*13 Techniques of Budding

learning objectives

- Discuss the importance and utilization of budding.
- Describe the different types of rootstocks utilized for budding.
- Explain the management practices of summer, spring, and June budding.
- Identify the different types of budding.
- Describe the processes of top-budding (topworking), double-working by budding, and microbudding.

INTRODUCTION

Budding is a form of grafting in which the **scion** consists of a single bud and a small section of bark with or without the wood. In other forms of **grafting** the scion has several buds.

budding A form of grafting that uses a smaller scion piece—sometimes just a portion of the stem with an axillary bud.

rootstock, understock, or stock The root system of the budded plant.

Budding accounts for the vast majority of grafted nursery stock. Millions of fruit and shade trees and roses are budded annually. *In turn, nearly all of this production is field-grown,* rather than container-grown. **Rootstocks** are lined-out in the field and grown until suitable for budding. After a season of scion growth, the trees are harvested when dormant and sold for orchard production or as landscape plants.

Chip budding and **T-budding** are the two most important types of budding for woody ornamentals and fruit trees (see Table 13–1, page 522). Chip and T-budding are much simpler and, therefore, much faster than manual grafting techniques. Single **budders,** working with one or more persons tying the buds **(tiers),** can bud 2,000 to 4,000 buds in a day—sometimes more. With well-grown rootstocks, healthy buds, and skillful budders, nurseries expect to achieve 90 to 100 percent successful unions or **"bud takes."** Managing production of budded liner plants is one of the more complex logistical problems in nursery production.

tier The person who completes the grafting process by tying and sometimes waxing the graft area.

topworking (top-budding) The process of budding onto an existing rootstock with new scion material.

In certain cases, budding is useful for **topworking (top-budding),** but because budding is confined to shoots less than 2.5 cm (1 in) diameter, it can only be used to topwork young trees or smaller shoots of older trees.

IMPORTANCE AND UTILIZATION OF BUDDING

Advantages of Budding Compared with Grafting

Budding makes very efficient use of scionwood, because only a single bud is needed to propagate a new tree. This efficiency reduces both the number of trees required to supply scionwood and the labor to maintain the trees and collect wood. Budding

also makes good use of plant material in cases when scionwood of a particular clone is limited. Budding may also result in a stronger union, particularly during the first few years, than is obtained by some grafting techniques, which reduces the likelihood that wind will damage the trees. The simplicity and speed of budding, especially the T-budding and chip budding techniques, makes these techniques useful for amateur horticulturists. A single, well-learned method can be used in a wide variety of applications.

Combining Budding and Grafting Techniques

A strategy of some ornamental and fruit tree nurseries in England is to chip bud or T-bud initially in the nursery row. Grafting with a whip-and-tongue graft is used as a backup for budded plants that do not take. There are other variations of this method where different budding and grafting systems are combined in nursery field production.

Conditions for Budding

Budding methods, such as T-budding and patch budding, depend on the **bark's "slipping."** This term is used to define the condition in which the "bark" (periderm, cortex, phloem, and vascular cambium) can be easily separated from the **"wood"** (xylem)—see Chapter 11 and Figures 11–6 and 11–22. Bark slippage denotes the period of the year when the plant is in active growth, when the cambium cells are actively dividing, and when newly formed tissues are easily separated as the bark is lifted from the wood. In Oregon, the bark slips from late June through August (19). However, adverse growing conditions, such as lack of water, insect or disease problems, defoliation, or low temperatures, may reduce growth, lead to a tightening of the bark, which will seriously interfere with the budding operation. If the bark has only the slightest adherence to the wood, the percentage of bud take will be severely limited. Irrigating nursery rootstock prior to and after budding enhances bud take. Of the budding types described here, only one—the chip bud—can be done when the bark is not slipping.

bark composed of tissue from the periderm to the phloem. For most budding systems the bark must be *slipping,* which occurs with active rootstock growth.

wood the secondary xylem that makes up the major mass of the rootstock tissues.

Budding height varies on nursery rootstock. Budding is done higher on dwarfing rootstock for fruit crops to prevent scion rooting. Higher budding also increases the dwarfing effect of the rootstock. Peaches tend to be budded low, about 2.5 to 5 cm (1 to 2 in) above the ground, while citrus is budded higher (see Fig. 13–12, page 527). Budding is done low on ornamental shade trees (see Fig. 13–4, page 517), since tree shape and appearance are important.

ROOTSTOCKS FOR BUDDING

Rootstock should have the desired characteristics of vigor. proper growth habit, and resistance to soilborne pests, as well as being easily propagated. Rootstock may be a rooted cutting, a rooted layer, a seedling, or a micropropagated plant (see Chapter 12). The length of time before budding depends on rootstock vigor, length of growing season, and climate. As little as six months to one year's growth in the nursery row is needed to produce a rootstock plant large enough to be budded, but seedlings of slow-growing species, such as pecan, and those grown under unfavorable conditions may require two or three seasons.

To produce nursery trees free of harmful pathogens (such as viruses, mycoplasmas, fungi, or bacteria) the rootstock plant, as well as the budwood, must be free of such organisms, see discussion in Chapter 16.

TIME OF BUDDING—SUMMER, SPRING, OR JUNE

Traditionally, budding is done when rootstocks are actively growing, so that the cambium divides and the bark separates readily from the wood (e.g., using the T-budding method). In the 1980s, however, chip budding replaced T-budding at many nurseries. This was based on research in England, which showed that chip buds of some species form a better graft union in cooler growing regions (7). Present consensus in the United States is to use chip budding for harder-to-graft varieties, and T-budding on easier budding material.

For any budding technique, however, well-developed vegetative buds of the scion variety must be available. For spring budding, the scion buds are used from dormant, stored budwood, whereas **quiescent** (nonelongating) buds are used from the current season's wood

quiescent (quiescence) Buds that are inhibited from growing and elongating via apical dominance of more distal buds produced during the current season on the same shoot.

spring budding
Budding that is done as soon as new seasonal growth occurs, in late March to early May, depending on location. A 1-year scion/2-year rootstock is generally produced.

June budding
Budding that is done from May to early June, which produces a smaller budded plant with a 1-year scion/1-year rootstock.

summer budding
Sometimes referred to as "**fall budding**," which is a misnomer since the budding occurs from mid-July to early September, not in autumn. A 1-year scion/2-year rootstock is generally produced.

in June and summer budding.

Budding is normally done during three periods of the year. In the Northern Hemisphere, these periods are March to early May **(spring budding),** May to early June **(June budding),** and mid-July to early September **(summer budding)** (Figs. 13–1 and 13–2, page 516). In the Southern Hemisphere, similar periods would be September to early November (*spring budding*), early November to early December (*June budding*), and mid-January to early March (*summer budding*).

The budding schedules listed (spring, June, summer) are for *production of nursery plants* that will later be dug from the nursery row and transplanted into an orchard or landscape site. Budding schedules can also be applied to container-produced nursery plants such as citrus, pecans, and selected woody ornamentals. **Top-budding (topworking)** *is done with established trees and shrubs in the field* and is scheduled during the year based on the plant species and budding method to be utilized. **Bench budding** (e.g., chip budding) can be done with dormant rootstock during wintertime, *working on a table.* Bench budding also includes budding onto *liner rootstocks in containers under protected culture conditions* (greenhouse, polyhouse). The budding could extend throughout the year, depending on the species and budding method. See Table 12–5 for optimum production windows when grafting/budding in the greenhouse (12).

bench budding (bench working) Budding under protected culture onto a dormant rootstock using a bench or onto a containerized rootstock that may be active or dormant.

Summer Budding

Summer is still the most important time for budding many species of fruit tree nursery stock and shade trees. Summer budding is sometimes referred to as "fall budding," which is a misnomer since the budding occurs from mid-July to early September, not in autumn. Summer budding is particularly important in northern areas where the growing season is short. The rootstock plants are large enough by midsummer to accommodate the bud, and the plants are still actively growing.

During the spring following lining-out, soil is mounded around the rootstock stem to protect the bark from sunburn and physical damage. During the spring and early summer, vigorous growth increases stem diameter; continued rapid growth is required for optimal budding. Poor growing conditions caused by drought, temperature extremes, insects, or disease may prevent or impair budding. During the period up to budding, suckers are removed from the roots, and sprouts are removed from the trunk area at or below where the bud will be inserted. Just prior to budding, the soil around the trunk is removed to expose the smooth, straight stem where the bud will be placed.

Budding starts when rootstock liners have sufficient growth, and vegetative buds on scion varieties are mature and well-developed. Buds are usually ready by late July (in Oregon). Budding peaks in August and finishes in September, particularly in areas with longer seasons. Nurseries maintain scion blocks to produce large amounts of high-quality scionwood. For tree fruits, scionwood is collected from trees provided by certification programs, depending on the state and nursery. These trees are certified as true-to-type; that is, they produce the accepted phenotype of a given fruit variety, and are free of known viruses and related pathogens (see Chapter 16). To produce a certified fruit tree, all parts of the tree must originate from certified blocks—scion, seed, stool, and cutting.

Scionwood (budwood, budsticks) is collected from the current season's growth and should be used promptly after cutting. Although budwood can be refrigerated for a short time, it is best to collect the budsticks as they are being used, a day's supply at a time. As the budsticks are selected, the leaves should be cut off immediately, leaving only a short piece of the leaf petiole attached to the bud to aid in handling the bud later on. Budsticks should be kept from drying by wrapping in material, such as clean, moist burlap, and placed in a cool, shady location until they are needed.

scionwood, budsticks, or budwood The scion pieces from which buds are collected for budding.

The best buds to use are usually on the middle and basal portions of the budwood. These buds are *quiescent*, and their growth is checked by apical dominance of more terminal buds. Buds on the succulent terminal portion of the shoot should be discarded. In

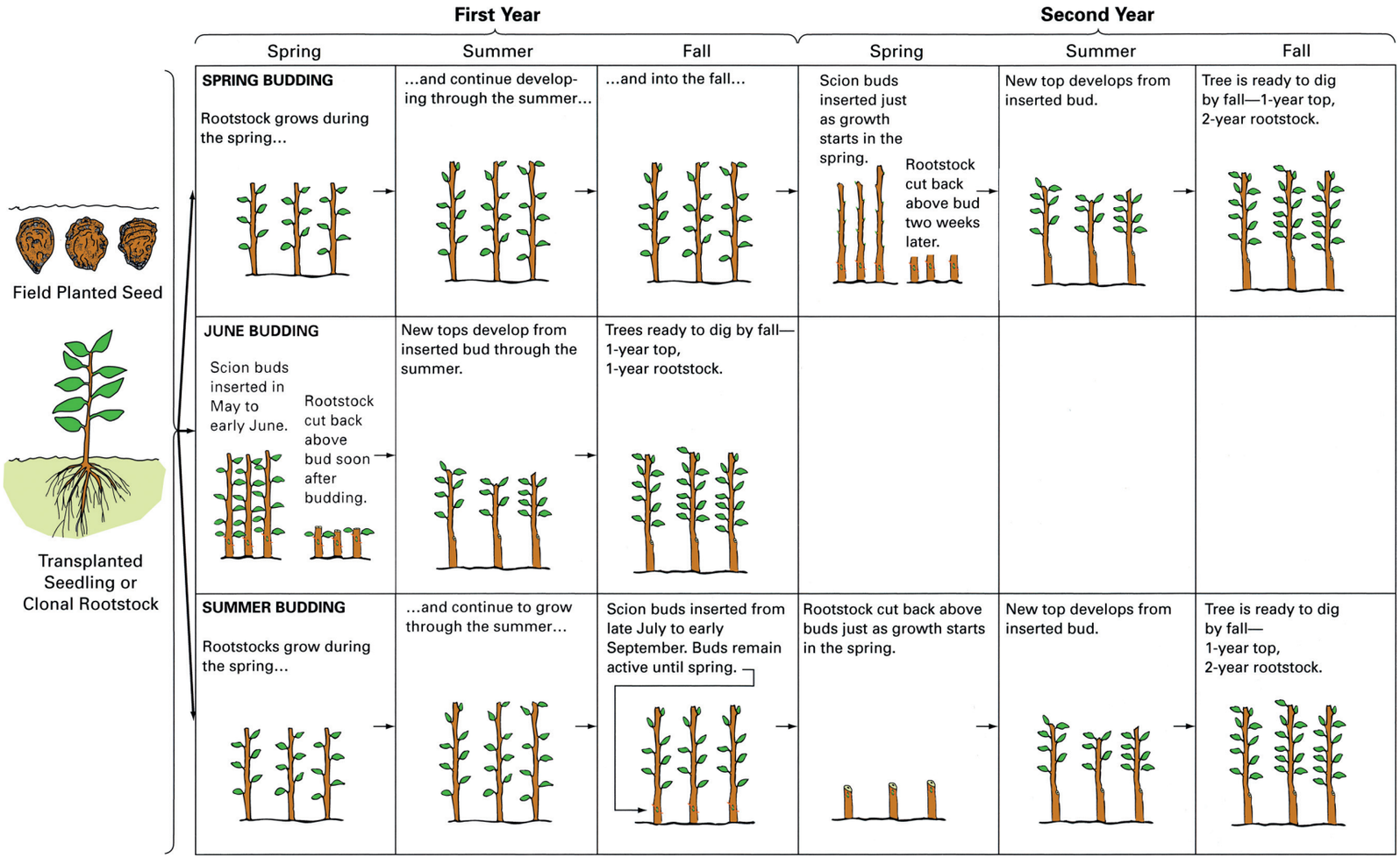


Figure 13–1
Comparison of the steps in spring, June, and summer budding for nursery production. The actual techniques in budding are not difficult, but it is very important that the various operations be done at the proper time. Rootstocks are field propagated from fall-planted or early spring-planted stratified seeds, seedling transplants, rooted cuttings or layers, or micropropagated plantlets.

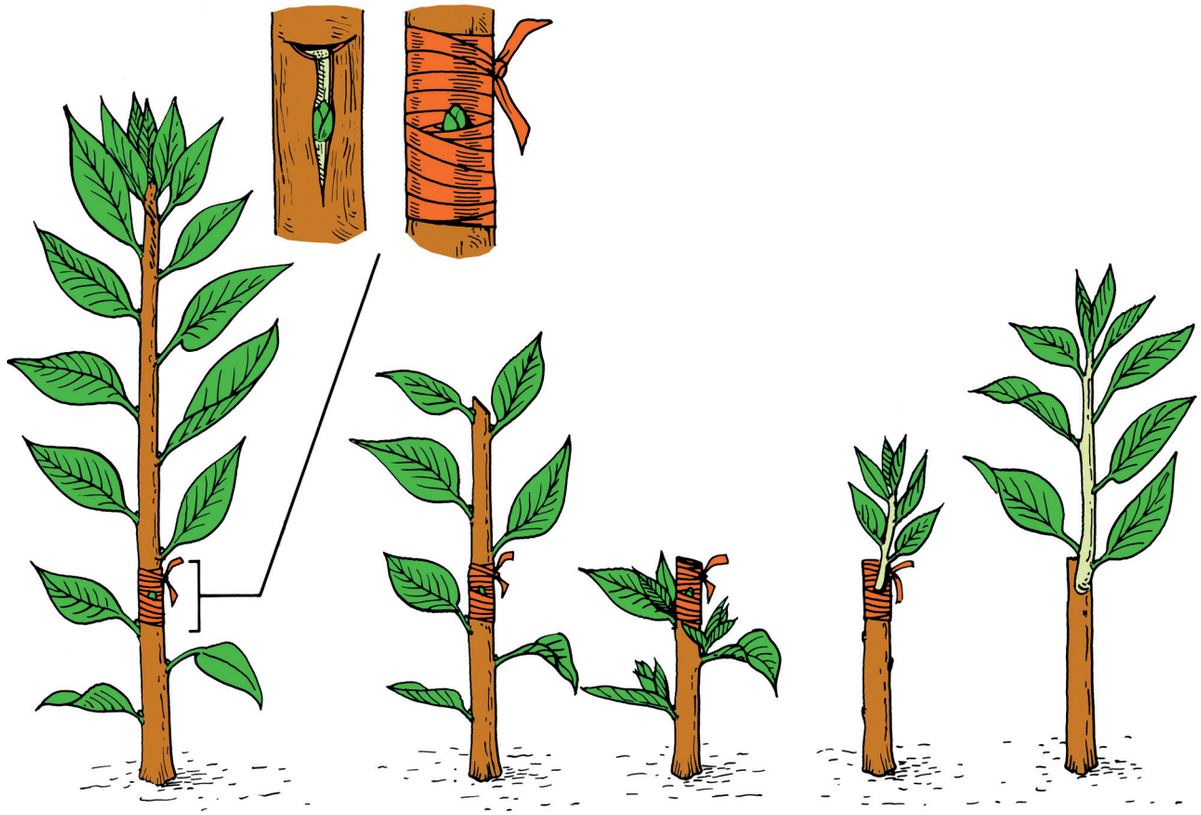


Figure 13–2
It is important in June budding that the rootstock be cut back to the bud properly. *Far left:* The shield bud is inserted high enough on the rootstock so that there are several leaves below the bud. *Center left:* Three or four days after budding, the stock is partially cut back about 9 cm (3 1/2 in) above the bud. *Center:* Ten days to two weeks after T-budding, the rootstock is completely removed just above the bud. *Center right:* This forces the shield bud and other buds on the rootstock into growth; the latter must subsequently be removed. *Far right:* Appearance of the budded tree after the new shoot has made considerable growth.

certain species, such as the sweet cherry, buds on the basal portion of the shoots are flower buds which, of course, should not be used (Fig. 13–3).

After the buds have been inserted and tied, nothing is done to the budded area until the following spring. However, it may be necessary to remove budding strips after bud take to prevent girdling. *Although the rootstock is eventually cut off above the bud, in no case should this be done immediately after the bud has been inserted.* The union of the bud piece to the rootstock is greatly facilitated by the normal movement of water, nutrients, and photosynthate in the stem of the rootstock. This flow is stopped if the top of the rootstock is cut off above the bud.

If the budding operation is done properly, the bud piece should unite with the rootstock in 2 to 3 weeks, depending on growing conditions. Abscission of the leaf petiole next to the bud is a good indication that the bud has united, especially if the bark piece retains its normal light brown or green color, and the bud stays plump. On the other hand, if the leaf petiole does not drop off cleanly but adheres tightly and starts to shrivel and darken, and the bark piece turns black—the operation has failed. If the bark of the rootstock is still slipping and budwood is still available, budding may be repeated.

Even though the union has formed, buds on most deciduous species usually do not grow or "push out" in the fall, since they are either quiescent or in a physiological **dormancy (rest)**. By spring, the chilling winter temperatures have satisfied the rest (dormancy) requirement, and the bud is ready to grow. Exceptions to the need for dormancy occur in maples, roses, honey locust, and certain other plants, where some of the buds start growth in the fall. In northern areas, such fall-forced buds usually fail to mature before cold weather starts and are likely to be winter-killed.

dormancy (rest) Buds that are inhibited from growing and elongating until sufficient fall and winter chilling needs are met to overcome an internal physiological requirement.

In the spring, the rootstock is cut off immediately above the bud, just before new growth begins. Cutting

(a) (b) (c)

Figure 13–3
In budding it is important to use vegetative rather than flower buds. Vegetative buds (arrows) are usually small and pointed, while flower buds are larger and more plump. Differences between vegetative and flower buds in three fruit species are illustrated here. (a) Almond: the shoot on the left has primarily flower buds and should not be selected for budding. The shoot on the right has vegetative buds, which are more suitable. (b) Peach: the shoot on the right has excellent vegetative buds, while those on the left shoot are mostly flower buds. (c) Pear: all the buds on the shoot at the left are flower buds, while buds on the shoot at the right are good vegetative buds, suitable for budding.

back the rootstock breaks apical dominance of the upper axillary buds and forces the inserted bud into growth. In citrus, the rootstock is partially cut above the bud and the top is bent or lopped over, away from the bud. This procedure is referred to as **"crippling"** or **"lopping"** (see Fig. 11–30). Leaves of the rootstock still supply the roots with photosynthate, but the partial cutting forces the bud into growth more rapidly than severely damaging the rootstock top. After the new shoot from the bud has started to grow, the rootstock top is completely removed. In colder northern regions, summer-inserted buds are sometimes covered with soil during the winter until danger of frost has passed, and are then uncovered and topped-back in late spring.

crippling or lopping
Bending (constriction) or cutting halfway through the rootstock stem above the bud union. This technique helps to force out the bud and maintain growth of the budded plant. At a later date, the rootstock stem is completely removed.

Where strong winds occur, support for the newly developing shoot may be necessary in species where new shoots grow vigorously. Sometimes the rootstock is cut off several centimeters above the bud, and the projecting stub is used as a support to tie the tender young shoot arising from the bud. Pecan patch buds are forced in the spring by girdling the rootstock a few centimeters above the inserted bud and stripping the phloem away; the tender scion shoot growing from the patch bud can then be tied to the rootstock. This stub is removed after the shoot has become well-established. With pistachio, stakes may be driven into the ground next to the rootstock, and developing scion shoots tied at intervals during their growth.

Metal shoot guide clips such as "Grow Straights" are used to obtain upright scion growth as the bud elongates (see Fig. 13–4). Since they are attached to the rootstock or inserted into the soil, they also give some mechanical support to the elongating scion shoot.

(a) (b) (c) (d)

Figure 13–4
(a) Spring budded Acer platanoides using a chip-bud system. (b) A chip-budded crab apple is being wrapped with poly tape (arrow), which will be removed after the graft has taken to prevent girdling the plant. (c) Grow Straight metal shield (arrow) to produce straight, upright growth from the scion bud. The top of the rootstock has been cut off to force out the scion bud. (d) The metal shield system with 'Crimson King' maple T-budded to a seedling rootstock. Courtesy of K. Warren (19).

Cutting back to force the scion bud also forces many latent buds on the rootstock. These must be rubbed off as soon as they appear, or they will soon choke out the inserted bud. It may be necessary to go over the budded plants several times before the developing shoot inhibits these "sprouts" from appearing. Nursery people refer to this procedure as **"suckering."**

suckering Sprouts from the rootstock that can crowd out and inhibit growth of the scion; hence, they must be removed.

The shoot arising from the inserted bud becomes the scion or top portion of the plant (Figs. 13–2 and 13–4). After one season's growth in the nursery, this shoot will have developed sufficiently to enable the plant to be dug and moved to its permanent location during the following dormant season. Such a tree would have a *1-year-old top and a 2- or perhaps 3-year-old rootstock, but it is still considered a "yearling" tree.* If the top makes insufficient growth the first year, it can be allowed to grow a second year, and is then known as a 2-year-old tree. Abnormal, slow-growing, stunted trees should be discarded.

Spring Budding

Spring budding is similar to summer budding, except budding takes place the following spring as soon as active growth of the rootstock begins and the bark separates easily from the wood. The period for successful spring budding is shorter, and budding must be completed before the rootstocks make any significant growth. As with summer budding, most spring-budded, yearling trees will have a *1-year-old top and a 2-year-old rootstock, when dug in the late fall or winter* (Fig. 13–1).

Budsticks are chosen from the same type of shoots—with regard to vigor of growth and type of buds (Fig. 13–3)—that would have been used in fall budding. However, they are collected when dormant, in late fall or winter, and placed in cold storage. Budwood collected in late winter must still be dormant, before there is any evidence of the buds swelling. Budwood is stored at about –2 to 0°C (29 to 32°F) to hold the buds dormant. The budsticks should be wrapped in bundles with slightly damp sphagnum, wood shavings, peat moss, moistened newspapers, or paper towels to prevent drying out.

With chip budding, the bark does not need to slip, and dormant rootstock can be worked with. In Oregon, spring chip budding of shade trees is done just before bud-break of the rootstock.

Other types of budding are done in the spring as soon as the bark on the rootstock slips easily. When the bud unions have formed, about 2 to 4 weeks after budding, the top of the rootstock must be cut off above the bud to force the inserted bud into active growth. At the same time, axillary buds on the rootstock begin to grow and should be removed. In California, spring budding is used to propagate plums, apricots, and almonds.

Sometimes shoots from the rootstock are allowed to develop in order to prevent sunburn and help nourish the plant. The shoots must be held in check, however, and eventually removed. In 2-year field rose bush production in California, Texas, and Spain, spring T-budded rootstock plants are not cut back until the late winter of the second and final growing season. In Texas, corn choppers, or machines that can cut and mulch the rootstock tops, are used to top the rootstock about 8 to 15 cm (3 to 6 in) above the union. In a subsequent operation, pneumatic pruning shears are used to prune back the scion shoot so lateral breaks can occur, in order to produce a #1 grade rose bush.

Although the new shoot from the inserted bud gets a later start in spring budding than in summer budding, spring buds will usually develop rapidly enough, if growing conditions are favorable, to make a satisfactory top by fall.

In California and Oregon, some nurseries use spring budding extensively to shorten the production time needed to sell the crop (budded and harvested the same year). As an example, 'Marianna 2624' rootstock are propagated as hardwood cuttings in the nursery row in the fall. When the rooted rootstock cuttings begin growth, they are spring-budded in April with apricot cultivars. After the bud takes, the rootstock top is cut

BOX 13.1 **GETTING MORE IN DEPTH ON THE SUBJECT**

ADVANTAGES OF SUMMER BUDDING COMPARED WITH SPRING BUDDING

In general, summer budding is preferred to spring budding for several reasons:

- The higher temperatures of summer promote more rapid, extensive bud union formation.
- The budding season is longer.
- There is no need to store the budsticks.
- The inserted buds start growth earlier in the spring, producing a larger tree at harvest.
- The demands of other nursery activities are usually not so great for propagators in summer as they are in the spring.

back and a nursery plant is produced in one growing season. This smaller, yearling tree will have a *1-year-old top and 1-year-old rootstock, when dug in the fall or late winter* so the nursery can get new varieties and rootstocks into production sooner. The nursery can also respond more quickly to changing market conditions, fill orders more quickly, and improve their cash flow.

June Budding

In June budding, both rootstocks and tops of the budded tree develop during a single growing season, producing a *1-year-old top and 1-year-old rootstock.* Budding is done in the early part of the growing season as soon as the budsticks reach their proper maturity, typically early May to early June in California. The inserted bud (from the current season's growth) is forced into growth immediately. As a method of nursery propagation, June budding is confined to regions that have a long growing season. In the United States, this includes the central valley of California and some of the southern states—such as Tennessee and Arkansas. June budding is not done in Texas because budding failure is too high when temperatures exceed 35°C (95°F).

June budding is used mostly to produce stone fruits—peaches, nectarines, apricots, almonds, and plums. Peach seedlings are generally used as the rootstock because they have the necessary vigor to produce a large enough seedling rootstock for budding. Budding is done by the T-bud method. If seeds are planted in the fall, or stratified seeds planted as early as possible in the spring, the seedling rootstock usually attain sufficient size—30 cm (12 in) high and at least 30 mm (1/8 in) in diameter—to start budding in early May to early June. Preferably, June budding should not be done after late June, or a nursery tree of satisfactory size will not be obtained by fall. June-budded trees are not as large by the end of the growing season as those propagated by summer or spring budding, but they are of sufficient size—10 to 16 mm (3/8 to 5/8 in) caliper and 90 to 150 cm (3 to 5 ft) tall—to produce entirely satisfactory trees (13).

Budwood used in June budding consists of the current season's growth; that is, new shoots that have developed since growth started in the spring. By early May or early June, these shoots will usually have grown sufficiently to reach the proper state of maturity and have a well-developed bud in the axil of each leaf. Buds are quiescent at the time of budding, but do not enter a rest period until fall. Consequently, the shoot continues to grow all summer to produce the top portion of the budded tree.

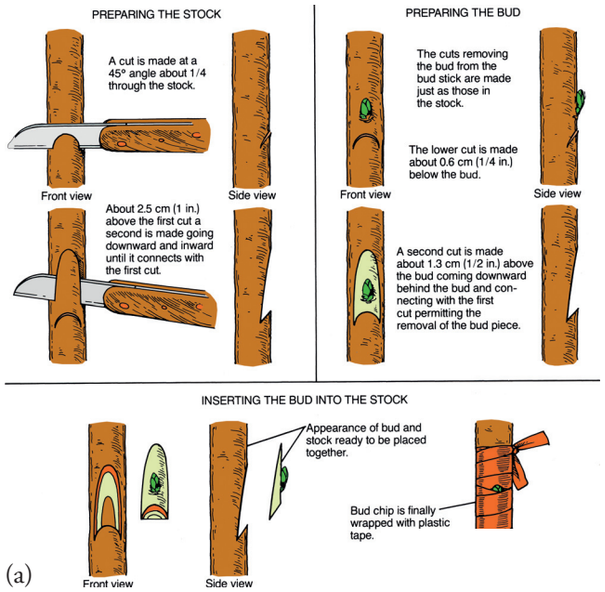
For June-budded trees, handling subsequent to the actual operation of budding is somewhat more exacting than for fall- or spring-budded trees. The rootstocks are smaller and have less stored carbohydrates than those used in fall or spring budding. The object behind the following procedures—shown in Figure 13–2—is to keep the rootstock (and later the budded top) actively and continuously growing so as to allow no check in growth, while at the same time converting the seedling rootstock shoot to a budded top. The bud should be inserted high enough (about 14 cm; 5 1/2 in) on the stem so that a number of leaves—at least three or four—can be retained below the bud. Some nurseries will also remove all leaves to a height slightly above the budding site on the rootstock to facilitate budding and typing.

The method of T-budding with the "wood out," also known as a "flipped bud," should be used (see Fig. 13–11, page 526). The bud union forms quickly, since temperatures are relatively high, and rapidly growing, succulent plant parts are used. By 4 days after budding, the bud union has started, and the top of the rootstock can be partially cut back—about 9 cm (3 1/2 in) above the bud—leaving at least one leaf above the bud and several below it. This operation will force the inserted bud into growth and will check terminal growth of the rootstock, but it will also stimulate shoot growth from basal buds of the rootstock, which will produce additional leaf area. This continuous leaf area is necessary because it ensures that there will always be enough leaves to manufacture photosynthate for the small plant. The rootstock can be cut back to the bud 10 days to 2 weeks after budding. If the budding rubber has not broken, it should be cut at this time. Poly budding strips would need to be removed or cut on the opposite side of the bud. Other shoots arising from the rootstock should be headed back to retard their growth. After the inserted bud grows and develops a substantial leaf area, it can supply the plant with the necessary photosynthates. By the time the shoot from the inserted bud has grown about 25 cm (10 in) high, it should have enough leaves so that all other shoots and leaves of the rootstock can be removed. Later inspections should be made to remove any rootstock shoots below the budded shoot. The steps in summer, spring, and June budding are compared in Figure 13–1.

TYPES OF BUDDING

Chip Budding

Chip budding works well in regions with shorter growing seasons (e.g., Northern Unites States, England). Chip budding has gradually replaced T-budding as the primary budding method for many woody ornamental trees, shrubs, and fruit trees in many parts of the world (10, 14, 18). Commercial nurseries have switched to chip budding because of better takes and straighter, more uniform tree growth (15). Chip budding in late summer gives excellent results in budding grape cultivars on phylloxera or nematode-resistant rootstocks (Fig. 13–5, page 520) (5, 11).



(a)

(b)

(c)

(d)

(e)

(f)

(g)

(h)

(i)

Figure 13–5
(a) Chip budding is widely used in propagating woody ornamentals and fruit trees. The bud piece is cut as shown here and covered completely with poly tape. Sometimes the bud is not completely covered. Steps in chip budding. (b) First downward cut in understock, (c) second downward cut, (d) finished cut, (e and f) removal of scion chip (g), insertion of bud, (h) wrapping bud, and (i) finished chip bud.

production "window" The time during the season when a budding procedure can successfully be done (i.e., T-budding can only be done when the bark of the rootstock is slipping).

The **production "window"** for chip budding—or for bench grafting dormant rose rootstock (2, 3)—is greater than with T-budding, since chip budding can be done with dormant or active rootstock (Table 13–1). Plant water status and temperature extremes are less of a problem with chip budding. More vigorous initial growth has been reported with chip buds than with T-buds (6, 7). Studies in England have shown that a better union is obtained with chip budding than with T-budding (8, 14). See Chapter 11 for further discussion on the anatomical and physiological advantages of chip budding compared to T-budding (16). Chip budding is easily mechanized and performed with budding machines (Fig. 13–6, page 523).

Chip budding is generally used on rootstock with small diameter stems, about 13 to 25 mm (1/2 to 1 in). It works well with late winter (Texas) grafting of small pistachio rootstocks that have too thin a bark for spring T-budding. As illustrated in Figures 13–4, 13–5, 13–6, 13–7 (page 523), and 13–8 (page 524), a chip of bark is removed from a smooth place between nodes near the base of the rootstock and replaced by another chip of the same size and shape from the budstick, which contains a bud of the desired cultivar. The chips in both rootstock and budstick are cut out in the same manner. In the budstick, the first cut is made just below the bud and down into the wood at an angle of 30 to 45 degrees. The second cut is started about 25 mm (1 in) above the bud and goes inward and downward behind the bud until it intersects the first cut. (The order of making these two cuts may be reversed.) The chip is removed from the rootstock and replaced by the one from the budstick. The bark on the rootstock is generally thicker than that of the scionwood. Therefore, the chip removed from the rootstock is slightly larger than that removed from the scion. The cambium layer of the bud piece must be placed to coincide with that of the stock, preferably on both sides of the stem, but at least on one side (Fig. 13–6).

The chip bud must be wrapped to seal the cut edges and to hold the bud piece tightly into the rootstock since there are no protective flaps of bark to prevent the bud piece from drying out. Nursery adhesive tape, Parafilm (2) and Buddy Tape works well for this purpose, although white or transparent plastic tape is more often used, covering the bud. Wrapping must be done immediately to prevent drying out (1). When the bud starts growth, the tape must be cut, except with Parafilm or Buddy Tape that is easily penetrated by the expanding bud (Fig. 13–6).

The rootstock is not cut back above the bud until the union is complete. If the chip bud is inserted in the fall, the rootstock is cut back just as growth starts the next spring. If the budding is done in the spring, the rootstock is cut back about 10 days after the bud has been inserted.

T-Budding (Shield Budding)

This method of budding is known by both names—the "T-bud" designation arises from the T-like appearance of the cut in the rootstock, whereas the "shield bud" is derived from the shield-like appearance of the bud piece when it is ready for insertion in the rootstock.

T-budding is widely used by nurserymen in propagating nursery stock of many fruit trees, shade trees, roses, and some ornamental shrubs. Its use is generally limited to rootstocks that range from 6 to 25 mm (1/4 to 1 in) in diameter and are actively growing so that the bark will separate readily from the wood (Table 13–1).

The bud is inserted into the rootstock 5 to 25 cm (2 to 10 in) above the soil level, where the bark is smooth (Fig. 13–9). Opinions differ on the proper side of the rootstock in which to insert the bud. If extreme weather conditions are likely to occur during the critical graft union period following budding, the bud is placed on the side of the rootstock in order to give as much protection from prevailing winds as possible. Some believe that placing the bud on the windward side gives less chance for the young shoot to break off. Otherwise, it probably makes little difference where the bud is inserted, and the convenience of the operator and the location of the smoothest bark are controlling factors. When rows of closely planted rootstocks are budded, it is more convenient to have all the buds on the same side for later inspection and manipulation.

The cuts to be made in the rootstock plant are illustrated in Figures 13–9, 13–10, 13–11; and 13–12, (pages 525–27). Most budders prefer to make the vertical cut first and then the horizontal crosscut at the top of the T. As the horizontal cut is made, the knife is given a twist to open the flaps of bark for insertion of the bud. Neither the vertical nor horizontal cut should be made longer than necessary, because additional tying would be required later to close the cuts.

After the proper cuts are made in the rootstock and the incision is ready to receive the bud, the shield piece or shield bud is cut out of the budstick.

To remove the bark shield with the bud, an upward slicing cut is started at a point on the stem about 13 mm (1/2 in) below the bud, continuing under the bud to

Table 13–1
UTILIZATION AND ROOTSTOCK CRITERIA OF SELECTED TYPES OF BUDDING

Type of budding	Diameter of rootstock	Rootstock condition	Uses	Plant species
Chip-Budding	Small: 13 to 25 mm (1/2 to 1 in)	Only budding system that can be done on either dormant or active rootstock	Nursery budding; bench budding; container budding; top-working in orchard; one of the two most popular budding systems	Wide variety of fruit crops and ornamental plants; thin-barked species such as pistachio that do not T-bud well
T-Budding (Shield Budding)	Small: 6 to 25 mm (1/4 to 1 in)	Active; bark must be slipping	Nursery budding; container budding; top-working in orchard; one of the two most popular budding systems; used in "June Budding" with the "wood out" or flipped bud method	Wide variety of fruit crops and orna-mental trees and shrubs, including apples, peach, roses, citrus
Inverted T-Incision of Rootstock	Small: 6 to 25 mm (1/4 to 1 in)	Active; bark must be slipping	Nursery budding; container budding; used in high rainfall areas or with species that have excess sap flow "bleeding"; the horizontal portion of the T-cut is made at the bottom rather than the top to allow the water or sap to drain; the shield bud is inserted with normal polarity	Citrus, chestnuts
Patch Budding	Small: 13 to 25 mm (1/2 to 1 in); same diameter as scion (budstick)	Active; bark must be slipping on both rootstock and scion piece (budstick)	Nursery budding; container budding; slower and more difficult graft than T-budding; most important pecan grafting system in Texas nurseries	Pecans, rubber tree (*Hevea brasiliensis*), walnuts
Flute and Ring (Annular) Budding	Small: 13 to 25 mm (1/2 to 1 in); same diameter as scion (budstick)	Active; bark must be slipping on both rootstock and scion piece (budstick)	Modification of patch budding; bud patch of flute bud has greater circumference than conventional patch bud; bud patch of ring (annular) budding completely wraps around the rootstock	Citrus, other tree and shrub species
I-Budding	Small: 13 to 25 mm (1/2 to 1 in); bark of rootstock is thicker than budstick	Active; bark must be slipping on both rootstock and scion piece (budstick)	Nursery budding; container budding; utilized when bark of rootstock is thicker than budstick; bud patch is cut in the form of a rectangle or square, just as for patch budding	
Microbudding	Very small; less than 6 mm (1/4 in)	Active	Similar to T-budding except bud piece reduced to very small size using only the bud and a small piece of wood under it. An inverted T-cut is made and the microbud is slipped into it, right side up. A modification of micro-budding is using 2 mm diameter rootstock, with the bud inserted as in a wedge graft; personal communication M. Skaria, http://aghs.tamuk.edu/uploads/media/ Microbudding_overview.pdf	

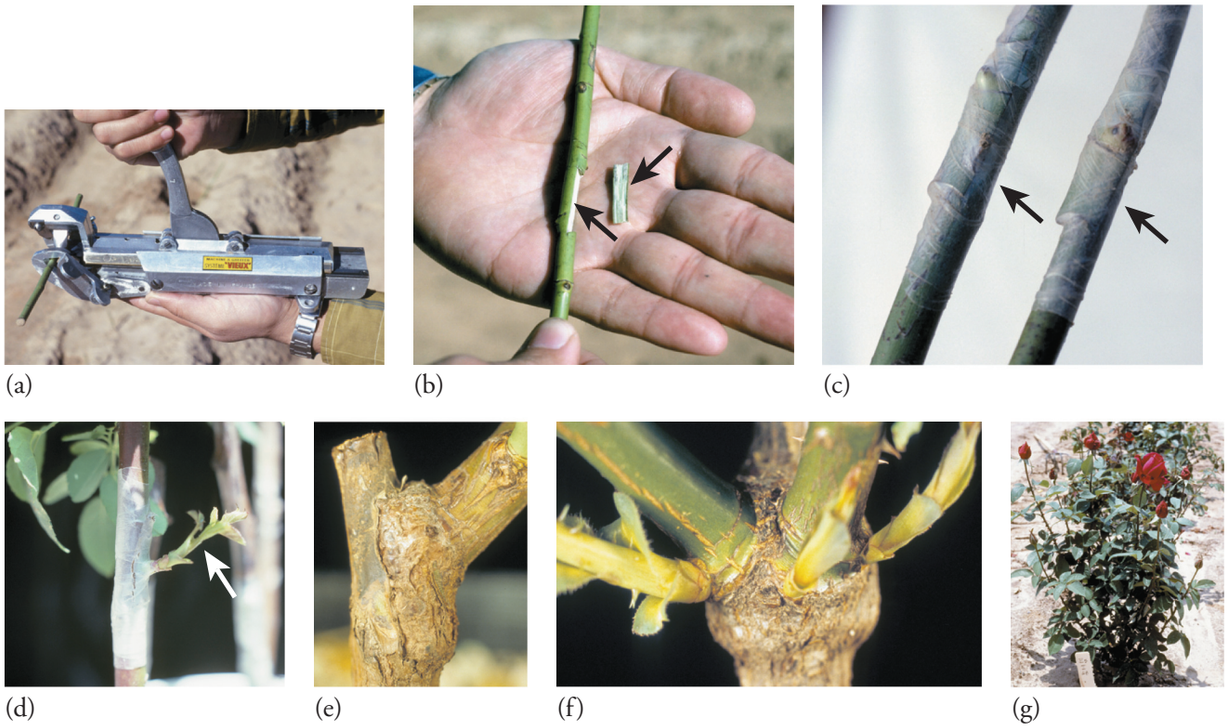


Figure 13–6
Chip budding of field rose bushes. (a) A tool for chip budding. (b) Machine-cut chip bud—the scion bud with stem section (*right*, arrow) is slid into the grooves of the machine-notched rootstock (*left*). (c) Ideally, the scion and rootstock should be of equal diameter. When the diameters are different, it is important that the cambiums of the graft partners be matched on one side. (d) The scion bud (arrow) penetrates through the Parafilm tape. (e) Chip-budded plants form a strong graft union (arrow) (see Chapter 11 for the discussion on chip budding). The rootstock top has been cut off and the scion shoot system established. (f) Multiple shoot breaks from the chip budded scion. (g) Chip-budded 'Mirandy' on Rosa multiflora rootstock.

about 2.5 cm (1 in) above. The shield piece should be thin, but thick enough to have some rigidity. A second horizontal cut is then made 1.3 to 1.9 cm (1/2 to 3/4 in) above the bud, permitting the removal of the shield piece. On many cultivars of shade trees in Oregon, professional budders use only a single cut to remove the bud. Two cuts are used on "wood-out" cultivars (see Box 13.2, page 524).

The next step is the insertion of the shield piece containing the bud into the incision in the rootstock. The shield is pushed downward under the two raised flaps of bark until its upper, horizontal cut matches the same cut on the stock. The shield should fit snugly in place, well covered by the two flaps of bark but with the bud itself exposed (see Fig. 11–22). A **"budder"** and **"tier"** in T-budding field roses are shown in Figures 13–13 and 13–14, pages 527–28.

Waxing is not necessary, but the bud union must be wrapped with poly tape, budding rubbers, buddy tape, or parafilm to hold the two components firmly together until healing is completed. Parafilm and tape works well for tying and sealing the bud, and the elongating shoot easily penetrates the tape (2, 3). Rubber budding strips, especially made for wrapping, are widely used for this purpose (Fig. 13–13), because their elasticity provides sufficient pressure to hold the bud securely in place. The rubber, being exposed to the sun and air, usually deteriorates, breaks, and drops off after

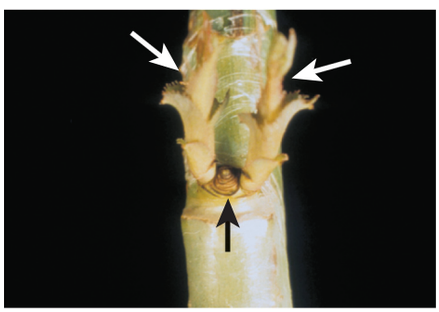


Figure 13–7
Chip budded rose. Not all chip buds have just one bud. With this chip budded rose, the primary axillary bud did not develop (black arrow), so the two secondary axillary buds (on the same chip bud) have elongated to form shoots. One of the shoots will be removed to allow the other to become the dominant shoot system.

(a) (b) (c) (d)

Figure 13–8
Understock removal prior to bud break of chipbud liners in the spring. (a) Healed chipbud. (b) Understock has been precut to remove most of the top; (c and d) pneumatic pruners make clean cuts and are ergonomic.

BOX 13.2 **GETTING MORE IN DEPTH ON THE SUBJECT**

WRAPPING MATERIALS FOR DIFFICULT-TO-BUD FIELD-GROWN TREES

Degradable budding rubbers that do not cover the actual bud work best when chip-budding on very rapidly growing rootstock, such as birch (*Betula pedula* 'Darecarlica') (8, 9). However, polyethylene budding strips work best for chip-budding black locust (*Robinia pseudoacacia* 'Frisia'), which has small sunken buds that are not subjected to physical damage and pressure of the poly strips. The pressure of the poly strips prevents the formation of large pads of undifferentiated rootstock callus, which hold the scion in place, but do not form a successful union (9).

several weeks, at which time the bud should be healed in place. If the budding rubber is covered with soil, the rate of deterioration will be much slower. Use of this material eliminates the need to cut the wrapping ties, which can be costly if many thousands of plants have been budded. The rubber will expand as the rootstock grows, reducing the danger of constriction.

In tying the bud, the ends of the budding rubbers are held in place by inserting them under the adjacent turn. The bud itself should not be covered. The amount of tension given the budding rubber is quite important: it should not be too loose, or there will be too little pressure holding the bud in place; on the other hand, if the rubber is stretched too tightly, it may be so thin that it will deteriorate rapidly and break too soon, before the bud union has taken place. Often the tying is done from the top down to avoid forcing the bud out through the horizontal cut. Novice budders should avoid the tendency to over-tie, as if the bud were a mummy. The inner layers of the tie will not deteriorate, so girdling can occur. See Chapter 12 for the description of different tying and sealing materials for budding and grafting. See Figure 13–15 for T-budding in a 2-year landscape rose production system and Figure 13–16 for T-budding dogwoods (*Cornus*) in Tennessee.

Inverted T-Incision of the Rootstock

In areas that experience a lot of rainfall during the budding season, water running down the stem of the rootstock may enter the T-cut, soak under the bark of the rootstock, and

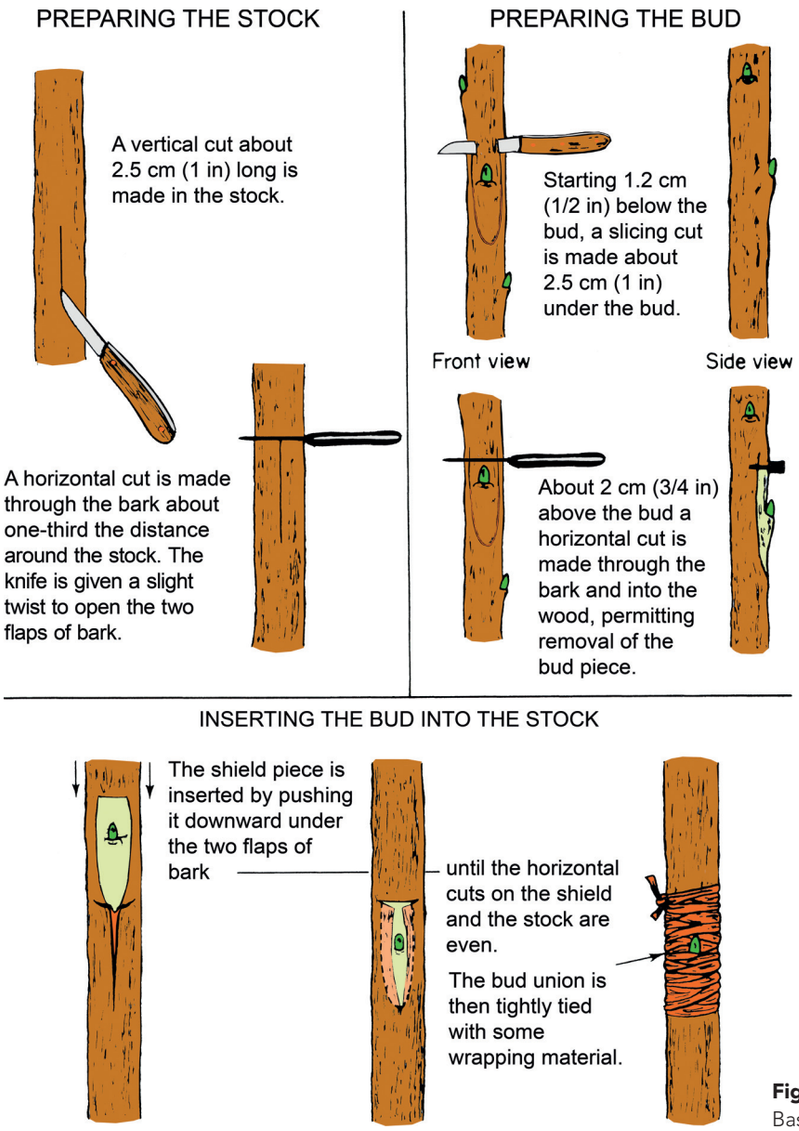


Figure 13–9
Basic steps in making the T-bud (shield bud).

bleeding Excessive sap flow that can occur from the rootstock during budding, such as with chestnuts; an inverted T-incision allows better drainage and better healing.

prevent the shield piece from healing into place (Table 13–1). Under such conditions, an inverted T-incision in the rootstock gives better results, since excess water is shed—*the scion bud is inserted with normal* ***polarity***. The inverted T-incision method is widely used in citrus budding, even though the conventional met-hod also gives good results. In species that **bleed** (excessive sap flow) during budding, such as chestnuts, the inverted T-incision allows better drainage and better healing. Proponents of both conventional and inverted T-budding can be found, and in a given locality the usage of either with a given species tends to become traditional.

In the inverted T-incision method, the rootstock has the transverse cut at the bottom rather than at the top of the vertical cut. In removing the shield piece from the budstick, the knife starts above the bud and cuts downward below it. The shield is removed by making the transverse cut 13 to 19 mm (1/2 to 3/4 in) below the bud. The shield piece containing the bud is inserted with normal polarity into the lower part of the incision and pushed upward until the transverse cut of the shield meets that made in the rootstock.

Patch Budding

The distinguishing feature of patch budding and related methods is that a rectangular patch of bark is completely removed from the rootstock and replaced with a patch of bark of the same size containing a bud of the cultivar to be propagated (Table 13–1).

(a)

(b)

(c)

(d)

(e)

Figure 13–10
T-budding crab apples. (a) Making "T" insertion in rootstock. (b) Shield bud from scion. (c and d) Inserting the shield bud and taping with poly tape that will later need to be removed to prevent girdling. (e) Staked, 1-year-old crabapples. Courtesy K. Warren.

(a)

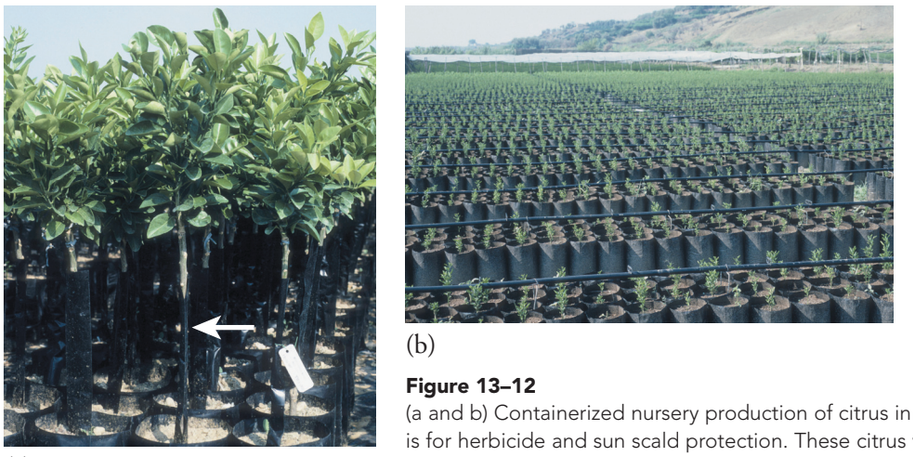
(b)

(c)

(d)

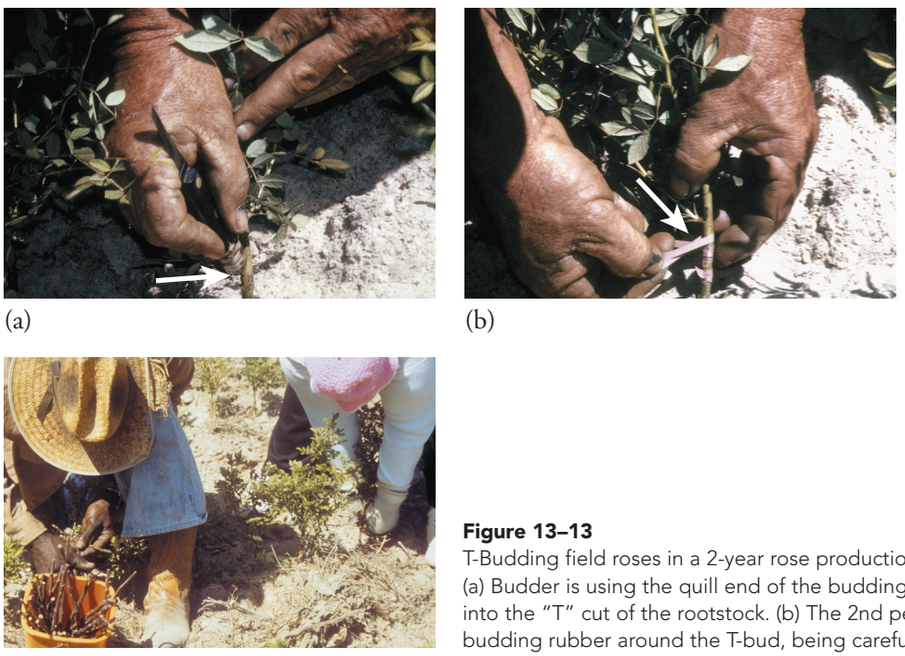
(e)

Figure 13–11
T-budding sequence. (a) Scion cuts. (b) Scion with "wood in" or "wood out" (arrow). (c) Scion shield inserted in t-cut. (d) Wrapped with bud exposed. (e) Budding band removal after bud heals.



(a) (b)

Figure 13–12
(a and b) Containerized nursery production of citrus in Sicily. (a) Black poly on trunks is for herbicide and sun scald protection. These citrus were T-budded on sour orange and Troyer citrange rootstocks.



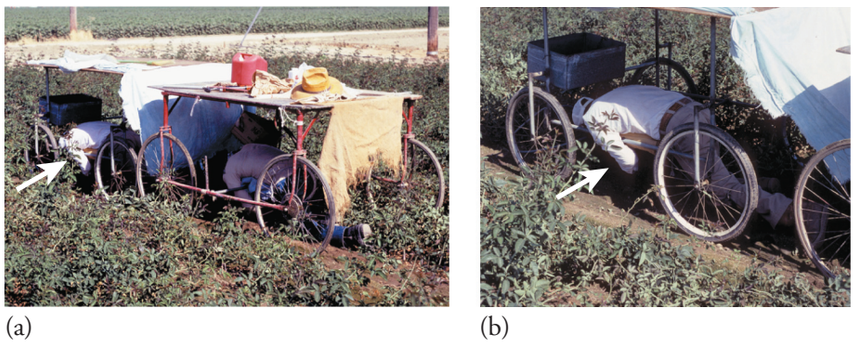
(a) (b) (c)

Figure 13–13
T-Budding field roses in a 2-year rose production cycle for landscape roses. (a) Budder is using the quill end of the budding knife to insert the shield bud into the "T" cut of the rootstock. (b) The 2nd person, the "tier," wraps the budding rubber around the T-bud, being careful not to cover the bud tip. (c) The budder and tier working in conjunction.

Patch budding is somewhat slower and more difficult to perform than T-budding. It is widely and successfully used on thick-barked species, such as walnuts and pecans, in which T-budding sometimes gives poor results, presumably owing to the poor fit around the margins of the bud—particularly the top and bottom. Patch budding, or one of its modifications, is also extensively used in propagating tropical species, such as the rubber tree (*Hevea brasiliensis*).

Patch budding requires that the bark of both the rootstock and budstick be slipping easily. In propagating nursery stock, the diameter of the rootstock and the budstick should preferably be about the same, about 13 to 25 mm (1/2 to 1 in) (17).

Special knives (see Fig. 13–17, page 530) have been devised to remove the bark pieces from the rootstock and the budstick. Some type of double-bladed knife that makes two transverse parallel cuts 2.5 to 3.5 cm (1 to 1 3/8 in) apart is necessary. These cuts, about 25 mm (1 in) in length, are made through the bark to the wood in a smooth area of the rootstock about 10 cm (4 in) above the ground. Then the two



(a) (b)

(c)

Figure 13–14
Improving the ergonomics of field budding. (a) To enhance the efficiency of T-budding field roses in California, the "budder" (*left*, arrow) and "tier" (b) are supported above the rootstock plants with a body harness, which minimizes muscle strain. The technicians work in the shade and propel the carts down the field row with their legs. (b) The budder inserts the shield bud, which will be wrapped with a budding rubber by the tier. The box next to the budder's head contains the scionwood (budwood). Both the budder and tier work as a team and are paid on piecework, with an incentive bonus based on successful "takes." (c) Two teams of budders and tiers.

transverse cuts are connected at each side by vertical cuts made with a single-bladed knife.

The patch of bark containing the bud is cut from the budstick in the same manner as the bark patch is removed from the rootstock. Using the same two-bladed knife, the budder makes two transverse cuts through the bark, one above and one below the bud. Then two vertical cuts are made on each side of the bud so that the bark piece will be about 25 mm (1 in) wide. The cut on the right side of the bud should form a 90-degree angle with the horizontal cut. Now the bark piece containing the bud is ready to be removed. It is important that it be slid off sideways rather than being lifted or pulled off. There is a small core of wood, the bud trace, which must remain inside the bud if a successful **"take"** is to be obtained. By sliding the bark patch to one side, this core is broken off, and it stays in the bud. If the bud patch is lifted off, this core of wood is likely to remain attached to the wood of the budstick, and the bud will fail.

After the bud patch is removed from the budstick, it must be inserted immediately on the rootstock, which should already be prepared, needing only to have the bark piece removed. The patch from the budstick should fit snugly at the top and bottom into the opening in the rootstock, since both transverse cuts were made with the same knife. It is more important that the bark piece fits tightly at top and bottom than along the sides. These procedures are illustrated in Figures 13–18 and 13–19 (pages 531–32).

Now the inserted patch is ready to be wrapped. Often the bark of the rootstock will be thicker than the bark of the inserted bud patch so that upon wrapping, it is impossible for the wrapping material to hold the bud patch tightly against the rootstock. In this case, the bark of the rootstock is pared down around the bud patch so

BOX 13.3 **GETTING MORE IN DEPTH ON THE SUBJECT**

WOOD-IN AND WOOD-OUT WITH T-BUDDING

In T-budding, there are two methods of preparing the shield—with the **"wood-in"** or with the **"wood-out."** (Fig. 13–11). The terms refer to the sliver of wood just under the bark of the shield piece, which remains attached if the second, or horizontal, cut is deep and goes through the bark and wood, joining the first slicing cut. Some professional budders prefer to remove this sliver of wood, but others retain it. In budding certain species, however, such as maples and walnuts, success is usually obtained with "wood-out" buds. To prepare the

shield with the wood-out, the second horizontal cut, above the bud, should be just deep enough to go through the bark and not the wood. If the bark is slipping, the bark shield can be snapped (slipped) loose from the wood (which still remains attached to the budstick) by pressing it against the budstick and sliding it sideways. The small core of wood comprising the vascular tissues remains with the wood. If the shield is pulled outward rather than slid sideways from the wood, the core pulls out of the bud—leaving a hole in the shield and eliminating any chances of success. **June-budded** fruit trees require that the shield piece be prepared with the wood-out. In most other instances, however, the wood is left in. In spring budding, using dormant budwood, this sliver of wood is tightly attached to the bark and cannot be removed (Fig. 13–11).


(a)


(b)


(c)


(d)


(e)


(f)


(g)

(h)

Figure 13–15
(a) Treating field with methyl bromide prior to sticking rootstock hardwood cuttings to root. (b) Roses are spring budded during the first production year, so scion (budwood) is collected dormant during early winter and stored at −1°C (31°F). (c and d) Maintaining budwood in moist burlap in (d) a movable field work station with budwood kept under shade. (e) Rose field in bloom during 2nd year production prior to digging roses in fall. (f and g) Digging roses bare-root with a U-blade and shaker; the spring-budded roses are dug as a 1-year scion–2-year rootstock. (h) Reducing the shoot and root system during processing and (i) packaged, dormant landscape rose ready for spring sale and planting into the landscape.

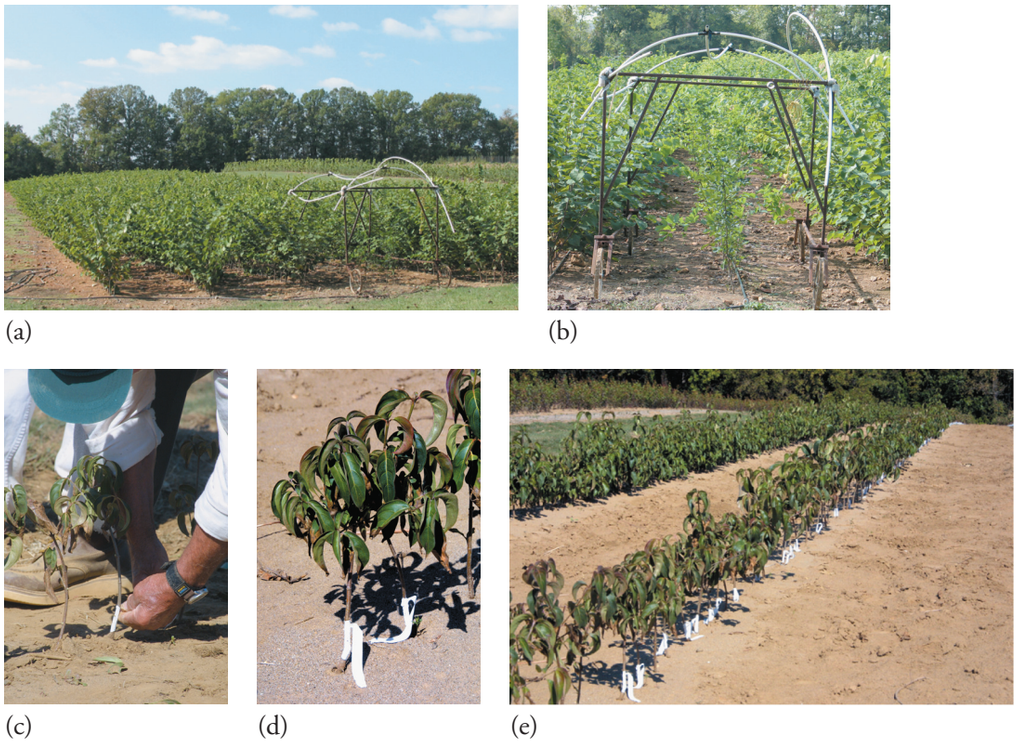


Figure 13–16
(a and b) Tennessee liner nursery of budded dogwoods. The frame on wheels will be tarped on top for shade during budding process for improved ergonomics and comfort of the budders. (c, d, and e) Field–budding dogwood on seedling rootstock.

that it will be of the same thickness, or preferably slightly thinner than the bark of the bud patch, until the wrapping material will hold the bud patch tightly in place.

The patch bud should be covered by a material that not only holds the bark tightly in place but covers all the cut surfaces. Air must not be able to enter under the patch in order to avoid drying and subsequent death of the tissues, but the bud itself must not be covered during wrapping. The most satisfactory material is nursery adhesive tape or ploy budding strips.

Patch buds, especially with walnuts, should not be wrapped so that they cause a constriction at the bud union. When the rootstock is growing rapidly, the tape is cut about 10 days after budding. A single vertical knife cut on the side opposite the bud is sufficient, but care should be taken not to cut into the bark.

Figure 13–17
Double-bladed knives used for patch budding. The quill (arrow) is used to help separate and lift up cut bark during the budding process.

Summer Patch Budding In California, Texas, and other areas with hot summers, patch budding is best performed in late summer when both the seedling rootstock and the source of budwood are growing rapidly and their barks slip easily. The budsticks for patch budding done at this time should have the leaf blades cut off 2 to 3 weeks before the budsticks are taken from the tree. The petiole or leaf stalk is left attached to the base of the bud, but by the time the budstick is removed, this petiole has dropped off or is easily pulled off.

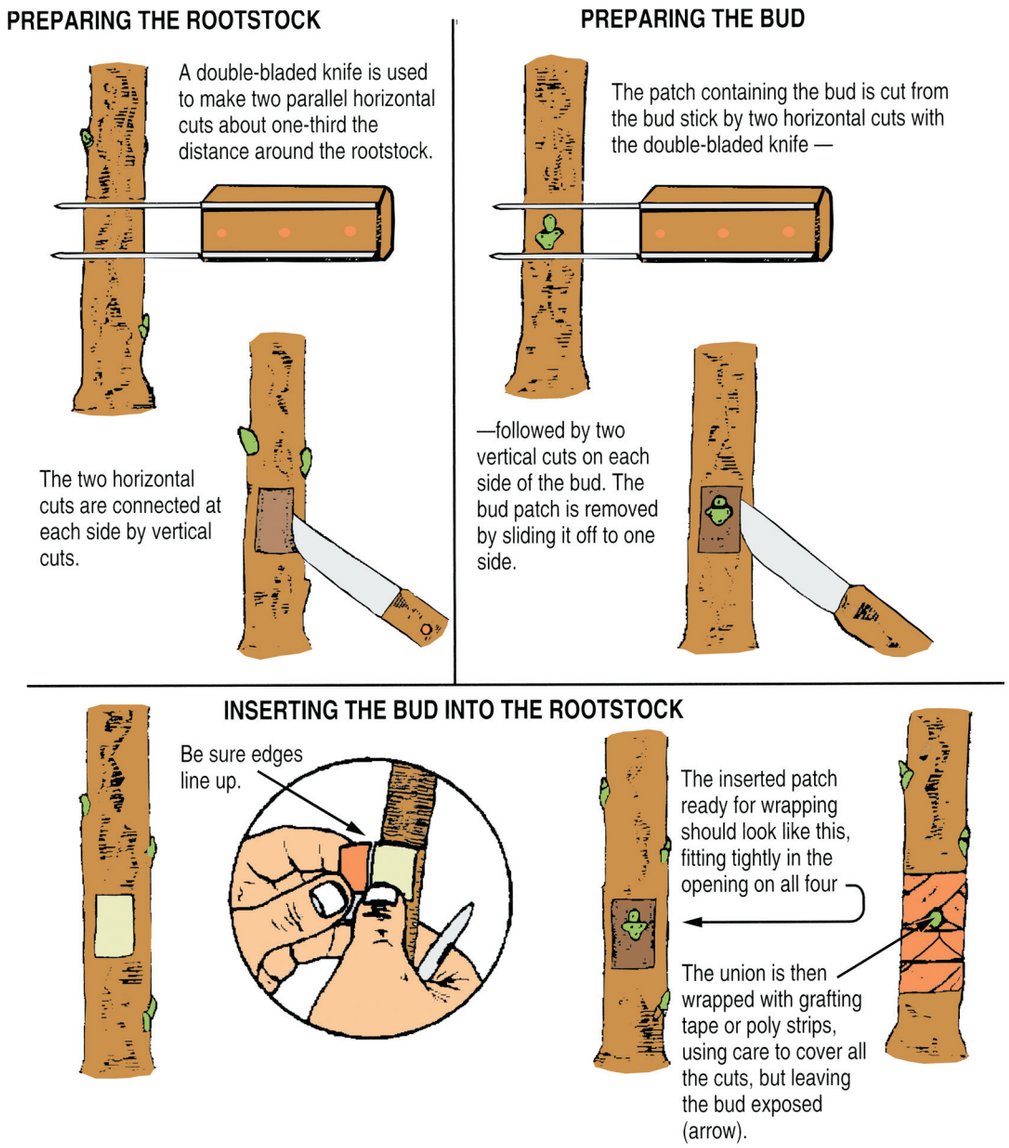


Figure 13–18
Steps in making the patch bud. This method is widely used for propagating thick-barked plants.

Spring Patch Budding Patch budding can be done in the spring after new growth has started on the rootstocks and the bark is slipping. The problem, however, in obtaining satisfactory buds to use at this time of year is that the bark of the budstick must separate readily from the wood. At the same time, the buds should not be starting to swell. There are two methods by which satisfactory buds can be obtained for patch budding in the spring.

One, used in Texas for pecans, uses budsticks selected during the dormant winter period and stored at low temperatures (about 27°C, 36°F) wrapped in *slightly moist* sphagnum or wood shavings to prevent drying out. Then, about 2 or 3 weeks before the spring budding is to be done, they are brought into a warm room. The budsticks may be left in the moist sphagnum or set with their bases in a container of water. The increased temperature will cause the cambium layer to become active, and soon the bark will slip sufficiently for the buds to be used. Although a few of the more terminal buds on each stick may start swelling in this time and cannot be used, there should be a number of buds in satisfactory condition.

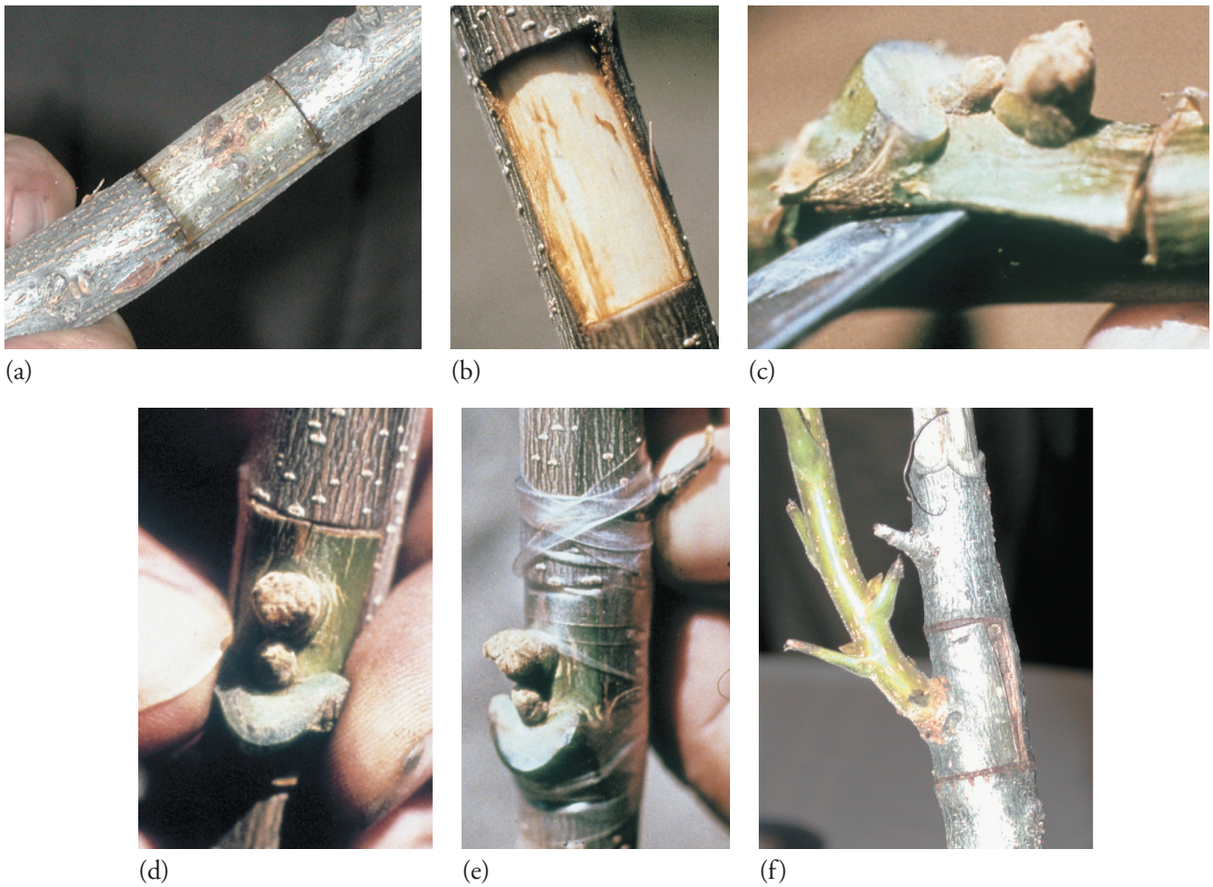


Figure 13–19
Patch budding process. (a and b) Making cuts on rootstock. (c) Removing patch bud from scion. (d and e) Inserting and wrapping the patch bud without covering the axillary bud. (f) Elongated shoot from patch bud. Photos courtesy L. Lombardini.

The second method of obtaining buds for spring patch budding is to take them directly from the tree that is the source of the budwood, in early spring, before the buds begin to force. The scions are refrigerated and stored as dormant scions, later brought to room temperature for a few hours to stimulate cambial activity, and then budded. Pecans should not be budded until at least 2 weeks after the rootstock begins to grow.

I-Budding

In I-budding, the bud patch is cut in the form of a rectangle or square, just as for patch budding (Table 13–1). With the same parallel-bladed knife, two transverse cuts are made through the bark of the rootstock. These are joined at their centers by a single vertical cut to produce the shape of the letter I. Then the two flaps of bark can be raised to insert the bud patch beneath them. A better fit may occur if the side edges of the bud patch are slanted. In tying the I-bud, be sure that the bud patch does not buckle outward and leave a space between itself and the rootstock (see Fig. 13–20).

I-budding is most appropriate when the bark of the rootstock is much thicker than that of the budstick. If the patch bud were used in such cases, considerable paring down of the bark of the rootstock around the patch would be necessary. No paring is necessary with the I-bud method (Fig. 13–20).

Flute Budding and Ring Budding

See details in Figure 13–20 and Table 13–1.

TOP-BUDDING (TOPWORKING)

Young trees with an ample supply of vigorous shoots at a height of 1.2 to 1.8 m (4 to 6 ft) can be top-budded (topworked) rapidly with a high degree of success. Older trees can be top budded by severely cutting back the prior year to provide a quantity of

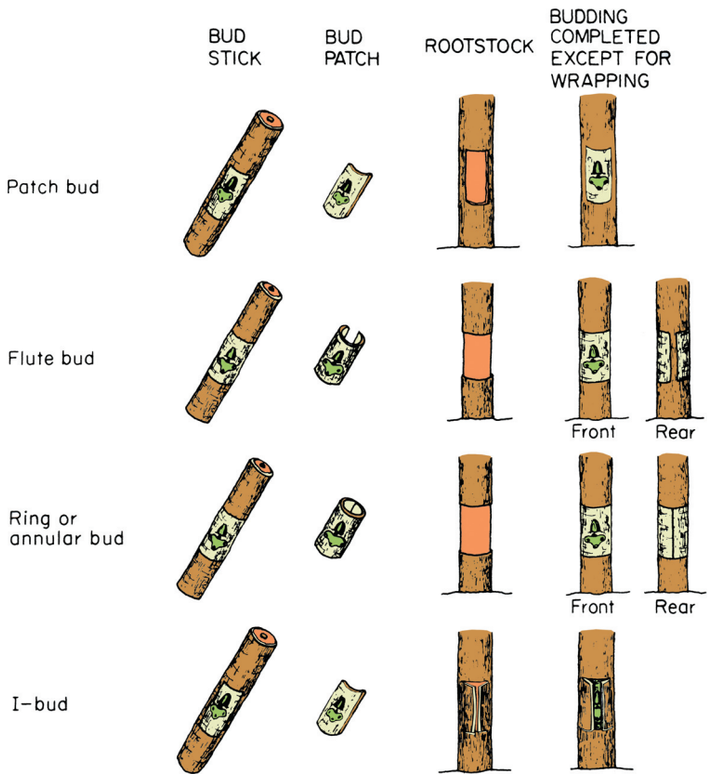


Figure 13–20
There are many variations of the patch bud, some of which are shown here. The naming of these types is somewhat confusing; the most generally accepted names are given.

vigorous water-sprout shoots fairly close to the ground.

Depending on the size of the tree, 10 to 15 buds are placed in vigorously growing branches 6 to 19 mm (1/4 to 3/4 in) in diameter in the upper portion of the tree—about shoulder height. A number of buds can be placed in a single branch, but usually only one will be saved to develop into secondary branches, to form the permanent new top of the tree. The T-bud or chip-bud method is used on thin-barked species, and the patch bud on those with thick bark.

Top-budding is usually done in midsummer, as soon as well-matured budwood can be obtained and while the rootstock is actively growing and the bark slipping. Orchard trees generally stop growth earlier in the season than young nursery trees; therefore, the budding must be done earlier. When top-budding is done at this time of year, the buds usually remain inactive until the following spring. As vegetative growth starts, the rootstock branches are cut back just above the buds to force the buds into active growth. They should develop into good-sized branches by the end of the summer. At the time the shoots are cut back to the buds, all nonbudded branches should be removed at the trunk. Inspect the trees carefully through the summer and remove all shoots that arise from any but the inserted buds. Top-budding is very labor intensive, so it is not commonly used.

frameworking A form of top-budding (topworking) where a few scaffold branches are retained on an established rootstock for multiple budding of a new scion.

DOUBLE-WORKING BY BUDDING

In propagating nursery trees, budding methods can be used to develop double-budded **(double-worked)** trees. **Interstocks** can be budded to the rootstocks; the following year the cultivar is budded on the interstock. Although effective, this process takes 3 years. Development of a double-worked tree—in one operation in 1 year—is possible by using the double-shield bud method (Fig. 13–21) (4, 7). First, a thin, budless shield piece of the desired interstock is inserted in the

double-working The budding of an **interstock (interstem)** between the rootstock and scion.

interstock or interstem The bud piece or stem section between the rootstock and the scion.

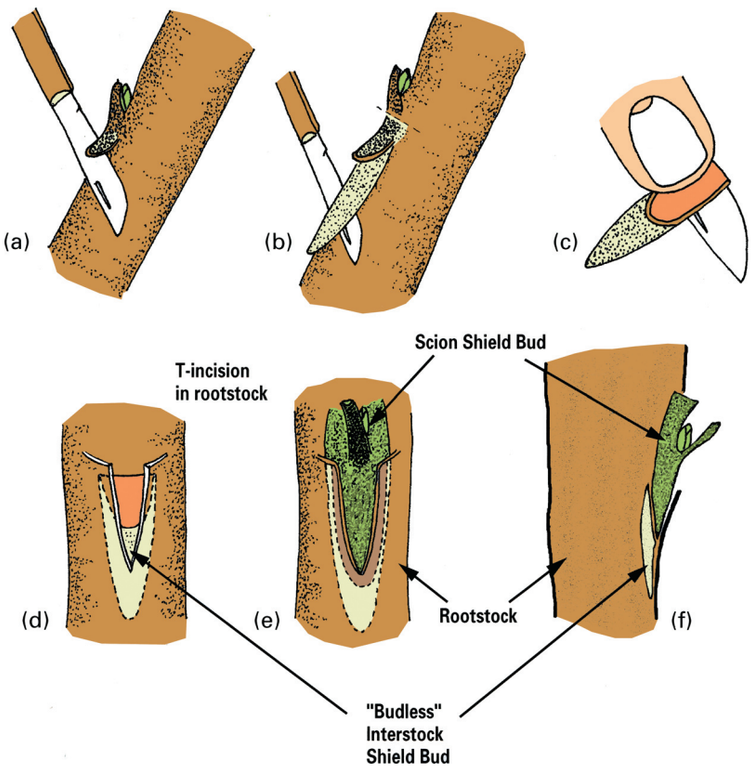


Figure 13–21
Double-working by budding. (a) A shallow incision is made in the interstock. (b) A second incision is made to debud the interstock shield bud (c), which is detached. (d) A T-cut incision has been made in the rootstock and the budless interstock shield bud inserted—as depicted by the shadowed area. (e) The scion shield bud is inserted in the rootstock T-incision on top of the budless interstock shield bud. (f) Side-view of the budding. The budless interstock will later grow and form a complete bridge between the scion and rootstock.

T-incision of the rootstock, then the scion shield bud is inserted on top of the interstock. If the scion shield bud is lined up properly with the interstock shield piece, the budless interstock will grow and form a complete bridge between the scion and rootstock.

Double-working is also done by bench-grafting on the lower union (interstock to rootstock) and transplanting the tree in the nursery. The scion is budded on the interstock later.

MICROBUDDING

Microbudding is used successfully in propagating citrus trees and can be utilized with other selected tree and shrub species. It has been of commercial importance in the citrus districts of southeastern Australia (20). Microbudding is similar to T-budding, except that the bud piece is reduced to a very small size. The leaf petiole is cut off just above the bud, and the bud is removed from the budstick with a razor-sharp knife. A flat cut is made just underneath the bud. Only the bud and a small piece of wood under it are used. In the rootstock an inverted T-cut is made, and the microbud is slipped into it, right side up. The entire T-cut, including the bud, is covered with thin, plastic budding tape. The tape remains for 10 to 14 days for spring budding and 3 weeks for fall budding, after which it is removed by cutting with a knife. By this time, the buds should have healed in place; subsequent handling is the same as for conventional T-budding.

A variation of micro-budding is described in Figure 13–22. Citrus greening, also called Huanglongbing or yellow dragon disease, is one of the more serious diseases of citrus. It is caused by bacteria in the phloem that is primarily spread by psyllid insects, and is devastating citrus in Brazil, Florida, and other major citrus-producing regions in the world. While the long-term solution is breeding genetic resistance, micro-budding is being adapted by commercial growers because it is an economical propagation system that allows a grove to be replanted and come into bearing within 1 to 2 years (see http://www.aphis.usda.gov/plant_health/plant_pest_info/citrus_greening/index.shtml).

(a)

(b)

(c)

(d)

(e)

(f)

Figure 13–22
"Micro budding" system of budding citrus to smaller rootstock. (a) Smaller 2 mm diameter rootstocks are used instead of pencil-size rootstocks. The bud size must match the rootstock. The rootstock is decapitated and the bud is inserted, as in a wedge graft, and capped. The wound calluses in 2 weeks and buds sprout in another 2 to 3 weeks. (b) Young, micro-budded citrus closely spaced at 100 plants per square foot, ready for shipment and field planting. (c) The smaller, micro-budded, field planted liners by-pass the 2-year conventional nursery, T-budding system and come into bearing within 14 to 18 months. (d) One-year old, container-grown 'Rio Red' grapefruit, bearing fruit. (e) Two-year old, field-grown 'Rio Red' grapefruit, bearing fruit. (f) Fruit load of 2.5-year old micro budded 'Valencia' orange. Besides grapefruit and orange, micro budding has been used with lemons and kumquat. Courtesy M. Skaria.

DISCUSSION ITEMS

1. Why are chip budding and T-budding the two most important types of budding for woody ornamentals and fruit trees?
2. Why are terms such as bark, wood, and the slipping of the bark important for a grafter?
3. What are the advantages and disadvantages of different budding schedules: spring, June, and summer budding?
4. Why has chip budding become one of the most dominant budding systems for ornamental and fruit crops that are grown under relatively short production seasons?
5. Describe double-working by budding. Give some horticulture examples.
6. What are advantages and disadvantages of budding compared with grafting?

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