain to grow, even under unfavorable circumstances. Plants which are difficult to root by other methods can usually be rooted by layerage.

Simple Layerage

Simple layers are made by bending branches over to the ground and covering them with soil, leaving only the tips of the branches uncovered. It may be necessary to peg the branches down with wooden or wire pegs to hold them in place. Often a trench from 4 to 6 inches deep is dug, and entire branches are covered in the trench.

Mound Layerage

Mound layering is followed with plants such as gooseberries, currants, quinces, and ornamental shrubs that make similar growth. Soil is heaped up around the plants, covering them entirely except for the tips (fig. 4). The soil is usually mounded up in the spring and kept in place until fall. By that time the shoots should have sent out roots. When rooted, they are removed and planted out in the field.

Where large numbers of plants are desired, the mother plants or "stool plants" are cut back to the ground in the spring. As the new shoots start to grow, the soil is mounded up around

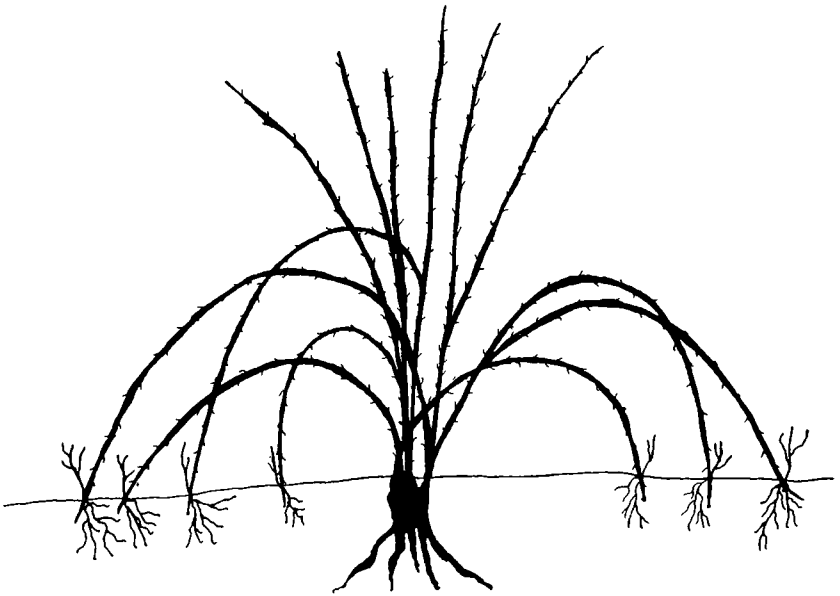


Figure 5.—Tip layering of black raspberry.

them. This is usually done in the early summer. Another method is to cut the stool plants back one spring and layer them the following spring.

With some hard, woody plants which will not root readily by layering, wounding the parts placed underground may encourage root formation. Any one of a number of methods may be used. Cutting, notching, bending, ringing, and twisting the branches or shoots are all successful.

Some plants propagate naturally by layers. Black raspberries and many purple raspberries root readily at the tips of the branches (fig. 5). The current year's canes bend over naturally in late summer until the young, growing tip touches the ground. Many of these tips will root without any attention, but covering each tip with a little soil will not only greatly increase the number rooted, but the plants obtained will usually be much stronger. The tips will have rooted by late fall and may be dug for transplanting either in the fall or in the following spring.

Runners

The strawberry produces its new plants on specialized shoots or "runners" during the summer. Each runner forms a cluster of leaves at each second node. Roots will develop here under proper conditions. It is often necessary to pin the runners down in contact with the ground to secure rooting. With the strawberry, early-rooted plants are the best.

Pot Layerage

Pot layers, also known as "aerial" or "Chinese" layers, are made in the greenhouse on plants with rigid, upright stems which will not bend easily. In pot layering, the stem is wounded and the wounded area is covered with material such as sphagnum moss to hold moisture. Split flower pots or small, split boxes are often used to hold the moss in place. When roots form, the rooted stem is cut off and potted. Pot layering is a greenhouse method. It is used only with valuable plants which are extremely difficult to root in any other manner.

Separation and Division

Separation and division are the simplest form of vegetative propagation. Although the two are very similar, and in some instances they may overlap, in the main they are distinct types.

Separation is plant propagation by means of naturally detachable vegetative parts such as bulbs and corms. Division is the separation of plant parts by force, as where the parts to be used in propagation are cut or broken from the parent plant. It usually involves units such as tubers, root stocks, suckers, and rhizomes.

Bulbs are specialized buds with extremely shortened stems. They are fleshy and are usually subterranean in nature. They have become accustomed to long periods of inactivity and have made provision for this by storing food material in the thickened leaves or bud scales. Bulbs are of two types. One is the loose, scaly bulb such as the lily. This type of bulb is made up of a series of narrow, loose scales. The other kind, of which the onion is a common example, is made up of a series of practically continuous layers.

Corms differ from bulbs in that they are solid throughout, although they frequently do have a husk or tunic.

Bulbs may reproduce in three ways. The mother bulb may separate into two or more complete bulbs. This is a slow process, and it is not desirable for flower production, since bulbs ready to separate do not produce satisfactory blooms.

Some bulbs form bulbels, or small bulbs, either around the base of the mother bulb or under the bulb scales. Bulbel formation may be induced by various means. Any injury to the mother bulb which checks stem or leaf growth will do this. Methods commonly used include cutting, notching, or scoring the mother bulb. One or more years are required to produce flowering-sized bulbs from naturally formed bulbels, while the time

required to mature bulbs from bulbels caused by wounding may be as long as 6 years.

Bulblets differ from bulbels in that they are produced above ground, usually in the axil of a leaf or flower. They will usually develop into fully matured bulbs in from 1 to 3 years. Both bulblets and bulbels may be planted in the open.

The term "sets" in the seed trade is applied to small bulbs. Often their small size is the result of intentional crowding, as is the case with onion sets. The small bulbs are dug, stored over winter away from frost, and then planted the following spring.

Corms may be grown in the same way as bulbs. They will produce "cormels" or "spawn" around the base of the mother corm. Some types, as the *Primulinus gladiolus*, will form large numbers of cormels without treatment, but wounding in the same manner as with bulbs may be necessary for others. The cormels are harvested, stored over winter, and lined out in the field or in beds the following year.

Division is a form of separation in which the parts used are not naturally detachable. Tearing, breaking, or cutting is usually necessary. Division is a method of propagation useful with plants which form crowns, rhizomes, tubers, or offsets.

Crown division is common in the growing of herbaceous perennials such as the peony, aquilegia, or phlox. It is also used for many woody shrubs. Crowns may be dug and divided into as many parts as there are vigorous buds. It is best, however, to have at least two or three good buds to each piece, since more vigorous plants will be obtained if this is done.

Rhizomes are a type of underground stem which have prominent "eyes" or leaf buds. Propagation or increase is accomplished by the use of pieces which contain one or more eyes. The iris is a common example.

Tubers are thickened portions of either underground stems or roots. Planting a tuber or a part of a tuber should result in the formation of several tubers. Common examples of tubers are the potato and the artichoke. Tubers may be cut into as many pieces as there are eyes or buds, but there must be at least one good eye on each tuber piece or cutting.

Some plants produce rosettes or crowns which will root readily when they come in contact with moist soil. These are usually designated as "offsets." Hen-and-chickens, pandanus, pineapple, and date palm all produce offsets which may be used for propagation.

Graftage (Grafting and Budding)

Graftage is the term used to denote the union of a scion or a bud of one plant with another plant, the stock, which is to furnish the roots. It is the operation of inserting a bud or scion in a branch, stem, or root of another plant in such a manner that the two will make a permanent union and develop as one plant. Graftage is used to increase stocks of plants which will not come true from seed and which cannot be easily nor satisfactorily grown by other means of vegetative propagation. It may alter the character of the top, as in dwarfing; it may be used as a means of changing the top from one type of variety to another; or it may be used to repair injured trees. It may also be the means of adapting plants to their environments.

All grafts are composed of two parts: scion and stock. The scion is the part which is placed on or inserted into the stock. The stock is the part which is to furnish the roots for the resulting plant.

Graftage can be divided into two simple classes: scion grafting or true grafting, and bud grafting or budding. These classes may be further subdivided according to the position of the cut or the manner in which the cut is made.

Grafting in some form and on some types of plants can be done in almost any month of the year. However, there are two periods when cambial activity is greatest. During these two periods, wounds heal more quickly, and unions between stock and scion are more uniform and satisfactory. The first period of cambial activity is in the early spring when growth is starting, and the second is in the late summer or early fall. The methods used in the different seasons are those adapted to the growth conditions occurring at those times. Plants resulting from either bud or grafts are very similar, regardless of the method of propagation used.

Scions

Scions should be cut and used while dormant. If they are cut in the late fall after the leaves have fallen, but before severe weather has set in, they will be free from winter injury. Wood of the previous season's growth that is vigorous is best. Scions should be cut, tied in bunches, and stored in damp sawdust or moss in a cool cellar. Sand is not desirable packing material for scions, since it is impossible to remove it all before cutting. One cut with a sharp grafting knife against a grain of sand will ruin the edge.

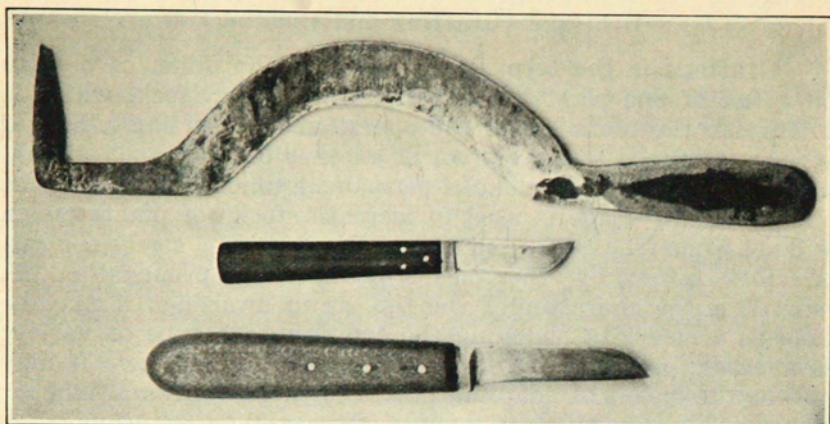


Figure 6.—Top, cleft-grafting chisel; center, budding knife; bottom, grafting knife.

Stocks

The stocks or roots to be used for bench grafting should be dug in the fall and stored under cool, moist conditions until needed.

The apple is usually propagated on either "French crab" or domestic apple seedlings when standard or full-sized trees are wanted. For dwarf trees, rooted layers of Paradise are used, while Doucin stock will give a semi-dwarf type of tree.

Cherries are chiefly grown on either Mazzard or Mahaleb roots. The Mazzard is the common stock for sweet cherries and Mahaleb for sour varieties.

Peaches are generally budded on peach seedlings grown either from seedling pits or from seeds of selected varieties.

The Myrobolan stock is the common one for plums, although native plum seedlings are sometimes used.

The French pear (*Pyrus communis*) seedling is the best known root for pears. Some Chinese and Manchurian species are sometimes used where blight resistance is desired.

Tools

The necessary tools for either grafting or budding are simple. Knives with stiff, straight blades with thin edges suitable for grafting are shown in figure 6, with one adapted for budding.

One essential for successful grafting or budding is the use of sharp tools. It means better workmanship and fewer cut fingers. A dull knife is a dangerous tool when used for grafting.

Materials

Materials necessary for the different methods will vary.

Grafting wax of some type is necessary for outdoor grafting where drying of cut surfaces is a problem. Waxing is one of the important factors in the success of many types of grafting. Properly made and applied, wax protects against drying out and the entrance of disease organisms. Most grafting waxes are combinations of rosin, tallow, beeswax, and linseed oil in varying proportions. There are two types of grafting wax: hand and hard wax. Hand wax is soft enough to be applied with only the warmth of the hands, while the hard waxes must be melted by heat and applied with a brush.

HAND WAX FORMULA.—One of the standard formulas for hand wax is the following: Rosin, 4 parts; beeswax, 2 parts; tallow, 1 part.

Melt the tallow first, then the beeswax, and finally the rosin. Mix thoroughly and then pour into cold water. When cool enough to handle, work the mixture with greased hands until it is a light straw color. Then roll it into balls or rolls and store in oiled paper until needed.

This wax can be applied with the hands, or it can be used melted. When used as a hand wax, keep the hands well greased. This wax will soften sufficiently for use by merely working and warming it with the hands.

A harder wax which can be used only when melted is often desirable. It is much easier and cleaner to handle than the hand wax.

HARD WAX FORMULA.—A common formula is as follows: Rosin, 5 parts; beeswax, 1 part; linseed oil, $\frac{1}{4}$ part; lampblack or powdered charcoal, $\frac{1}{2}$ part.

Melt the beeswax and rosin, then add the linseed oil. Take the mixture off the fire and slowly stir in the lampblack or charcoal. This makes a good, tough wax which will not crack badly. It is hard enough not to soften and run in hot weather.

Paraffin has been used as a grafting wax. Used alone, it will check and crack in cool weather, although it will give good results in hot weather if applied hot. Paraffin with a high melting point is often used as an ingredient for grafting wax.

PARAFFIN WAX FORMULA.—A brush wax containing paraffin, which is recommended by J. A. Neilson of Michigan, is made as follows: Rosin, 1 pound; raw linseed oil, 3 fluid ounces; paraffin, 5 pounds.

Melt the rosin and linseed oil and pour it into the melted paraffin. Mix thoroughly and pour into pans that have been greased or lined with oiled paper. This is a satisfactory wax for scion coating and as a general brush wax.

TYING MATERIALS.—Waxed string, waxed bands, or adhesive tape are used for tying grafts. For budding, raffia is the most common tying material, although the use of strips of rubber is increasing.

Waxed string may be purchased ready to use from nursery-supply houses, or it may be prepared at home. It is made by soaking balls of No. 18 or No. 20 knitting cotton in hot wax for a few minutes, after which they are removed, drained, and cooled. This string is sufficiently strong to make a tight tie on whip grafts, but it can be broken easily with the hands.

Waxed bandages or wraps are sometimes used on top grafts and bridge grafts. They are waxed in the same manner as grafting thread.

MELTERS.—When a hard wax is used, or when wax is to be used in the melted form and applied with a brush, some means of melting the wax out of doors is necessary. Several types of wax melters or lanterns are on the market, or the grower can make his own. A small can inserted in the top of an ordinary lantern will suffice.

BRUSHES.—In using grafting wax, the cut surfaces should be covered airtight and watertight. Consequently, the application requires care. In applying hot wax, a 1- or 2-inch paint brush will be satisfactory. The wax should not be hot enough to injure the wood.

Methods of Grafting

There are many methods of grafting, but only six of the more commonly used will be included here. These are whip or tongue grafting, budding, cleft grafting, bark grafting, veneer or channel grafting, and bridge grafting.

WHIP GRAFTING.—The whip or tongue graft is adapted only to small stocks which are about the same diameter as are the scions. It is also used for top-working small branches. The cut on the lower end of the scion and that on the upper end of the stock are diagonal, each with a cut face about 1 to 1½ inches long. Each cut must be made in one smooth motion, and the faces should be perfectly true and smooth. At a point about one-third of the distance from the tip of the cut face on both stock and scion, a tongue is cut as is shown in figure 7-A. Then stock and scion are fitted together (fig. 7-B). Care should be taken to

get at least one margin with the cambium layers of each part in close contact. Then the parts should be tied to hold the graft firmly together (fig. 7-C). Waxed knitting cotton, raffia, adhesive tape, or similar material may be used. When tied, the cut surfaces may be waxed over with paraffin or grafting wax to prevent drying out.

Whip grafts are especially adapted to fruit stocks, and the work may be done inside in the winter. The stocks, usually seedlings, are dug in the fall and stored under suitable conditions in some accessible place. The roots may be cut so as to place the union between stock and scion at the crown of the seedling. When so placed, the graft is a "whole-root" graft, since the stock part includes both top and root material. "Piece-root" grafts are made by using a section of root from 2 to 4 inches long. Often several piece-root grafts may be made from each seedling root.

Scions are usually cut 4 or 5 inches long, so that they carry about three buds. The total length of a complete graft is usually from 8 to 10 inches.

There is one variation in the length of the whip graft which is worthy of mention. If own-root plants are desired, a long scion, from 8 to 12 inches long, may be used with a short root piece. Such grafts are planted deep and will develop roots on the scion itself.

BUD GRAFTING OR BUDDING.—Budding is a type of grafting in which a single bud detached from the bud stick is inserted under the bark of the stock. It is usually done from midsummer on to early fall, as long as the bark "slips" or peels easily. Buds

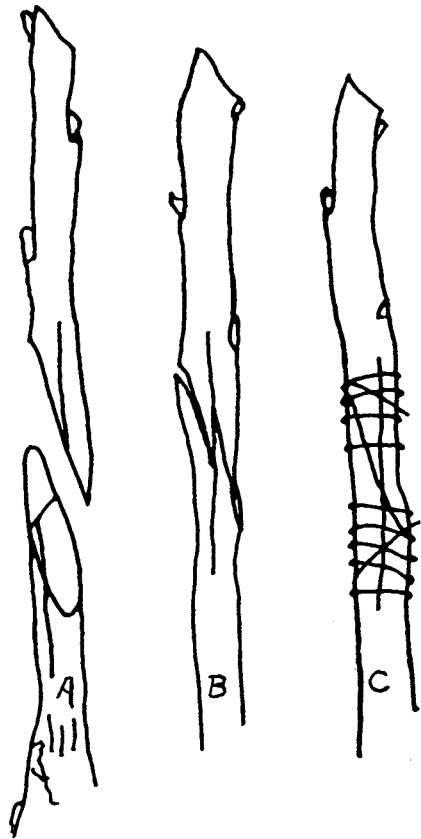


Figure 7.—Whip graft: A, cuts used in preparing stock and scion; B, stock and scion together; C, completed whip graft, showing method of tying.

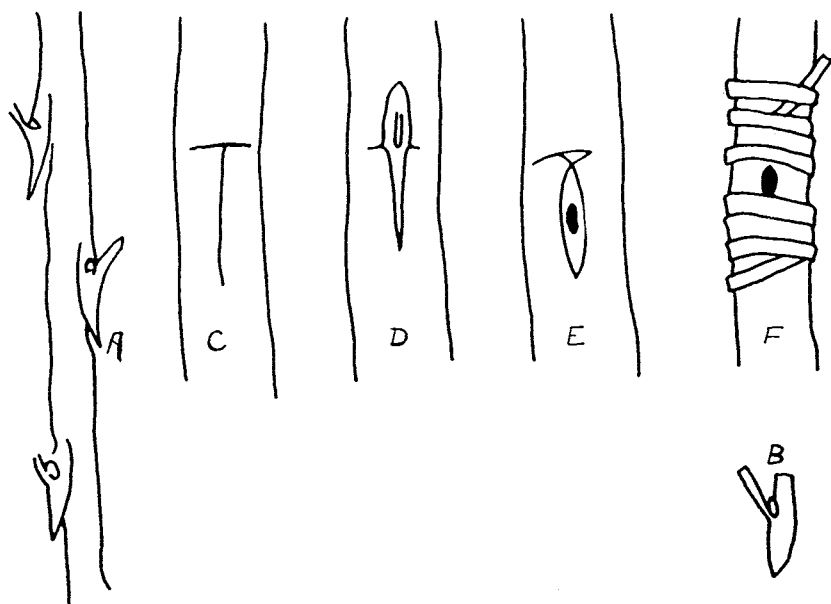


Figure 8.—Shield budding: A, method of cutting back from bud stick; B, bud cut ready for use; C, T-cut; D, method of inserting bud into T-cut on stock; E, bud in place; F, method of tying.

from the current season's growth are used, and leaf buds only can be used. Flower buds are not desirable, as they either blossom and die or make very weak growth.

Budding is a method which can be used both for the propagation of nursery trees and for top-working young trees. It is better adapted to stone fruits than scion grafting, since the wood of these fruits will not split satisfactorily.

Shield Bud.—The shield bud is the type in most common use. Shoots carrying buds of the desired variety are cut from the tree, and the leaves are removed (fig. 8-A). A short piece of petiole is left in place to serve as a handle (fig. 8-B). The shoots or "bud sticks" are then wrapped in moist cloths to keep them from drying out.

Stocks for budding should not be over $\frac{1}{2}$ inch in diameter. Buds preferably should be inserted in the stock on the north side, where they will be shaded. In the nursery, buds are usually inserted not more than 1 or 2 inches above the ground. In fact, nurserymen frequently pull the soil away from the stocks so that the bud can be set even lower.

In preparing the stock to receive the bud, the first cut (which should parallel the stock) is made on a smooth section, cutting just through the bark but not into the wood. Then the second cut is made across the stem, forming a T (fig. 8-C).

Ordinarily, the cross cut is made at the top of the longitudinal cut, although some propagators reverse this position.

To prepare the bud, it is cut with a sharp knife from the bud stick. Starting $\frac{1}{4}$ inch below the bud, cut through the bark and upward along the stick to about $\frac{1}{4}$ inch above the bud (fig. 8-A). With fruits and most ornamental trees, a sliver of wood is usually left with the bud to protect it, but with plants such as roses it should be removed. Using the stub of petiole as a handle, the bud is then inserted in the T-cut and pushed firmly into place (fig. 8-D, E). If the slit on the stock will not open easily, lift the corners with the point of the knife or with the lifter end of the budding knife. When in place, the bud is wrapped with raffia, soft twine, or similar material to hold the bud in place against the stock until they unite. In wrapping the bud, start below the bud, crossing the first turn to hold it in place. Continue up to the bud and then above it, but never across it. Then slip the free end under the last turn and pull it snug. Three or four wraps above and below the bud are sufficient. Wrapping in this way will give a smooth, snug tie without any knots (fig. 8-F). Waxing is not usually practiced, as healing should take place in a short time, not more than 2 or 3 weeks. Then the tie must be cut to prevent pinching out the bud. Rubber bands are often used for tying. Since they will stretch as the stock grows, they do not need to be cut.

Buds inserted in the late summer remain dormant over winter and should start to grow the following spring. When growth starts, cut the stock off $\frac{1}{2}$ inch above the bud. All sprouts from below the bud should be rubbed off.

TOP-WORKING.—It frequently happens that a grower wishes to change fruit trees from one variety to another. There are several ways whereby this can be done. Of the ways for "top-working" which have proved successful, three will be given. In addition, budding or whip grafting can be used on small trees.

Top-working is best done in the early spring, at the time growth is starting. The scions used should be dormant wood which has been stored at a cool temperature. It is not desirable to change the entire top of a large tree in one season. Better results are obtained by working over but part of the tree the first year.

Cleft Grafting.—Cleft grafting is the most common type used for top-working, and limbs from 1 to 3 or 4 inches in diameter are well adapted to its use. Cleft grafting consists essentially of cutting off squarely the branch to be worked, splitting the stub, and inserting one or two scions in the split stub. The cleft is made with a special "cleft grafting chisel" (fig. 4), or it may

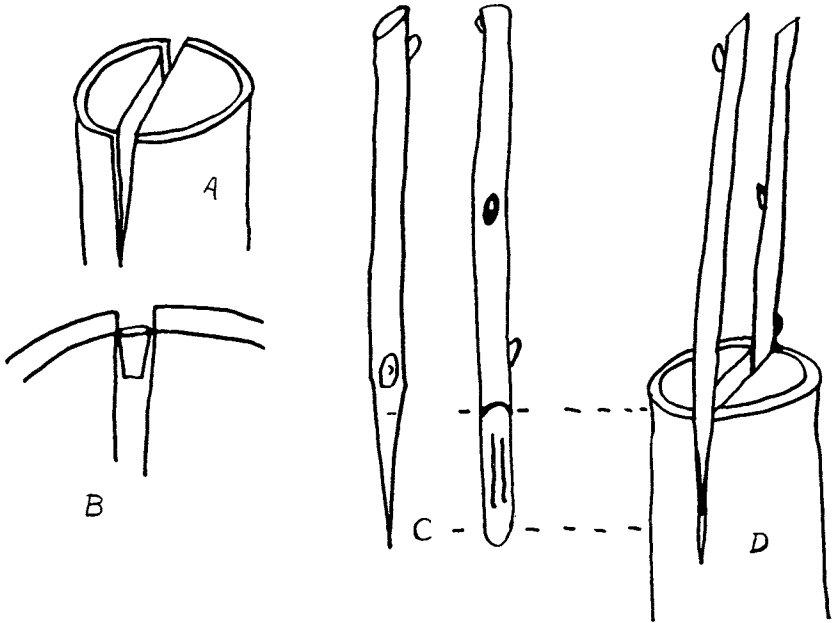


Figure 9.—Cleft grafting: A, split stick of branch; B, partial cross-section of split stub, showing cross-section and position of scion; C, cut scions; D, completed cleft graft ready to be waxed.

be done with a heavy butcher knife. The stock or branch should be cut off at a point where the limb is smooth and free from knots. Split the stub down 2 or 3 inches by driving the chisel down with a mallet. Then remove the chisel and open the split with the wedge end of the chisel (fig. 9-A).

The scion is prepared by making a smooth cut on one side of the lower end of the scion from $1\frac{1}{2}$ to 2 inches long. Then make a similar cut on the other side, forming a thin wedge. One side of the wedge should be thicker than the other. The scion should have 2 or 3 buds above the upper end of the wedge, and the lowest of these buds should be just above and on the wider side of the wedge (fig. 9-C). Branches 1 inch in diameter require one scion, while those over 1 inch should have one at each side of the cleft. Larger branches, 4 or 5 inches in diameter, may be split twice and carry four scions.

The scion is inserted into the split stock with the thicker side of the wedge outside. Force the scion into the cleft until the bud at the upper end of the wedge is about level with the cut end of the stock. Be sure that all the cut faces are in the cleft (fig. 9-D). Care should be taken to place the cambium layers of both stock and scion in contact (fig. 9-B). When the scions are in place, remove the wedge and allow the stock to close and hold the scions firmly in place. Then the cleft should

be filled with grafting wax and all cut, exposed surfaces carefully covered with wax to prevent drying out.

Bark Grafting.—Bark grafting is a usable method of top-working large trees. It is preferred by some because the stub of the branch to be grafted need not be split. Consequently, it is believed to heal over more quickly. There is some objection to this method, in that the scions may be blown or broken out easily.

The branch to be top-worked is cut off straight across, in the same manner as for cleft grafting. The scion is cut (fig. 10-A) with a long bevel. Then, with a sharp knife, slit the bark down 2 or 3 inches as shown in figure 10-B. Raise the bark at the top of the slit, and insert the wedge end of the scion and push it into place (fig. 10-C). Fasten the scion in place with two small, flat-headed box nails. When the graft is in place, wax it over with grafting wax or paraffin, covering all cut surfaces carefully. Several scions should be set in a fair-sized branch, spacing them about 2 inches apart.

Veneer or Channel Grafting.—This type is very similar to bark grafting. The difference is that the scions are fitted into narrow grooves or channels cut in the bark of the branch to be grafted.

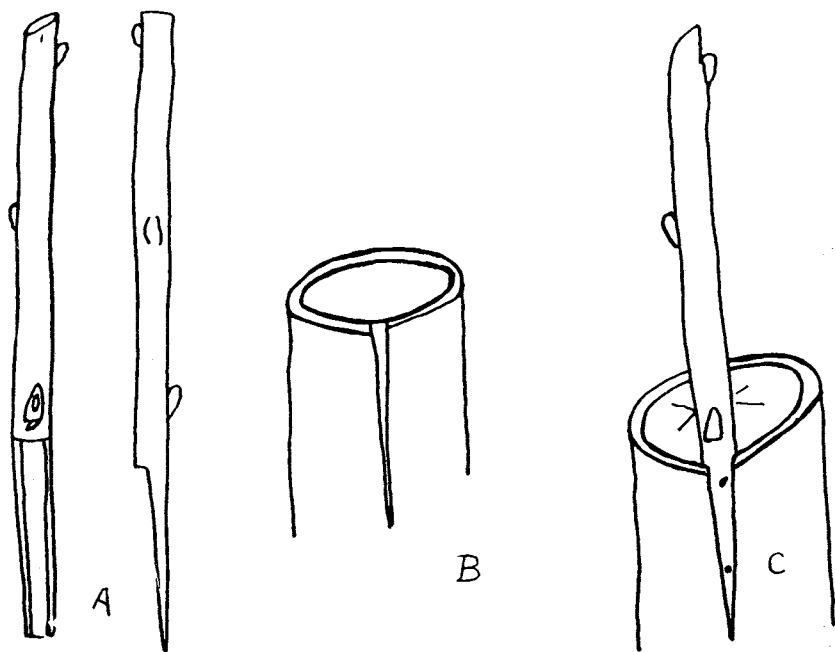


Figure 10.—Bark graft: A, cut scions; B, split bark; C, scion in place ready for wax.

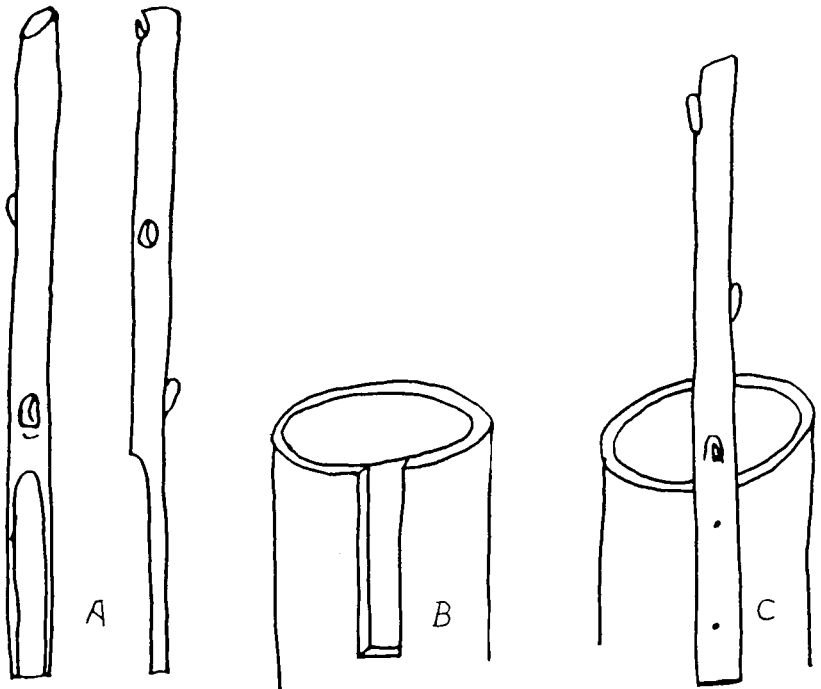


Figure 11.—Veneer or channel graft: A, cut scions; B, channel cut in branch; C, completed graft ready to be waxed.

The scions are shaped by cutting away about half the diameter for a distance of 2 or 3 inches from the lower end (fig. 11-A). Then the branch to be grafted is sawed off and a channel cut the exact size of the face of the scion (fig. 11-B). A simple way to do this is to hold the scion against the stub of the branch and outline the shape of the scion with a sharp knife. Remove the marked section of bark and fit the scion in place, fastening it with two small, flat-headed nails (fig. 11-C). Then wax the graft as with the cleft graft or bark graft.

Bridge Grafting.—Bridge grafting is a means of repair rather than a method of plant propagation. Orchard trees often are severely damaged by rodents, disease, or insects, or by mechanical or winter injury. They may be left with the trunk at least partially girdled. Trees injured in this manner may often be repaired and saved by bridge grafting. By bridging across damaged parts, severely injured trees can frequently be made to function normally again. In preparing the tree for bridge grafting, all damaged bark should be cut back to clean, live bark. Then the girdled area should be painted. As with other forms of scion grafting, the scion wood used should be dormant.

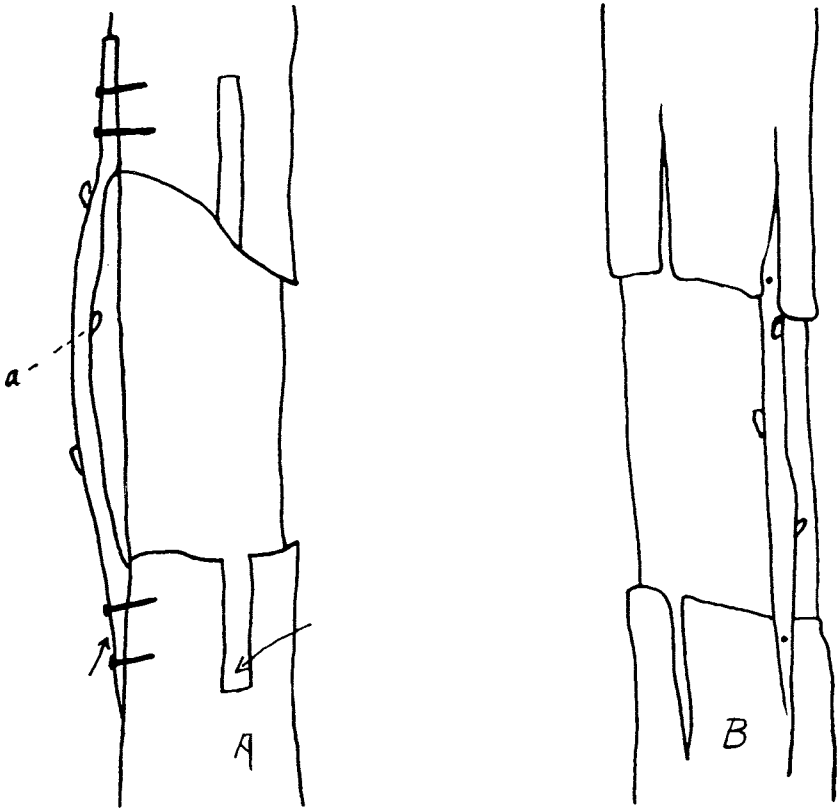


Figure 12.—Bridge grafting: A, using inlay or channel graft; B, using bark graft. Note bulge in scion at "a."

There are many ways of applying the scions. Some form of bark or inlay grafting may be used. Both top and bottom of scions should be inserted (fig. 12-A, B). Some bow in the scions is necessary to give extra length to allow for tree movement in the wind without pulling the scions out. The length of the scion may be from a few inches to several feet, according to the size of the area to be bridged over. Where the injury is large, scions should be inserted at intervals of 2 or 3 inches across the injured area. After the scions are in place, wax over the cut surfaces.

Notes

Notes

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