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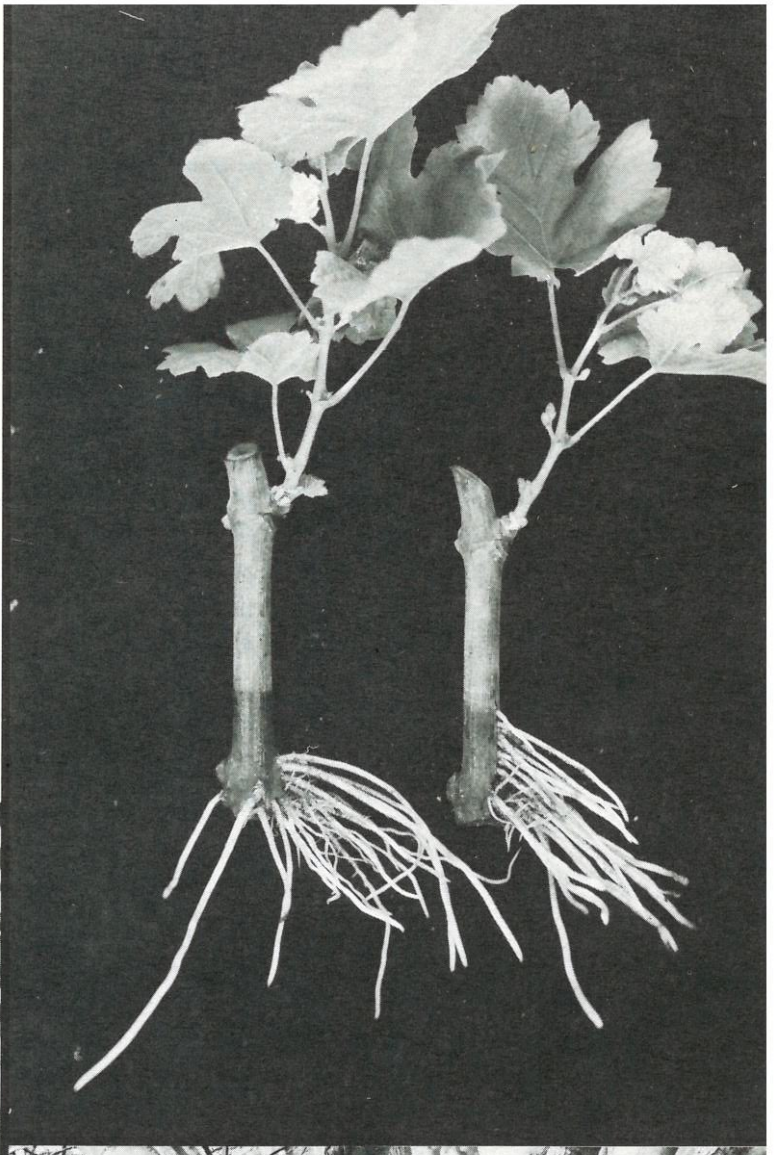
PROPAGATION of Temperate-Zone Fruit Plants



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This publication is designed for commercial fruit growers and students of plant propagation who wish to learn the techniques of budding and grafting for the propagation of fruit trees, vines, and berries. It provides information about the rootstocks recommended for temperate-zone fruit plants grown under California conditions and gives directions for propagating fruit plants by seeds, cuttings, layering, suckers, and runners.

The publication only discusses the propagation of temperate-zone fruits and nuts. Propagation methods for citrus are described in chapter 1 of *The Citrus Industry,* vol. III (Reuther 1973).

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To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products which are not mentioned.

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CONTENTS

INTRODUCTION

Fruit and nut crops grown in California may be divided into two general groups.

- ☐ Temperate-zone fruits, primarily deciduous (except the olive), that are mainly produced in the northern part of the state.
- ☐ Subtropical fruits, such as citrus and avocados, which are primarily grown in the southern San Joaquin Valley and southern California.

Plants can be propagated by two methods: by seeds or by vegetative procedures. As a rule, using seeds to propagate fruit cultivars, although simple and economical, is not satisfactory. The seedlings are usually different from the parent plants, especially in size, shape, and quality of the fruit. In addition, the various seedlings are likely to differ from one another. This great variation in plants produced from seed, although undesirable to the fruit grower, is necessary for the plant breeder who is trying to produce better plants.

Breeding and selection over many plant generations might make it possible to obtain, from seed, fruit cultivars that are reasonably true to horticultural type. However, it takes a number of years to reproduce each generation, so the time required to develop propagating material becomes prohibitive. Therefore, for fruit plant propagation, it is best to use a vegetative part of the plant, such as a stem or root, to prepare cuttings or layers or to use grafting or budding to connect a part of one plant to another plant so that the two parts grow together to become one plant.

A plant propagated by vegetative methods is ordinarily identical to the parent. *Clone* is the term used to designate a cultivar that must be propagated by vegetative methods to retain its distinctive characteristics.

Placing a cutting (a piece of stem a few inches long) in soil or in sand so it forms roots and new shoots is neither difficult nor expensive. Propagation by cuttings is used for quince, fig, pomegranate, grape, olive, currant, gooseberry, and some other fruits.

Unfortunately, some of the principal tree fruits—pears, apples, cherries, peaches, apricots, almonds, walnuts, and most plums—are difficult to propagate by cuttings. Therefore, the common technique for propagating these fruits is to grow seedlings or rootstock cuttings and to bud or graft the desired cultivar on them.

The plants on which fruit cultivars are budded or grafted are called *rootstocks*. Seedlings are usually used as rootstocks, but vegetatively propagated plants are sometimes used as rootstocks to secure such benefits as disease resistance, uniform vigor, or small size (dwarf) trees. Some seedling lines also provide rootstocks that are resistant to nematodes or diseases or that can tolerate adverse soil conditions.

Rootstocks for Fruit Plants

Most commercial cultivars of fruit and nut trees are budded or grafted on selected seedling plants, all of which are commonly called rootstocks. This section provides information about the selection, identification, and performance of rootstock species and cultivars for the temperate-zone fruit, vine, and nut crops produced commercially in California.

Cultivar, a term now common in the scientific literature, is used in this publication in place of the more familiar, but less precise, term variety. Cultivar is a contraction of cultivated variety and refers to plant material that can be reproduced by various methods without losing its genetic identity. Examples of named cultivars are 'Bing' cherry and 'Bartlett' pear.

SELECTING ROOTSTOCKS

If possible when selecting rootstocks for propagation, obtain both vegetative and seed material free of known viruses from agencies that index material for viruses, such as the Foundation Seed and Plant Materials Service, University of California, Davis. Once obtained, take precautions to maintain the material clean and check it regularly by indexing.

In recent years, a new problem, Stem Pitting, has caused trees on rootstocks of almond, apricot, peach, 'Marianna 2624' plum, and mahaleb cherry to decline in vigor and to develop pitted wood and thickened bark. The cause is the tomato ringspot virus, which is spread by the dagger nematode *(Xiphinema americanum)*. Fumigation of nursery soils for nematode control is now considered essential to prevent the spread of Stem Pitting.

ALMONDS

The principal rootstocks used for almond are seedlings of peach and almond. In the past, almond seed was obtained from bitter almond seedling trees; now it is obtained from commercial sweet almond cultivars, such as Mission (Texas). At present, peach seedlings are used more frequently as rootstocks than are almond seedlings. If root-knot nematodes *(Meloidogyne* species) are present in the soil, select a nematode-resistant peach rootstock, such as 'Nemaguard'. (Refer to the section on peaches and nectarines for more information about peach rootstocks.)

Myrobalan plum *(Prunus cerasifera)* has been tried as a rootstock for almonds, but it is not commercially satisfactory.

'Marianna 2624', a vegetatively propagated selection of Marianna plum *(P. cerasifera* × *P. munsoniana* [?]*)*, has been used to a limited extent as a rootstock for almonds grown in heavy, wet soils and in areas infected with oak root fungus *(Armillaria mellea)*. 'Marianna 2624' is easily propagated by hardwood cuttings.

Ne Plus Ultra, Mission (Texas), Peerless, and Jordanolo almond cultivars make satisfactory growth on 'Marianna 2624', although considerable overgrowth usually occurs at the graft union. Limited observations indicate that Ballico, Thompson, and Merced cultivars also grow satisfactorily on 'Marianna 2624'. Nonpareil, Drake, Davey, Kapareil, and Milow (12-38) cultivars are not directly compatible with 'Marianna 2624', although grafts of 'Nonpareil' are successful if a 'Havens 2B' interstock is used.

Almond trees on 'Marianna 2624' roots are usually smaller than are those on almond or peach roots. 'Marianna 2624', while not immune, is more resistant to oak root fungus than are other rootstocks that may be used for almond. However, it is probably justified to grow almond

trees on 'Marianna 2624' only if the trees are to be planted in wet areas of an orchard or in areas infected with oak root fungus.

Peach-almond hybrid rootstocks are also used to a limited extent in the propagation of almonds. These hybrid rootstocks are more vigorous than peach rootstocks and so make excellent replant trees. Some of the hybrids can tolerate nematodes; others can tolerate higher levels of boron in the soil than peach rootstocks can.

APPLES

In the past, rootstocks for apples were grown from French crab seed imported primarily from France where the fruit was used for making cider. In recent years, the use of large quantities of seed of domestic commercial apple cultivars has become common. Domestic seed now accounts for a considerable part of the United States' supply of seedling rootstocks for apples. Nurseries that grow most of the apple seedling rootstocks for California, Oregon, and Washington primarily obtain the seed from cultivars of Winesap, Rome Beauty, Delicious, McIntosh, and Yellow Newton. For various reasons, seeds of 'Baldwin', 'Rhode Island Greening', or 'Gravenstein' are unsuitable for use as apple rootstocks.

If dwarf trees are desired, use specific rootstocks propagated by vegetative methods. Several stocks, which were developed in England, are available. The most important of these stocks are listed below and are classified into four levels of vigor as determined by the size of mature trees grafted or budded on these rootstocks. (Trees on seedling rootstocks are classed Standard in vigor and would equal 100 percent in the following table.) Under rootstocks, the numbers above 100, such as M 106, indicate that the rootstocks are resistant to woolly apple aphid; numbers below 100, such as M 26, indicate rootstock susceptibility to this pest.

Vigor	Approximate Tree Size Expressed as a Percent of Mature Tree Size if Worked on a Seedling Rootstock	Clonal Apple Rootstocks
Standard (extremely vigorous)	90 to 100	M 104
Semi-standard (semi-vigorous)	65 to 80	M 111, M 106
Semi-dwarf	40 to 60	M 7, M 26
Dwarf	30 to 40	M 9

A second way to produce dwarf trees is to use a seedling or semi-vigorous rootstock with an intermediate stem piece of a dwarfing cultivar, such as M 9 or M 26.

The smaller growing apple selections, commonly called spur types, produce medium size trees when budded on seedling or semi-standard rootstocks.

Research on English rootstocks has been conducted in other parts of the world; most studies in California have been limited to small trial plantings. Further evaluations are necessary before definite recommendations can be made about the use of these clonal stocks in California.

If you plan to grow apples in California, consider using seedling stocks or the clonal stocks M 111, M 106, M 7, or M 26, depending on the amount of tree vigor desired.

APRICOTS

The chief rootstocks used for apricots are apricot, peach, and plum seedlings. 'Royal' ('Blenheim') apricot seeds, which are easily obtained from apricot drying yards, are commonly used.

If root-knot nematodes are present in the soil, you can use apricot seedlings or seedlings of a resistant peach rootstock, such as 'Nemaguard'. However, some patented, shipping apricot cultivars have not grown well on 'Nemaguard' peach rootstock. Apricots on trees on peach roots mature a few days earlier than does the fruit on trees on apricot or plum roots. On the other hand, apricot trees on peach rootstocks live a shorter time than they do on other rootstocks. (See the section on peach and nectarine rootstocks.)

Select plum rootstocks for apricot trees if the trees are to be planted on clay loam soils that tend to remain wet or to have restricted drainage during winter or summer. Rooted cuttings of 'Marianna 2624' are commonly used as plum rootstocks. Apricot trees on rooted cuttings of 'Marianna 2624' grow well and produce heavy crops for a long time. 'Marianna 2624', although not immune, is more resistant to oak root fungus than are other rootstocks.

Seedlings of myrobalan plum do not make satisfactory rootstocks for apricots because the bud union is sometimes susceptible to breakage during heavy winds. (Refer to the section on plums and prunes for more information about plum rootstocks.)

CHERRIES

Mazzard *(Prunus avium)* and mahaleb *(P. mahaleb)* cherry seedlings are often used as rootstocks for sweet cherries. Mahaleb rootstock produces trees with some resistance to buckskin disease, root-lesion nematode, and bacterial canker. On the other hand, mahaleb rootstock is susceptible to *Phytophthora* crown and root rots and injury caused by gophers. Some cultivars, such as Van and Early Burlat, grow poorly on mahaleb seedlings; it is best to graft these cultivars on mazzard seedlings. Mazzard is a good rootstock for all sweet cherry cultivars, but produces excessively large trees.

A sour cherry, 'Stockton Morello', has occasionally been used for adapting sweet cherries to heavy, wet soils. However, 'Stockton Morello' actually grows best on well-drained, medium textured soils.

While 'Stockton Morello' is considered a commercially satisfactory rootstock, 'Early Burlat', 'Chapman', and a few less important cultivars sometimes do not make satisfactory growth on it. 'Stockton Morello' rootstock frequently gives a small to moderate amount of dwarfing to the sweet cherry top. Most cultivars on this stock make a definite overgrowth at the union, and the stock tends to sucker badly from the roots. Propagate 'Stockton Morello' by leafy softwood cuttings under mist or by suckers; do not use seedlings because of their variability.

FIGS

Fig trees are propagated by hardwood cuttings and, therefore, are on their own roots. Rootstocks are not used for

propagating figs. All cultivars are susceptible to root-knot nematodes.

GRAPES

If the soil is free of root-knot or root-lesion nematodes as well as phylloxera *(Dactylosphaera vitifoliae)*, grapevines are usually propagated by dormant hardwood cuttings and, thus, are on their own roots. To produce new or scarce cultivars grown on their own roots, propagate grapevines by leafy softwood cuttings under mist in a greenhouse. The use of this method gives the largest quantity of plants in the shortest amount of time. (See page 58 for details about this propagation technique.)

If the soil is infested with root-knot nematodes, use 'Couderc 1613', *(Vitis solonis* × *Othello)* rootstock. However, '1613' does not grow well in sandy soils of low fertility, so two *Vitis champini* rootstocks—'Salt Creek' and 'Dog Ridge'—are recommended. 'Dog Ridge' is quite vigorous and is best used only in the poorest of sandy soils where 'Salt Creek' does not grow well. In good soils, the extreme vigor and rank vegetative growth of 'Dog Ridge' often cause poor fruit set of the cultivars grafted on it.

The USDA Horticultural Field Station at Fresno developed two rootstocks for use in propagating grapes. One rootstock, released in 1965, is named 'Harmony'; the other, released in 1974, is named 'Freedom'. Both rootstocks are more vigorous than '1613', but less vigorous than 'Salt Creek' or 'Dog Ridge', and are reported to have more resistance to root-knot nematodes and phylloxera than '1613'. 'Freedom' is more vigorous than 'Harmony'.

If phylloxera is the principal problem in an area, *Vitis rupestris* 'St. George' rootstock is recommended for hillside and rocky soils where irrigation is not used. On irrigated lands and on soils that are deep and loamy in texture, 'Ganzin #1' or 'AXR #1' ('Aramon' × *V. rupestris* 'Ganzin') stock is recommended. 'Ganzin #1' is only moderately resistant to phylloxera. These resistant rootstocks are all propagated by hardwood cuttings.

KIWIFRUIT

Seedlings of Hayward or Bruno cultivars are often used as rootstocks. Year-old seedlings are whip grafted in January or May or T budded in May, using stored wood. Heavy sap flow (bleeding) precludes budding or grafting from February through April. Semi-hardwood cuttings taken in summer, rooted under mist, and grown for a full year in the nursery develop into plants equal to budded seedlings. All rootstocks are susceptible to root-knot and root-lesion nematodes, oak root fungus *(Armillaria mellea)*, and *Phytophthora* crown and root rots.

OLIVES

Olive cultivars can be propagated by cuttings and, therefore, are often grown on their own roots. Olives can also be propagated by budding or grafting on various rootstocks.

In California, Mission, Ascolano, and Manzanillo cultivars produce strong, fruitful trees on their own roots. 'Sevillano' trees, if started from cuttings, are somewhat smaller than grafted trees are. Cuttings of 'Sevillano' are difficult

to root; those of 'Mission', 'Ascolano', and 'Manzanillo' root readily. 'Mission' seedlings are sometimes used as rootstocks for the major cultivars, especially Sevillano, but the resulting trees often vary in vigor and growth habit. Rooted cuttings of a vigorously growing cultivar, such as Mission, make more suitable rootstocks and produce more uniform trees than do seedlings.

In the San Joaquin Valley where Verticillium wilt is a problem, use a wilt-resistant rootstock, such as 'Oblonga' or 'Allegra', which can be propagated by cuttings.

PEACHES AND NECTARINES

Peaches and nectarines are propagated almost entirely by budding on peach seedlings grown from the seed of the commercial cultivar Lovell and on seedlings of the nematode-resistant cultivar Nemaguard.

'Lovell' seedlings are seriously injured by both species of root-knot nematodes *(Meloidogyne incognita* and *M. javanica),* which are common in many California soils. 'Lovell' is successful where root-knot nematodes are not a serious problem. 'Nemaguard' is immune or highly resistant to *M. incognita* and *M. javanica* and, as a consequence, is the rootstock most widely used in California for peaches, nectarines, and almonds. Trees on 'Nemaguard' are vigorous and productive, but are more likely to become deficient in zinc and to develop crown rot and bacterial canker than are trees on 'Lovell' seedlings.

'Nemaguard' and 'Lovell' are not resistant to large populations of other nematode species, such as lesion *(Pratylenchus vulnus),* ring *(Criconemoides xenoplax),* and dagger *(Xiphinema* species). Preplant fumigation may be necessary to establish successful orchards where nematodes and diseases are problems or where second or third generation orchards are to be planted.

PEARS

The French pear, *Pyrus communis,* is the primary rootstock used for pears. All pear cultivars grow and produce well and are long lived on French pear seedling rootstocks.

The main source of seed for commercial orchards is fruit of commercial pear cultivars, such as Bartlett and Winter Nelis. These cultivars are sometimes called domestic French seedlings to distinguish them from imported French seedlings, which were commonly planted in orchards 70 to 100 years ago. Most pear trees on domestic French ('Bartlett' and 'Winter Nelis') seedling rootstocks have survived pear decline, while many trees on imported French rootstocks have died.

Bartlett and other pear cultivars may be budded or grafted on blight- and decline-resistant cultivars of *P. communis,* such as 'Old Home' and the many numbered, vegetatively propagated selections of 'Old Home' × 'Farmingdale'. These resistant stocks are propagated by means of softwood or hardwood cuttings.

The Bartlett cultivar grows and produces well on its own roots, developing into an early bearing, semi-dwarf tree. 'Bartlett' can be rooted by hardwood cuttings or by softwood cuttings under mist, but the rooting percentages tend to be low.

Pear cultivars will grow on seedling rootstocks of several species of *Pyrus*. 'Bartlett' trees on *P. betulifolia* seedling rootstocks are vigorous, decline resistant, and grow and produce well, especially on wet soils, clay loams, slightly saline soils, and shallow hillside soils. On deep valley soils, *P. betulifolia* rootstock produces an excessively vigorous tree. 'Bartlett' trees grow vigorously and produce well on *P. calleryana*, but good pear psylla control is necessary; otherwise trees develop symptoms of pear decline, although they rarely die.

Before the outbreak of pear decline in California in 1958, many old, irrigated orchards grew well on *P. serotina* and *P. ussuriensis* rootstocks. However, the pear psylla insect spread the decline pathogen to these trees, most of which died. As a consequence, *P. serotina* and *P. ussuriensis* are no longer used as pear rootstocks in California.

If dwarf pear trees are desired, use specific cultivars of quince *(Cydonia oblonga)*, such as 'Quince A' and 'Provence', as rootstocks. 'Comice' and 'Hardy' grow well directly on quince rootstock, but other cultivars, such as Bartlett, Bosc, and Anjou, do not make a good union with quince. Bartlett, Bosc, and Anjou cultivars require double working, using an interstock (a short piece of a compatible cultivar, such as Old Home or Hardy) between the rootstock and the top or fruiting cultivar.

'Bartlett' trees on quince rootstocks (with an interstock) can be severely stunted by pear decline, but usually do not die. In contrast, 'Comice' trees grow well on quince rootstocks despite pear decline. 'Comice' trees produce at a younger age on quince than on any other rootstock and, for this reason, quince ('Provence') is preferred for 'Comice' orchards.

Cultivated types of Oriental pears—'20th Century', 'Shinseiki', 'Kikusui', 'Chojuro', and 'Ya Li'—grow more vigorously and produce larger fruit when grown on *P. calleryana*, *P. betulifolia*, or *P. serotina* rootstocks than when grown on French stocks *(P. communis)* or quince stocks (with a 'Hardy' or 'Old Home' interstock).

The following table indicates the size of mature 'Bartlett' trees on various rootstocks.

Vigor	Approximate Tree Size *(percent of standard tree)*	Rootstocks
Vigorous	125	*P. betulifolia* and *P. calleryana* seedlings
Standard	100	'Winter Nelis' and 'Bartlett' seedlings
Semi-dwarf	75 to 85	'Bartlett' on own roots (from rooted cuttings) and on some 'Old Home' × 'Farmingdale' rootstocks
Dwarf	30 to 40	'Quince A' and 'Provence' quince rooted cuttings

PECANS

Use pecan seedlings as rootstocks. Obtain the seedlings from nuts of either seedling trees or commercial pecan cultivars.

PERSIMMONS

Seedlings of any one of three persimmon species can be used as rootstocks for most cultivars of the Oriental persimmon.

Diospyros kaki is probably the best rootstock for general use, although the seedlings are difficult to transplant because they have a long taproot and few laterals. *D. kaki* stock makes a good union with all cultivars. Trees on this rootstock grow well and yield satisfactory commercial crops. You can obtain seeds for rootstock use from any of the Oriental persimmon cultivars that produce seeds.

D. lotus seedlings are vigorous, drought resistant, and produce rather fibrous roots that transplant easily. This stock is preferred by nurserymen, although it is susceptible to crown gall and does not tolerate poorly drained soils. In southern California, 'Hachiya' on *D. lotus* stock does not produce well because of excessive fruit shedding, a problem that does not occur in central and northern California. Scions of 'Fuyu' are reported to make a poor union with this stock, although 'Fuyu' topworked on *D. lotus* roots produces a satisfactory tree.

D. virginiana seedlings are used as rootstocks in the southern part of the United States. Most Oriental persimmon cultivars make a good union with this stock, which tolerates excess soil moisture and produces a desirable fibrous root system. In California, 'Hachiya' on *D. virginiana* stock produces a dwarf tree that yields poorly because of sparse bloom.

PISTACHIOS

Seedlings of *Pistacia atlantica* and *P. terebinthus* are commonly used as rootstocks in California. These species are more resistant to nematodes and some soil-borne fungi than are seedlings of *P. vera*, the species used for commercial production of nuts.

Although seedlings of both *P. atlantica* and *P. terebinthus* grow more slowly in the nursery than do those of *P. vera*, scion cultivars budded on either of these two species grow and yield better than do trees on *P. vera* roots. All *Pistacia* species are quite susceptible to Verticillium wilt.

Best results with any *Pistacia* seed are obtained when germination temperatures do not exceed 70° F. (21° C). Once germination occurs, strict temperature control is no longer necessary. You can improve *P. atlantica* germination by soaking the seeds in cool water for 2 to 3 hours. You can improve *P. terebinthus* germination by soaking the seeds in water for 1 to 2 hours, mixing with damp sand (or a mixture of sand and peat moss), and then storing in a refrigerator for 6 weeks at 40° to 45° F. (4° to 7° C).

Some nurserymen prefer to wrap *Pistacia* seeds in moist burlap and store in a cool, dark place until the seeds begin to germinate. The germinating seeds are then planted and the remainder returned to storage. After germination begins, examine the seeds in the moist burlap ("rag dolls") at least every other day. The seeds must be planted soon after sprouting. To obtain uniform orchard trees, select only the most vigorous seedlings for use as rootstocks.

Germinated seed may be transferred to 1-inch, nutrient peat cubes or to small peat pots. Place cubes or pots in a well-illuminated greenhouse and grow the seed until it is thoroughly rooted. When the roots permeate the cube or pot and protrude, rub them off. Then transplant the seedlings from the cube or peat pot to individual containers that are 4 to 6 inches in diameter by 18 inches in depth and filled with fumigated, loamy soil. Or

sow germinated seeds in deep flats and carefully transplant them bareroot to suitable containers.

PLUMS AND PRUNES

The important rootstocks for plums and prunes are seedlings of myrobalan plum *(Prunus cerasifera)* and vegetatively propagated hardwood cuttings of 'Marianna 2624' and 'Myrobalan 29C' plum. In some plum-growing districts where bacterial canker is a serious problem, trees are grown on peach seedling rootstocks.

'Myrobalan 29C' and 'Marianna 2624' roots, unlike those of many myrobalan seedlings, are not susceptible to injury from root-knot nematodes. 'Marianna 2624', while not immune, is more resistant to oak root fungus than are other rootstocks used for plums and prunes.

During the first 3 or 4 years, the roots of 'Marianna 2624' and 'Myrobalan 29C' have a shallow growth habit. In contrast, the roots of myrobalan plum seedlings grow deeper in the soil. Young trees on 'Marianna 2624' and 'Myrobalan 29C' roots, because of the shallow rooting habit, are sometimes blown over by heavy winds.

In some orchard sites, bacterial canker is so severe that plum trees can only be grown on peach rootstocks because peach is partly resistant to this disease. However, a few plum cultivars, such as Laroda, are not satisfactory on peach roots. Use plum roots in soil that is fine textured and tends to remain wet during part of the year. Use peach roots only in sandy soils where bacterial canker is a problem.

Do not use peach roots for prunes grown in the interior valleys of California. In some years, this practice contributes to excessively heavy crops, which aggravates potassium deficiency and causes severe die-back of trees.

Almond is occasionally used as a rootstock for plums and prunes grown on well-drained soils. However, it is best not to use this rootstock except in soils high in lime or boron, which almond roots can tolerate to some extent.

WALNUTS

For many years, northern California black walnut *(Juglans hindsii)* seedlings have been the standard rootstock used for Persian, or English, walnut *(J. regia)* plantings in California. In good, deep soils suitable for walnut production, northern California black walnut seedlings are vigorous and are highly resistant, but not immune, to oak root fungus. On the other hand, seedlings of northern California black walnut are susceptible to crown rot, root-lesion nematode *(Pratylenchus vulnus)*, and black line.

In recent years, the use of Paradox hybrid seedlings as rootstocks has increased. These hybrids result from natural crosses between northern California black walnuts and Persian walnuts. Paradox hybrid seedlings usually grow more vigorously in foothill soils and in the less fertile valley soils than do northern California black walnuts. Paradox roots also make excellent replants. Paradox is better able to withstand a fluctuating water table and is more resistant to crown rot than is northern California black walnut. In addition, many Paradox hybrid seedlings show

moderate to high resistance to root-lesion nematode, although they are susceptible to black line and highly susceptible to crown gall *(Agrobacterium tumefaciens).*

In a few situations, Persian walnut seedlings have been used where black line is a serious problem. However, lack of experience with Persian walnut seedlings and their susceptibility to oak root fungus has limited their use as rootstocks. Persian walnuts are less able to tolerate high soil salinity than are northern California black walnuts.

STRATIFICATION OF ROOTSTOCK SEEDS

After removal from harvested fruit, seeds of most deciduous fruit trees ordinarily do not germinate, even under ideal conditions of moisture and temperature. This delay in germination is partly due to the fact that the seed embryos are in a state of physiological rest, which must be broken by exposing the moist seeds to cold. In addition, the seeds of many plants have a hard, impervious, outer layer that must be softened before germination can begin.

A common process used to break the rest and to soften the hard seed coat is called stratification. Stratification can be accomplished by putting the seed between layers of moist sand or other materials, such as vermiculite, or in a mixture of sand and peat moss and then storing in a cool place.

Begin stratification in the fall or winter, depending on the species of tree. Keep the seeds in the stratification medium until you plant them in the nursery. As a rule, continue stratification until you can see the embryonic root starting to push through the seed covering. Then plant the seeds immediately. However, seeds of some species do not require stratification for germination.

It is advisable to soak seeds in water for about 24 hours before putting them in the stratification material. Depending on the quantity of seed to be treated, the size container to use may vary from a fairly large box or can to a small size polyethylene bag (figure 1).

Always keep the stratification medium moist, but do not allow it to become excessively wet. It is a good practice to check the seeds at intervals during stratification and to add water if necessary. Make sure any excess water can drain from the stratification medium. Do not use air-tight containers; aeration is necessary during stratification.

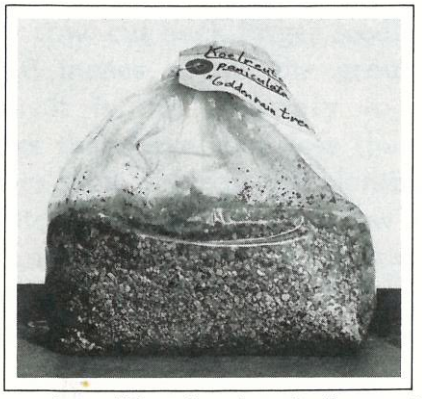

Figure 1. A small lot of seed ready for stratification. The seeds are in moist vermiculite in a polyethylene bag and will be held in cold storage for the prescribed length of time before planting.

If necessary, cover the containers with wire screens to protect the seed from birds or rodents.

If winters are not too warm, seeds receive enough exposure to cold in a shady, outdoor location. However, you may achieve better germination by stratifying seeds in cold storage at about 35° to 40° F. (2° to 4° C). The table gives suggested stratification periods for seeds of different fruit plant species.

Plant seeds immediately after stratification. If germination temperatures are too warm, however, the seeds may develop secondary dormancy and fail to germinate.

In the fall, you can plant seeds of most temperate-zone fruit species outdoors in the nursery row, where the seeds receive naturally the cold, moist conditions necessary for stratification. Use preemergence herbicides to prevent weed growth during the winter and early spring. It may also be necessary to control rodents; otherwise, the seeds may disappear by spring.

Species	Suggested Stratification Time in Days at 35° to 40° F. (2° to 4° C)
Kiwifruit	20
Almond	30
Apricot	30
Apple	60 to 90
Pear	60 to 90
Cherry	90 to 120
Peach	90 to 120
Plum	90 to 120
Walnut	90 to 120

PLANTING ROOTSTOCK SEEDS

There are three methods of planting fruit tree seeds:

- plant in the nursery row in the fall so the seeds receive cold stratification in the nursery during the winter;
- plant directly in the nursery row after cold storage stratification;
- sow thickly in a seedbed and transplant the seedlings to the nursery row the following winter or early spring.

The third method produces trees with roots 1 year older than those produced by the first two methods.

Apricot, almond, peach, walnut, pecan, and sometimes myrobalan plum and mahaleb and mazzard cherry are rootstock seeds that can be planted directly in the nursery row. (The tops of pecan seedlings grow rather slowly, so it is usually necessary to delay budding or grafting until the second year after planting.)

When planting seeds, space rows 4 to 6 feet apart and plant the seeds about 4 inches apart in the row. If experience has shown that particular kinds of seed tend to germinate poorly, it may be preferable to plant the seeds closer together than 4 inches and to thin later if necessary. Plant walnut seeds, which are large, about 4 to 5 inches deep; plant medium size seed —apricot, almond, peach, and pecan— about 3 inches deep; and plant smaller seed, such as myrobalan plum, about 1½ inches deep. To prevent seeds from drying out, it is usually best to plant them deeper in coarse textured (sandy) soils than in fine textured (clay loam) soils. This practice may not be necessary if irrigation water is always available.

Rootstock seeds that are usually grown one season in a seedbed and then transplanted to the nursery row include apple, pear, and sometimes myrobalan plum and mahaleb and mazzard cherry. The type of seedbed varies considerably, but it is common to plant seedling trees in rows far enough apart for convenient use of tractor-drawn cultivators. Plant 10 to 15 seedlings per foot to keep the trees from growing too large for satisfactory transplanting. Plant apple and pear seeds about 1 inch deep; cherry and myrobalan plum seeds, about 1½ inches deep.

Immediately after transplanting to the nursery row, cut back larger seedlings to 6 to 10 inches above the ground. In general, it is not necessary to prune seedlings that have tops less than 8 to 10 inches high. To expedite planting, cut back lateral roots to stubs a few inches long. Cut taproots to induce branching of roots and to make the seedlings easier to transplant.

Vegetative Methods of Propagation

The vegetative methods that can be used to propagate deciduous fruit plants are budding, grafting, layering, and the use of cuttings, suckers, and runners. It is often possible to propagate plants by more than one of these methods. A nurseryman must consider time and cost when deciding which propagation method to use. However, a grower can sometimes use a method that would not be practical on a large scale.

BUDDING

Budding is the insertion of one detached bud of the desired cultivar into a root-stock plant. (See figure 3.) Nurserymen use budding to propagate 1- to 2-year-old nursery trees. Growers may sometimes use budding to change a bearing tree over to a different cultivar.

Some of the names used to describe budding are based on the time of year the work is done. In the Northern Hemisphere, late-summer or fall budding is done mainly in August or a little later; spring budding, in March or April; June budding, in May or the first half of June. Other names used for budding are based on the method of cutting and inserting the bud, such as T (or shield) budding, patch budding, I budding, chip budding, and other less important methods. Regardless of time of year or method, budding success depends on matching the cambiums of the stock and the bud. The cambium is a layer of dividing cells located between the wood and the bark.

SELECTION OF BUD WOOD

For late-summer or fall budding and for June budding, take buds of the selected cultivar from the current season's growth at the time of budding. For spring budding, collect shoots from dormant trees and store them under refrigeration until you are ready to do the budding.

Although it is best to choose bud sticks that have vegetative (leaf) buds only, many propagators use shoots that have clusters of both vegetative and flower (fruit) buds. Do not use flower buds exclusively because they will only blossom and die. Vegetative buds are usually smaller and more sharply pointed than flower buds are. (See figure 2.)

In plums, apricots, peaches, and walnuts, a leaf bud usually occurs at each node, either alone or together with one or more flower buds. These mixed buds are satisfactory to use for budding. A single flower bud is occasionally found on the bud sticks of these species, but not often enough to cause the propagator much concern.

Pear, apple, and almond bud sticks often have a number of single flower buds near the apical end. In pear and apple, these are really mixed buds, but they usually respond in the same way as ordinary flower buds. However, the apical ends of most bud sticks are customarily discarded because of their small size, which minimizes the danger of using these undesirable buds.

The sweet cherry is most likely to cause trouble because its flower buds are located on the basal part of the shoot, a part the propagator is likely to use as a source of buds. In addition, the flower buds are essentially the same size and shape as the vegetative buds. When budding sweet cherries, discard the basal part of the bud stick and select vigorously growing shoots as the bud source.

In all the fruit tree species discussed, a higher percentage of leaf buds are usually found on the most vigorous shoots. You can greatly reduce the danger of using flower buds by only using vigorous shoots for bud wood.

An important consideration in the selection of bud wood is to obtain wood free of known viruses from trees that have produced fruit typical of the cultivar. You can obtain propagation wood that is certified free of known viruses and true to horticultural type at moderate cost from the Foundation Seed and Plant Materials Service, University of California, Davis 95616, or from some California nurseries. This wood is usually sold in quantities of a hundred buds or more of each cultivar, not as single bud sticks.

KINDS OF BUDDING

Late-summer or fall budding is the most important method used for propagating deciduous fruit trees in the United States. However, June budding is an equally important method in California because it is used for propagating all almonds and peaches. Spring budding is not normally used in California, except when late-summer or fall budding is not successful or in other special situations.

Late-Summer or Fall Budding

Late-summer or fall budding is usually done in late July and August, but may be continued into September or until the bark can no longer be separated from the wood. Collect bud wood from the current season's growth at the time you plan to do the work. You can store bud wood a short time if you keep it cool and moist.

When budding, use either seedlings or vegetatively propagated rootstocks that were transplanted to the nursery in the spring. To prevent trees from becoming too large to transplant the next year, bud rootstock plants that are ¼ to ½ inch in diameter. Fall budding is best used for the propagation of apples, cherries, pears, and prunes. (June budding is the preferred method for almonds, apricots, peaches, and nectarines.)

About the time growth starts the spring after budding, cut back the top of the rootstock to approximately ⅝ inch above the bud (just above the cross-cut of the T or the top of the patch). Make this cut so it slopes downward and away from the side of the stock where you inserted the bud. Remove all shoots that grow on the rootstock plant below the bud. Dig up the nursery trees the winter after the shoots from the buds have grown one season.

Trees produced by this technique have either 2- or 3-year-old roots and 1-year-old tops. However, the trees are called 1-year-old trees, or yearlings; the age of the roots is not considered. In California where the growing season is long, 2-year-old deciduous fruit trees (trees with 2-year-old tops) are not usually offered for sale because they are too large for planting.

June Budding

Most nurseries in California propagate a considerable number of tree species by June budding, using the T bud method. Essentially all almonds, nectarines, peaches, and most plums and apricots are June budded.

At the time of budding, collect bud wood

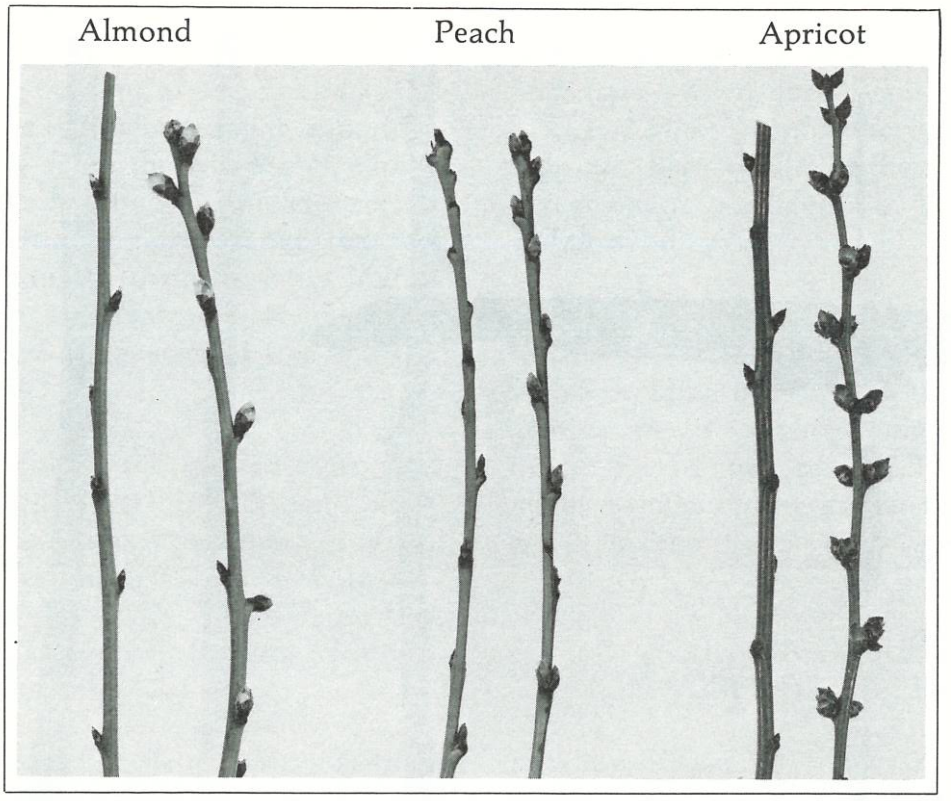

Figure 2. The difference in appearance between vegetative buds (shoots on left in each pair) and flower buds (shoots on right in each pair). Note that the vegetative buds are smaller and more pointed than the flower buds, which are large and plump.

from the current season's growth of the desired cultivar trees. For ease in handling small size June buds, remove most of the wood from the bud shield, except for a small core beneath the bud. The easiest way to remove the wood is to make a long cut under the bud. Then, at the upper end of this cut, make a horizontal cut through the bark only—not through the bark and the wood. (See figure 3, A.) Use a sliding motion to remove the shield of bark so the wood remains attached to the bud stick. If you pull up the shield instead of sliding it sideways from the bud stick, you may separate the small core of wood that runs into the bud from the bud itself—a practice that often results in failure.

It is common to cut off the top of the seedling 2 to 5 inches above the bud 3 or 4 days after budding. Cut so as to retain at least one leaf above and several leaves below the bud. It may be necessary to bud as high as 8 inches above the ground so there are a sufficient number of leaves below the bud. Photosynthesis in these rootstock leaves manufactures food for the tree until the leaves produced by the bud are large enough to take over this function.

Cut back the stock just above the bud 10 to 18 days after budding. Thereafter, shorten, but do not remove, any shoots, except those that grow from the inserted bud. When the bud has grown into a shoot 6 to 8 inches long and has enough leaves of its own, remove all other leaves and shoots from the rootstock.

Under ideal growing conditions, you can

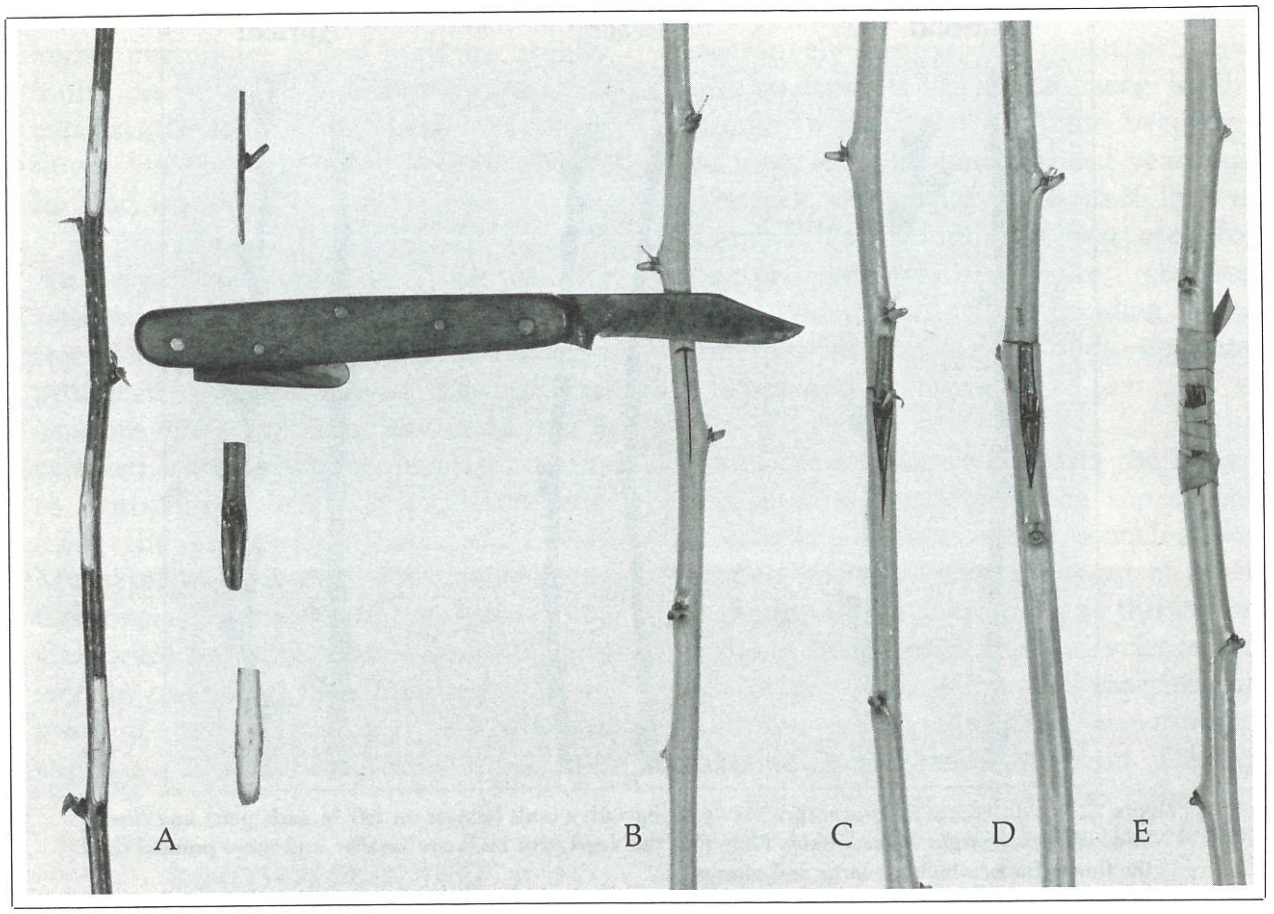

Figure 3. T (shield) budding.

- **A) A bud stick with some of the buds removed.**
- **B) T cut made on the bud stick.**
- **C) The bud piece partly inserted in place by slipping it under the two flaps of loosened bark. The bark must be slipping to make this possible.**
- **D) The bud piece completely inserted and ready for tying.**
- **E) The budding operation completed and the bud wrapped with budding rubber. When wrapping, do not cover the bud. The amount of tension placed on the rubber is quite important. If wrapped too tightly, the rubber stretches too thin and breaks too soon, allowing the bud piece to fall out. If the rubber is too loose, it does not bring the bud piece and the stock into close enough contact for healing to occur.**

obtain a medium size tree suitable for planting in the orchard by the time growth stops in the fall. This means that a nursery tree can be produced 1 year sooner than when fall budding is used.

Although the method described for June budding is relatively simple, losses are likely to occur unless you do the work carefully. Seedlings must grow rapidly if they are to become large enough for budding in May or the first half of June.

Most June budded trees offered for sale are on peach rootstock because this rootstock best meets the rapid growth requirement.

Nursery catalogs often list various cultivars of June budded peaches, nectarines, almonds, apricots, and plums. However, June budding is feasible only in regions where the growing season is long, such as in California or in the southern United States.

Spring Budding

Begin spring budding early, as soon as the bark of the rootstock plant separates (slips) easily from the wood and allows insertion of the bud. Complete spring budding before the trees have time to make much new growth—usually March or April in the Northern Hemisphere, depending on the species of tree and the season.

As a rule, collect the bud sticks in late winter while the trees are dormant. Store the bud sticks in moist peat moss or wood shavings under refrigeration at about 36° to 40° F. (2° to 4° C). You can use this wood for T (shield) budding without further treatment.

If you plan to patch bud thick-barked species, such as walnuts or pecans, transfer the bud sticks to a warm location, about 70° F. (21° C), and store until the bark separates readily from the wood. By that time, a few terminal buds may have started to grow and cannot be used, but the other buds on the stick will still be dormant.

When patch budding in the spring, you can cut bud sticks directly from a tree of the desired cultivar at the time of budding, a practice preferred by many propagators. If you use patch budding, cut bud sticks on which the terminal buds have started to grow. It is best to use the basal buds because they are still mostly dormant, yet you can separate the bark of the patches from the wood of the bud sticks.

Approximately 2 weeks after you do spring budding, the patch will have healed in place sufficiently to allow you to cut off the tops of the rootstock plants to force the buds into growth. The following winter, after shoots from the inserted buds have grown one season, dig up the trees and plant them in the orchard. The trees are then essentially the same as the 1-year-old trees produced by late-summer or fall budding.

A tree propagated by spring budding is usually less satisfactory than late-summer or fall budding because the top does not grow as much as when budding is done in the late summer or fall. The primary use of spring budding is when fall budding is not successful or in other special cases.

POSITION OF BUDS IN NURSERY PRACTICE

Budding is usually done as near the ground as is convenient. But, northern California black walnut stock, which is resistant to oak root fungus, is often budded a foot or more above the ground. Other species of rootstocks are commonly budded 4 to 5 inches above the soil surface.

Insert buds on the north side of the seedlings to protect the buds from the sun during healing. In the hot, interior valleys of California where north winds are common during the spring and fall, some propagators prefer to bud on the south side of the tree. This practice prevents the bud from drying out, even though it may increase the possibility of winds breaking off the growing bud. Another advantage of budding on the south side is that, after the bud has started growth, the short section of seedling trunk below the bud is less subject to sunburn than is the side opposite the bud.

Sunburn can seriously damage trees; it also makes the trees more susceptible to attack by flat-headed borers. You can overcome much of the sunburn damage by coating the affected areas with a white, interior, water-base paint diluted 1:1 with water. You can virtually eliminate sunburn problems by irrigating frequently and by using correct fertilization practices to maintain nursery trees in a vigorous state of growth.

METHODS OF BUDDING

T (Shield) Budding

T (shield) budding is the most common method used for budding deciduous fruit plants, except for walnut, pecan, and grape. (See figure 3.)

Use a sharp budding knife to remove the bud, together with some bark and a thin layer of wood ¾ to 1¼ inches long, from the bud stick. Remove the leaves from the bud stick by severing the leaf stems (petioles) about ¼ inch from the buds. While you can use such leaf stems as handles to aid in inserting the bud, experienced budders usually hold the bud between the knife blade and the thumb. If you cannot easily push the bud into place in the T cut, it may be necessary to use the knife point to pull it into position. You can do this with little injury to the bud by inserting the end of the knife a short distance into the shield, just below the stub of the petiole.

You can use the T bud method both for late-summer or fall budding and for spring and June budding. However, no petioles are present on the bud sticks used for spring budding because the sticks are collected in winter when there are no leaves on the trees. When June budding, it is usual to remove the wood from the bud by some method, such as the one described on page 17.

The T cut in the stock to receive the bud is usually upright, although an inverted T is sometimes used. Most propagators make the vertical cut of the T first. Then, using one movement, they make the upper cross-cut and throw open the bark to receive the bud. However, some propagators prefer to make the vertical slit last. Regardless of how you make the T cut, be sure to insert the bud far enough in so the top does not project above the cross-cut of the T. Make the vertical slit only as long as necessary to accommodate the bud. If the vertical slit is too long, the lower part of the shield may not be adequately protected by the bark.

Budding rubbers, available in various sizes, are manufactured especially for tying T buds into place. The rubber stretches as the tree grows and, after a few weeks, deteriorates and falls off. When inserting only a few buds, you can use ordinary rubber bands cut open into one length. Begin wrapping at the top of the T and proceed downward so the bud is forced downward. If you use an inverted T, wrap upward to hold the bud in place. Hold the budding rubber in place by inserting the end back under the last turn. Do not cover the bud with the wrapping material.

In the budding of some species, better results have been obtained when the wood was removed from the buds than when it was retained. However, in the budding of deciduous tree fruits, remove the wood from the bud only when June

budding and when T budding walnuts and persimmons.

To force the bud into growth, it is necessary to cut back the top of the rootstock to about 5/8 inch above the bud (just above the cross-cut of the T). The time to do this depends on whether you fall, June, or spring bud the trees.

Patch Budding

Patch budding is the technique commonly used to propagate thick-barked trees, such as walnut and pecan. To patch bud, remove a square or rectangular patch of bark from the seedling and replace it with a similar patch that includes the bud of the desired cultivar. (See figure 4.) Slide rather than pull the replacement patch from the bud stick to retain the small core of wood in the bud. To make the horizontal cuts, use one of several tools that have two parallel blades that are 1 to 1 3/8 inches apart. This type of tool helps ensure a good fit at the top and the bottom of the patch. Use an ordinary budding knife to make the vertical cuts.

You can easily make a cutting tool from a small piece of wood, two safety razor blades, two bolts, and two metal strips, one on the outside of each blade to hold it in place. (See figure 5, A.) However, if you plan to do a large amount of budding, use a stronger knife, one that has two

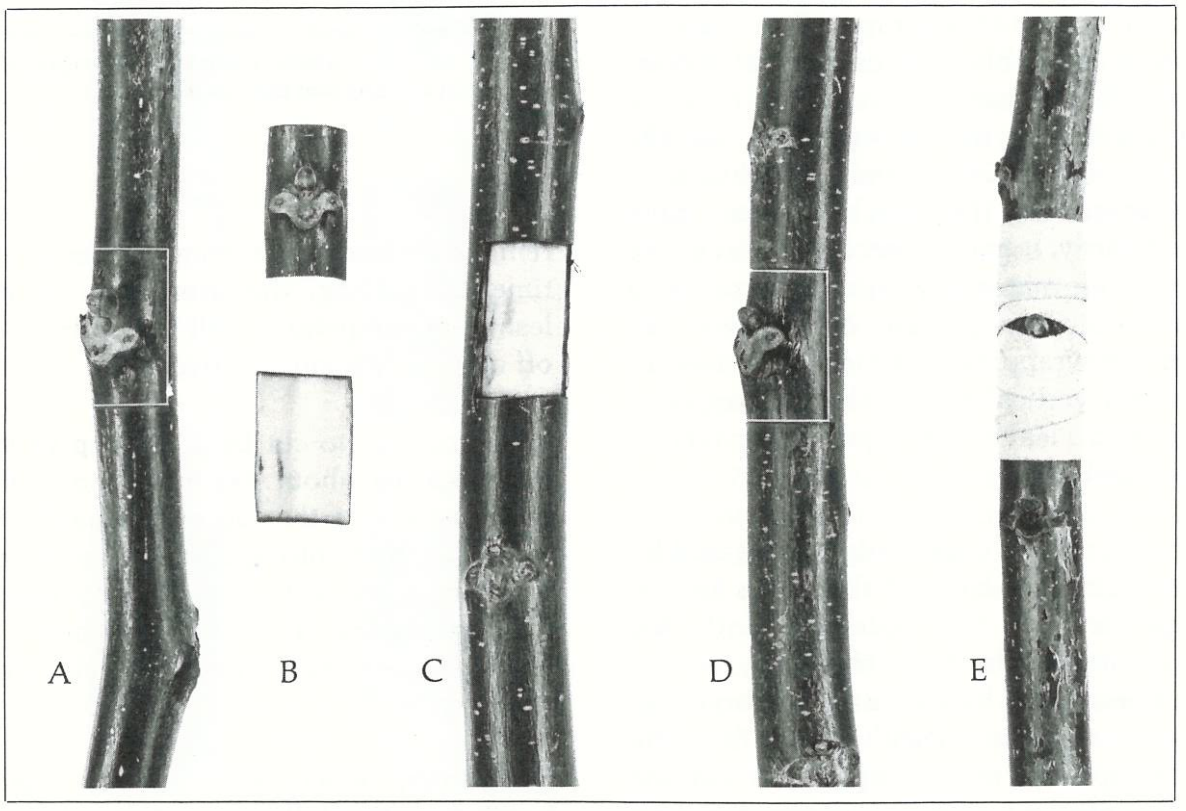

Figure 4. Patch budding.

A) A bud stick with the patch cut, but not removed.
B) Patches with attached buds after removal from the bud stick.
C) A patch of bark removed from the stock that is to be budded.
D) The bud inserted in place.
E) Wrapping completed. Note that the bud itself is not covered.

parallel budding knife blades rigidly attached to each other with a spacer block of wood between the blades. (See figure 5, B.) This type of tool is the one commonly used by commercial propagators. Some tools have vertical blades in addition to the horizontal blades, but this type of budding knife has not been entirely satisfactory. (See figure 5, C.)

If the bark of the stock is thicker than that of the bud wood, pare down the bark on the stock. (See figure 6.) Paring down the bark on the stock makes it possible to tie the patch firmly in place. Once the patch is in place, be sure to wrap it to prevent drying out.

The wrapping material commonly used is an adhesive budding tape. (See figure 4.) String and rubber bands are not recommended because they are not effective in preventing drying out. Cut off the wrapping tape 2 or 3 weeks after budding. However, if the stock grows quite vigorously, it may be necessary to cut the wrapping material within 10 days or so of budding to prevent constriction. To remove wrapping materials, it is best to make a vertical cut on the side opposite the bud; leave the tape still covering the patch.

On tree species commonly propagated by T budding, the bases of the leaves are not large and do not interfere with the wrapping of the bud. However, walnut and pecan leaf bases are rather large and make wrapping difficult. When budding these species, most propagators cut the leaves off the bud wood, except for short stubs, 2 or 3 weeks before removing the shoots from the cultivar tree. However, do not cut off the leaves on the terminal ends of the bud sticks. By the time you remove the bud sticks from the tree at the time of budding, the short stub of the leaf stem, or petiole, will have dropped off or may be easily removed.

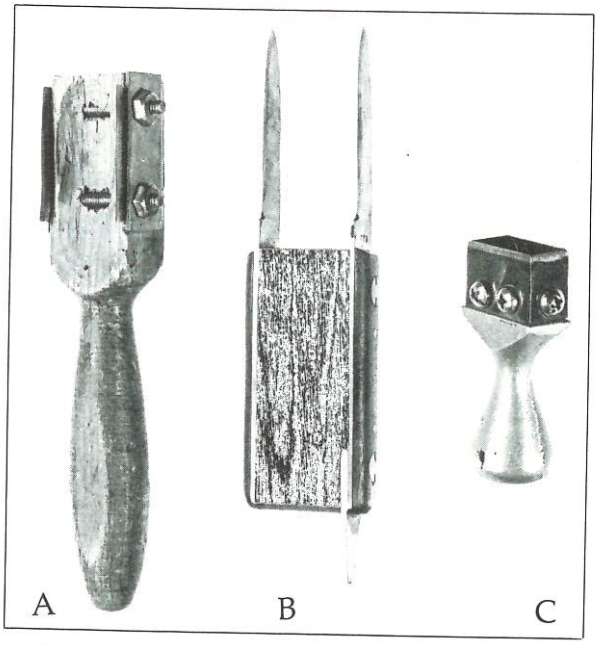

Figure 5. Tools used in patch budding.

A) A budding tool that has two parallel blades. This tool is suitable for a limited amount of work.

B) A two-bladed budding knife of the type commonly used by commercial propagators.

C) A budding tool that has four blades.

It is necessary to cut back the top of the rootstock to about 5/8 inch above the bud (just above the top of the patch) to force the bud into growth. If you fall bud the trees, cut back the rootstock the next spring. If you spring bud the trees, cut them back about 2 weeks after budding.

Sometimes, when walnuts are patch budded in the fall, the patches fail to unite with the stock. If this occurs, you can either patch bud the rootstocks again or graft the following spring, using the whip graft method (page 30).

Hinge, I, or Modified H Budding

Hinge budding is a variation of the patch bud method and is normally used when the bark of the stock is considerably thicker than that of the bud wood. If you use the hinge bud method, it is not necessary to pare down the bark of the stock to hold the patch firmly in place.

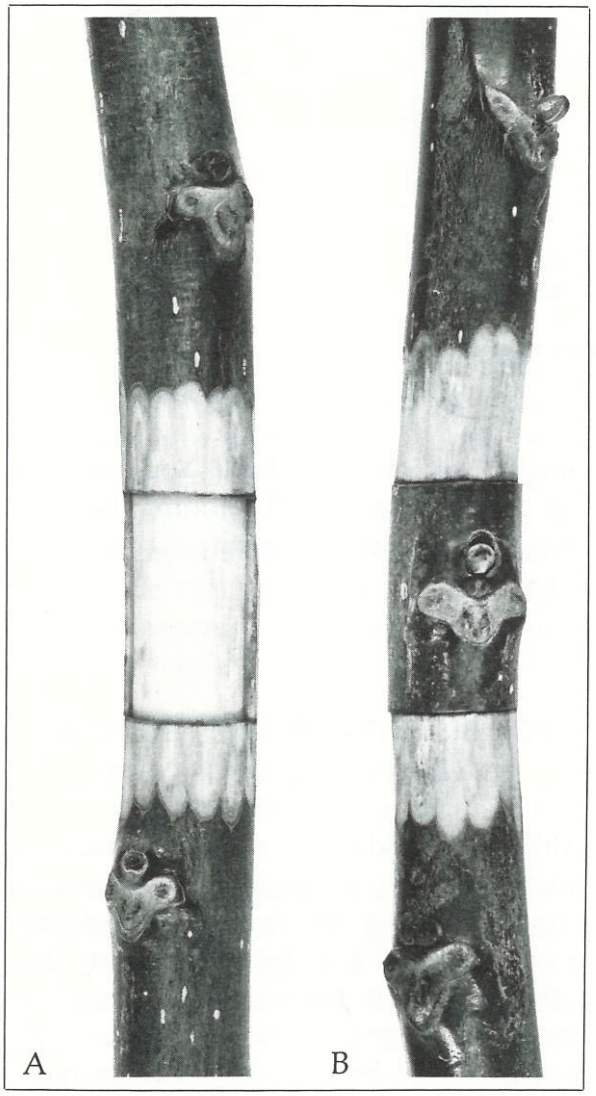

Figure 6. Patch budding a stock branch that has bark thicker than that of the bud wood.
A) The patch removed and the bark of the stock pared down.
B) The bud inserted in place and ready for wrapping.

Make the cut in the stock in the form of an I (like an H on its side). Cut a patch containing a bud the same way as for patch budding and insert it under the flaps of the I. Wrap the bud as described for patch budding. Be sure the patch is held firmly to the stock; otherwise the patch may buckle slightly and not touch the cambial surface of the stock under the bud.

Chip Budding

Chip budding is the method commonly used for propagating grape rootstocks because better results have been obtained with chip budding than with other propagation methods. In the spring, plant rooted cuttings in the vineyard; plant cuttings that are resistant to phylloxera or root-knot nematodes. In nonirrigated vineyards, bud the cuttings the following August; in irrigated vineyards, bud the following September. For good results, take buds from mature canes on which the bark color has changed to brown. Only bud plants that are actively growing. At least 4 weeks of warm weather are necessary after budding to permit the bud union to heal correctly.

Figure 7 illustrates how to remove a chip from the stock and replace it with a chip, similar in size and shape, that carries a bud of the desired cultivar. To facilitate the removal of the bud from the bud stick, make the first cut at the base of the chip deep into the stock at an angle of about 45 degrees. (Sometimes a narrower angle, 25 degrees, may be better because it permits the bud to fit more deeply into the rootstock and allows a tighter fit.) Make a second cut, starting about ½ inch above the bud, to connect with the base of the first cut.

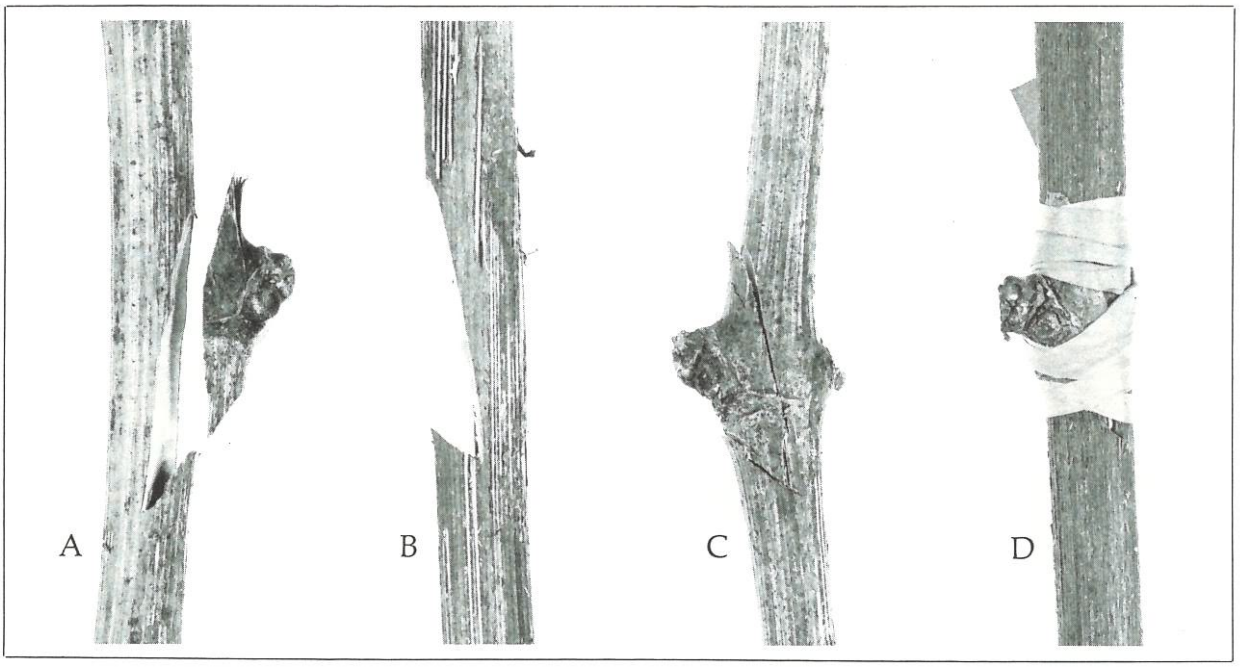

Figure 7. Chip budding grapes.
A) The bud removed from the bud stick.
B) A notch made in the stock to receive the bud.
C) The bud inserted in place.
D) The bud tied in place and ready to be covered with soil.

Place the buds above ground level and tie with rubber budding strips. Cover the budded vines immediately with 6 to 10 inches of loose, moist soil. In the spring, remove the soil mound and cut back the top of the rootstock severely to force growth of the bud. At this time, you can place a loose layer of soil 1 to 2 inches deep over the bud. After the shoot is 2 to 4 inches long, remove the top of the rootstock. To remove the top of the rootstock, make a slanting cut about 1 inch above and away from the bud so that any bleeding of the vine occurs on the side opposite to that of the inserted bud. Cut and remove the budding rubber or tape after the shoot has grown 18 to 24 inches.

Studies have shown that chip budding, when done in the spring and tied with plastic tape, gives good results. If you use this method, it is not necessary to mound soil over the bud. You can also use plastic tape for fall budding, but you may have to force growth of the bud in the spring.

TOP BUDDING IN THE ORCHARD

Although budding is primarily used by nurserymen to propagate fruit trees, a grower can use top budding to change a fruit tree to a different cultivar. The only difference between procedures in the nursery and those in the orchard is that, in the orchard, it is necessary to insert the buds higher in the trees to be topworked, usually in the small branches. If you use late-summer or fall budding to topwork trees, it is necessary to do it earlier in the year in the orchard than in

the nursery. This is true because trees in the orchard do not keep growing as vigorously as do trees in the nursery, making it impossible to lift the bark later in the season.

July is a good time to top bud because well-matured bud wood is available and the bark is slipping easily. If you top bud in July, do not cut back the branch above the bud until growth starts the following spring. Spring budding in March or April is usually less satisfactory than fall budding because the buds and shoots are slower to develop than are those on fall budded trees.

While it is possible to top bud fairly large limbs, it is difficult. If you wish to bud old trees, cut them back the winter before budding to force out new branches in which to place the buds during the summer. It is usually best to top bud only young trees and to use some method of grafting—such as cleft, bark, saw-kerf, or wedge—for larger branches in older trees.

GRAFTING

Grafting consists of inserting a scion (a short section of a shoot of the desired cultivar) into a rootstock plant. As a rule, closely related plants may be grafted one on the other. However, there are many exceptions to this rule. Use table 1 as a guide to the grafting combinations possible among the common deciduous fruit tree species.

SELECTION AND STORAGE OF SCION WOOD

In commercial grafting or budding, it is extremely important to use propagation materials—seedlings and scion wood—that are free of known viruses and that are true to type for the cultivar. When planning to graft old trees known to be infected with viruses, there is no advantage in using wood free of known viruses. In fact, *Prunus* ring spot virus from old stock may kill buds on scions that are free of ring spot. Virus infected stock will spread the virus to the new scions after the graft union has healed.

Collect scion wood for grafting during the winter when the buds are dormant. For some grafting methods, such as cleft grafting, you may use the scion wood immediately; for other grafting methods, such as bark grafting, it is necessary to store the scion wood for several weeks.

To store scion wood, pack it in some damp peat moss or wood shavings and wrap in moist paper, cloth, or burlap. It is important to have the packing material moist, but not too wet; when squeezed, the material should release only a small amount of water. Then enclose the wrapped wood in waterproof paper or a polyethylene (plastic) bag.

It is best to store scion wood at a temperature a little above freezing. A cold box maintained at 32° F. (0° C) is satisfactory for storing wood because this temperature

TABLE 1. GRAFTING COMPATIBILITIES OF COMMON DECIDUOUS FRUIT TREES.

ROOTSTOCK	SCION								
	Almond	Apple	Apricot	Cherry	Peach and Nectarine	Pear	Plum (European and Japanese)*	Quince	Walnut, English
Almond	S	I	U	I	P[2]	I	P	I	I
Apple	I	S	I	I	I	U	I	U	I
Apricot	U	I	S	I	P[3]	I	P[5]	I	I
Cherry:									
Mazzard	I	I	I	S	I	I	I	I	I
Mahaleb or 'Stockton Morello'	I	I	I	P	I	I	I	I	I
Peach	S	I	P	I	S	I	P	I	I
Pear	I	U	I	I	I	S	I	U	I
Plum:									
Myrobalan	U	I	P	I	U	I	S	I	I
'Marianna 2624'	P[1]	U	S	I	U	I	S	I	I
Quince	I	U	I	I	I	P[4]	I	S	I
Walnut:									
Northern California Black or Paradox	I	I	I	I	I	I	I	I	S

S = Satisfactory for grafting.

U = Unsatisfactory for grafting, although grafts may grow for a time.

I = Incompatible combination for grafting; the grafts either do not grow or growth is quite weak and short lived.

P = Partly satisfactory for grafting. Most cultivars grow and fruit normally on this rootstock, although some cultivars and some trees do not make satisfactory or permanent graft unions.

P[1] Some almond cultivars, such as Nonpareil, do not make a satisfactory union with 'Marianna 2624', so an interstock of 'Havens 2B' plum must be used to work such cultivars on this stock. Other cultivars, such as Ne Plus Ultra and Mission, make reasonably satisfactory unions with 'Marianna 2624'.

P[2] Peach trees are short lived and become dwarfed on almond rootstock.

P[3] Many individual peach trees fail to grow well on apricot rootstock, but those that are successful make normal trees.

P[4] Some pear cultivars, such as Bartlett, do not make good unions with quince, although other cultivars, such as Old Home and Hardy, do. Therefore, such cultivars as Bartlett are double worked, using one of the compatible cultivars.

P[5] Some Japanese plum cultivars are compatible with some apricot seedlings. In contrast, most European plums are not compatible with apricot rootstocks.

* In general, many European and Japanese plums may be grafted on most European plums. Although many Japanese cultivars do well on other Japanese cultivars, European cultivars are not successful on Japanese stocks. Peaches, almonds, and apricots may sometimes be grafted on Japanese and European plums with reasonable success, but, as a rule, the grafts either fail to grow or do not grow satisfactorily.

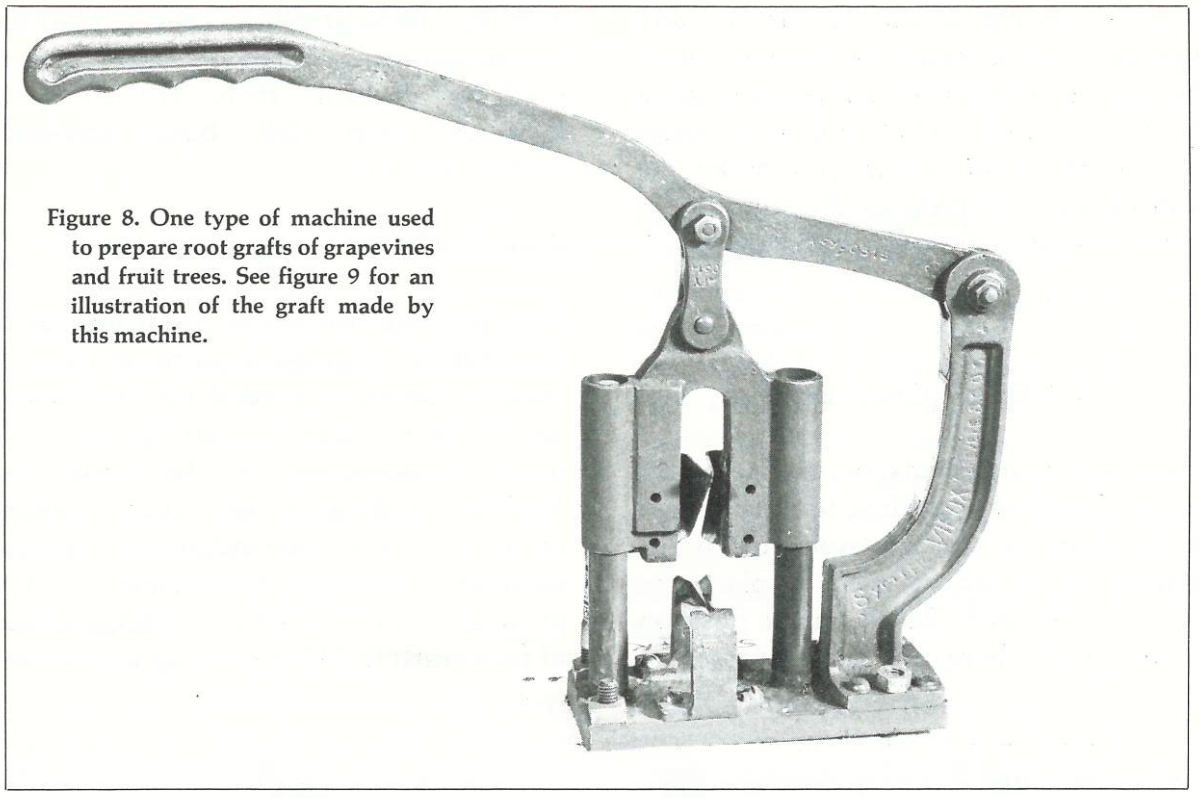

Figure 8. One type of machine used to prepare root grafts of grapevines and fruit trees. See figure 9 for an illustration of the graft made by this machine.

prevents the buds from growing for 3 to 5 months. Household refrigerators, which are usually kept at a temperature of 35° to 38° F. (2° to 4° C), only keep wood satisfactorily for about 2 months. If you plan to store scion wood for a month or less, a cool cellar or similar location is adequate. If the buds start to grow in storage, you cannot use the scion material for grafting.

Shoots that are soft and that have a large pith (the central, soft portion of the stem surrounded by wood) do not make satisfactory scions. Discard these shoots in favor of a more solid type of growth. To eliminate soft, immature growth, it is often necessary to discard the apical one-third, or even more, of each shoot. These precautions apply, in particular, to the English (Persian) walnut.

In grafting, there is less danger of using flower buds in place of vegetative buds than is true in budding. (For more information, refer to the section on "Selection of Bud Wood.") When grafting, you need two or three buds on each scion, so the likelihood of having at least one vegetative bud is greater than in budding where only one bud (or cluster of buds) is present. It is also easier to distinguish flower buds from leaf buds at the time of grafting (in the spring) than at the time of budding (usually in the late summer). Do not use scion wood that has numerous flower buds, especially when propagating cherry.

Most scion wood consists of shoots that have grown for one season. In general, these 1-year-old branches are a suitable size for grafting and have an adequate number of strong vegetative buds. If satisfactory buds are present, you can sometimes use older wood, such as in the grafting of fig trees when the use of 2-year-old scion wood is preferred.

When preparing to cut scions for any type of grafting, start the desired cut at the base of the scion stick after discarding the first ½ inch. This makes it easier to hold the scion while you make the grafting cut and reduces the amount of wood wasted in cutting.

KINDS OF GRAFTING

There are many kinds of grafts, which can be classified according to the position of the graft on the rootstock or to the method or procedure used to place the scion on the stock. Based on the position of the graft, there are three classes of grafting: root grafting, crown grafting, and top grafting. Based on the technique used for grafting, there are six basic methods: whip, cleft, bark, saw-kerf, wedge, and side.

Root Grafting

Root grafting consists of inserting a 3- to 4-inch-long scion on a piece of root. A table or bench is needed for this work, so the term "bench grafting" is often used. Nurserymen in the East and Midwest ordinarily use root grafting because it can be done indoors during cold weather. California nurserymen usually propagate fruit trees by budding instead of root grafting. Whip grafting or machine

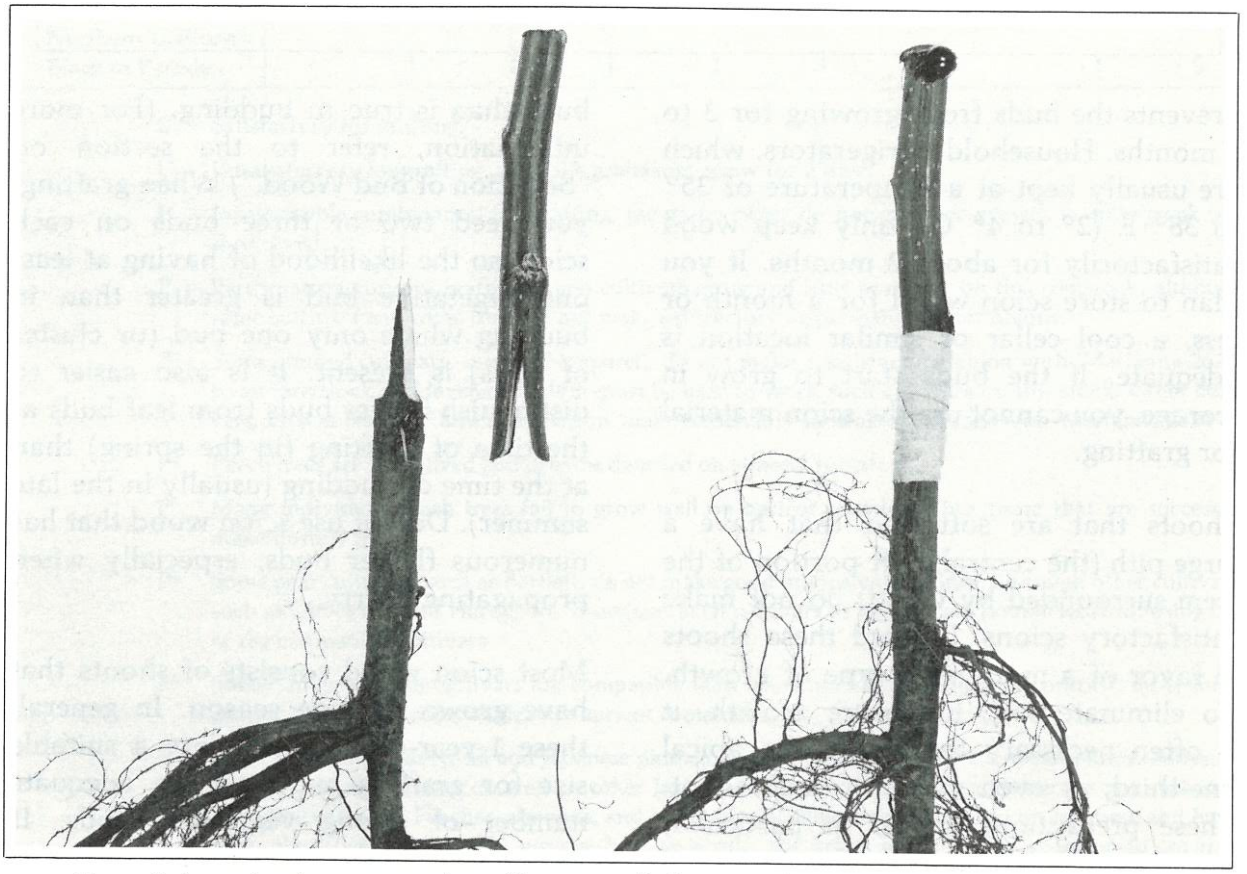

Figure 9. An apple scion on an apple seedling rootstock illustrates the type of graft made by the grafting machine shown in figure 8. After grafting, the union is tightly wrapped with adhesive tape.

grafting is the method commonly used for making root grafts. (See figures 8 and 9.)

Crown Grafting

Crown grafts are made at or just above the crown[1] of the plant. (The crown is the junction of the root and the shoot at the soil line.) In the propagation of walnuts and persimmons, California nurserymen frequently crown graft, using the whip graft method. Growers who decide to change cultivars in a vineyard may crown graft, using the cleft or wedge methods.

Top Grafting

Top grafting is often used to change fruit trees from one cultivar to another. Top grafting and top budding are sometimes called topworking. When top grafting, place the scions in branches no larger than 3 to 4 inches in diameter because it is almost impossible to exclude wood-rotting fungi from large cuts. If you need to topwork large trees, place the grafts high in the trees where the branches are 3 to 4 inches in diameter. This procedure is more expensive because it requires more grafts, but it minimizes the possibility of trunk decay occurring at the graft union. However, topworking has the disadvantage of leaving more branches that must be kept free of fruiting wood of the original cultivar. On the other hand, trees where grafts are high in reasonably small branches usually start bearing sooner than do trees where grafts are closer to the ground.

Trees that have been cut back heavily are susceptible to sunburn damage. Use a white, water-base (not oil-base) paint to help protect the trunks and limbs of grafted trees until the new top provides shade.

Leave a limited number of small shoots below the grafts on topworked trees to help protect the tree from sunburn and also to manufacture some food for the roots until the grafts are large enough to take over this function. Cut back the shoots to keep them reasonably small. Also cut back any watersprouts that appear. Later, completely remove these shoots and watersprouts. See figure 10 for an example of a typical top grafted tree.

When grafting broadleaved evergreen trees, such as citrus and olives, leave a few branches to serve as nurse limbs until the new tops are well established; then remove the nurse branches. Retaining such nurse limbs may also be helpful when grafting deciduous fruit trees in California.

The time to top graft trees depends on the method used. In California, the preferred times for cleft, saw-kerf, whip, and side grafting are January, February, and sometimes March. It is possible to graft earlier in the winter, but it is not recommended because the scions may dry out before bud growth starts. Bark grafting is possible only in the spring after the bark of the stock has begun to slip.

When grafting trees that "bleed," such as walnuts, make slanting cuts at the base of the trunk to allow the bleeding to occur in this area rather than at the graft union. (See figure 26.)

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[1]The term crown has various meanings in plant terminology. It can refer to the top of a tree, or the branching part of a grapevine at the top of its trunk, or—as used in this publication—to the junction of the root and the stem.

METHODS OF GRAFTING

Whip Grafting

Make a sloping cut 1½ to 2½ inches long at the base of the scion and at the top of the stock. (See figures 11 and 12.) Adjust the size of the cuts to the size of the branches or roots you are grafting; make the longest cut on the piece that has the largest diameter. Make a reverse cut ½ to ⅞ inch long on each of the cut surfaces, about one-third the distance from the tip. Make this second cut partly parallel to the first cut; not with the grain of the wood. However, if the first cut is long enough, you can make a reasonably satisfactory graft even though the second cut follows the grain.

Figure 10. A topworked tree just after completion of grafting. The graft union has been waxed and the entire tree covered with white, interior, latex paint (diluted 1:1 with water) to prevent sunburn.

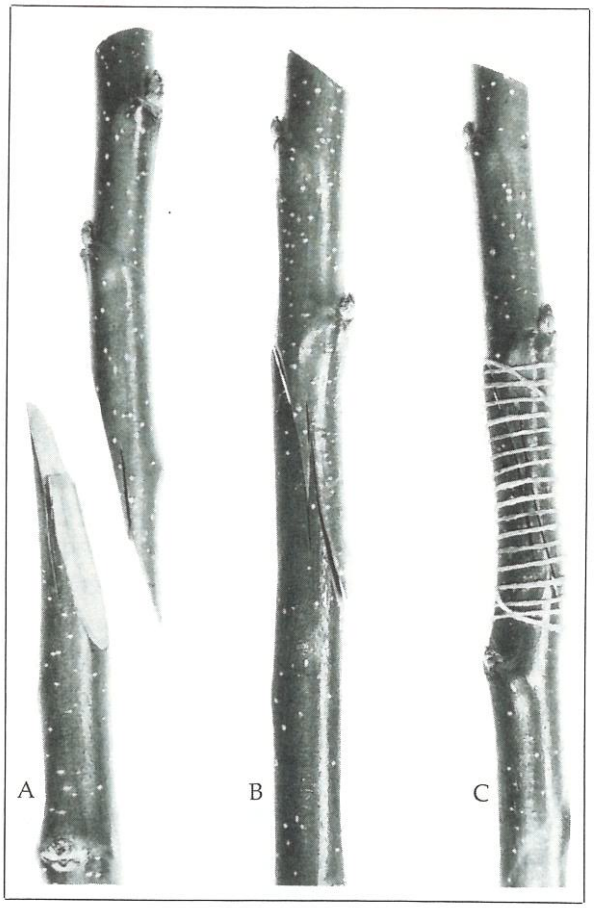

Figure 11. Whip grafting.
A) The stock and the scion correctly prepared for grafting.
B) The stock and the scion fitted together.
C) The completed graft wrapped with light twine. If topworking where the graft union is above ground, thoroughly wax the union or wrap it with adhesive tape.

Fit the cut surfaces of the two pieces together and wrap them with nurseryman's adhesive tape, plastic tape, or a light twine dipped in melted grafting wax. The various materials you can use for wrapping whip grafts have advantages and disadvantages; nurseryman's tape is considered best for most situations.

If the soil temperature is about 50° to 60° F. (10° to 16° C) and callusing (healing) of the graft union occurs, you can plant apple and pear root grafts

immediately. If you do the work in mid-winter when the nursery soil is too cold for good callusing, store the grafts until early spring in moist sawdust, wood shavings, or a similar material at about 50° to 60° F. (10° to 16° C). Handle the stored root grafts carefully so you do not disturb the graft union; otherwise a good callus connection may not occur. Plant the grafts deep enough so that only the upper bud of the scion is above ground.

Grapes are sometimes whip grafted to rootstocks resistant to phylloxera or root-knot nematodes. Instead of using root pieces, it is common to use disbudded cuttings, 12 to 15 inches long, of the rootstock cultivar. Cover recently grafted grapevines with moist soil 3 inches deep to prevent drying out (as described for chip budded vines, page 24).

The above information primarily applies to root grafting. However, whip grafting can also be used for crown grafting or for top grafting trees that have small branches, ⅜ to ⅝ inch in diameter.

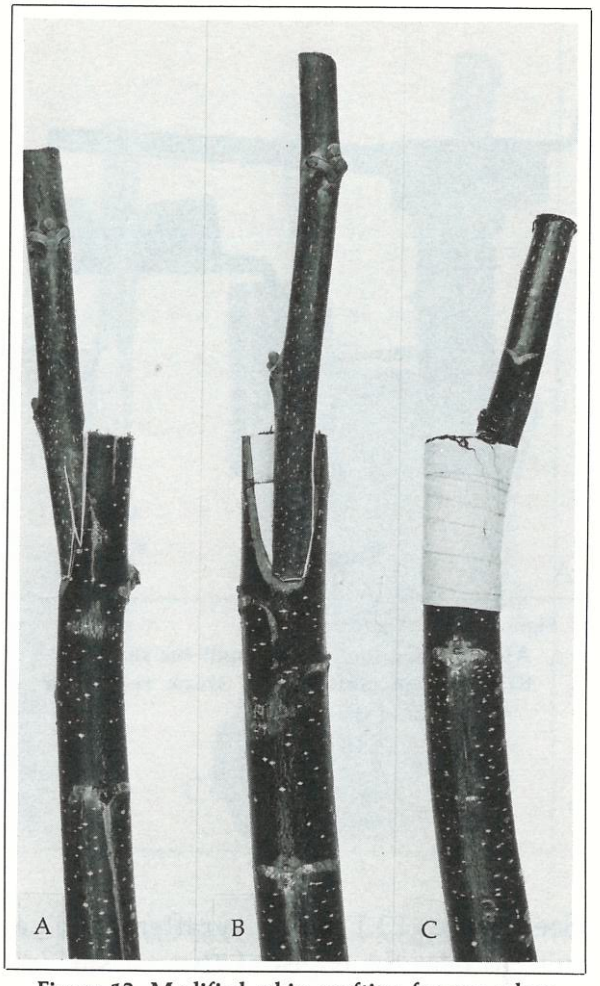

Figure 12. Modified whip grafting for use when the stock is considerably larger than the scion.
A) Side view of the prepared graft.
B) Front view of the prepared graft.
C) Completed graft wrapped with nursery-man's tape and cut surfaces waxed. When the stock and the scion are not the same size (view B), it is impossible to match the cambiums of the stock and the scion on both sides. Therefore, fit the scion into the stock so that the cambiums come together on one side.

Cleft Grafting

This method of topworking trees is used more frequently than are all the other methods combined. Cleft grafting is best done toward the end of the dormant season. However, if necessary, the work can be continued after the stock has begun to grow if the scions are kept dormant by storing under refrigeration.

To cleft graft, first saw off the tops of the limbs to be grafted. Then split the branches of the stock down the center. (See figure 13.) For splitting branches, use either a thin chisel, an old kitchen knife, or a special tool that has a concave blade designed to cut the bark first and so prevent peeling. Regardless of the type of tool you use, drive it 1½ to 2 inches into the wood to split the stock. Then remove the tool and drive a narrow wedge, such as a heavy screwdriver or a wood chisel, into the center of the cleft to hold it open while you insert the scions. A wedge is often part of most splitting tools.

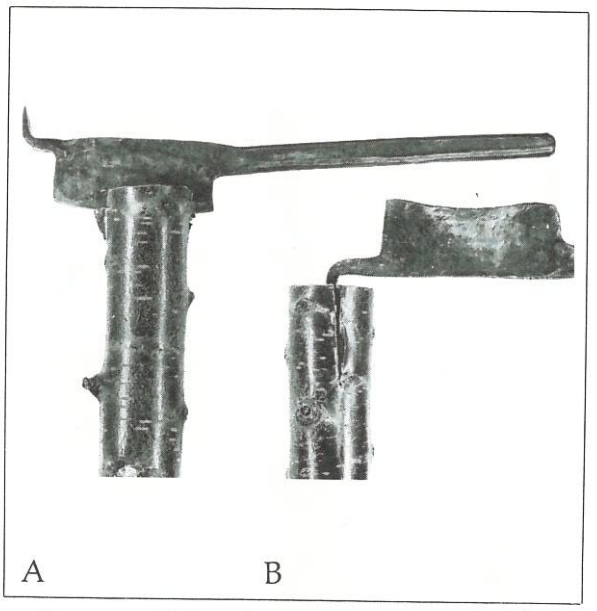

Figure 13. Cleft grafting.
A) A grafting tool used to split the stock.
B) The open cleft in the stock ready for insertion of the scions.

(See figure 13.) Some grafters use a knife to trim the edges of the cut surface of the limb, but this procedure is necessary only when rough cuts are made.

In general, use 1-year-old wood of the desired cultivar as a source of scion wood. Select scions that are 3 or 4 inches long and that contain no more than two or three buds. (See figure 14.) Cut each scion in a wedge shape so the outer edge is slightly thicker than the inner one. This unequal cutting ensures contact between the cambium of the stock and the cambium on the outer part of the scion. Good contact of the cambiums is essential to obtain satisfactory healing of the graft union.

Figure 15 (B) shows part of the stock cut away and the scions inserted in the correct position. Note that the cambium on the

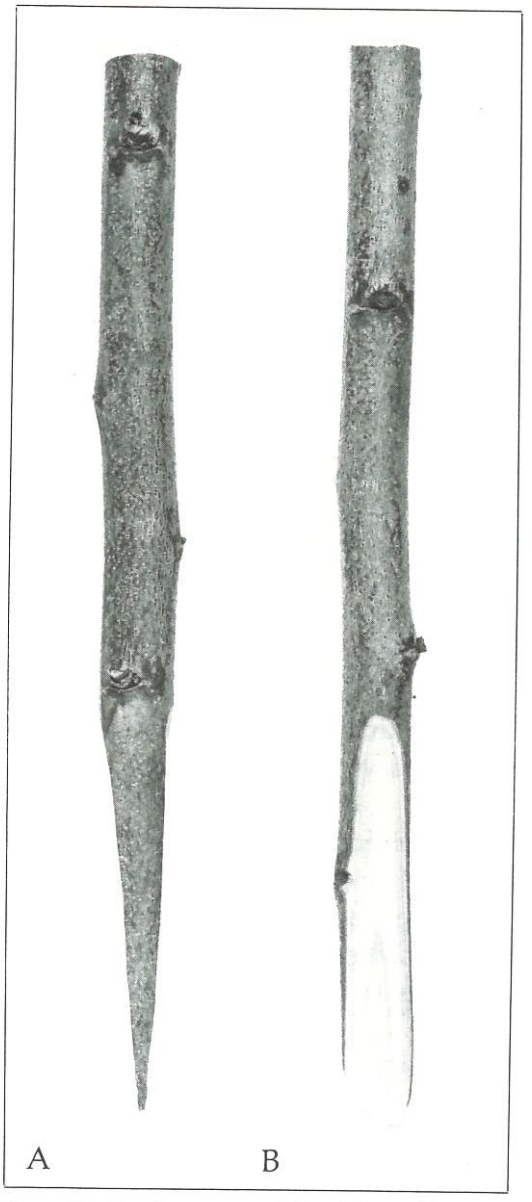

Figure 14. A scion prepared for cleft grafting.
A) Side view of the prepared scion. Note that the lower end of the scion is cut in a wedge shape so the outer edge is slightly thicker than the inner one. This shaping ensures contact of the cambium layers. The lowest bud is on the outside edge of the scion just above the top of the wedge-shaped cut.
B) The side of the scion that rests against the wood of the stock.

inner side of the scion does not touch the cambium of the stock. If you accidentally place the thick side of the scion to the inside of the stock, it will hold the cleft open and prevent contact between the

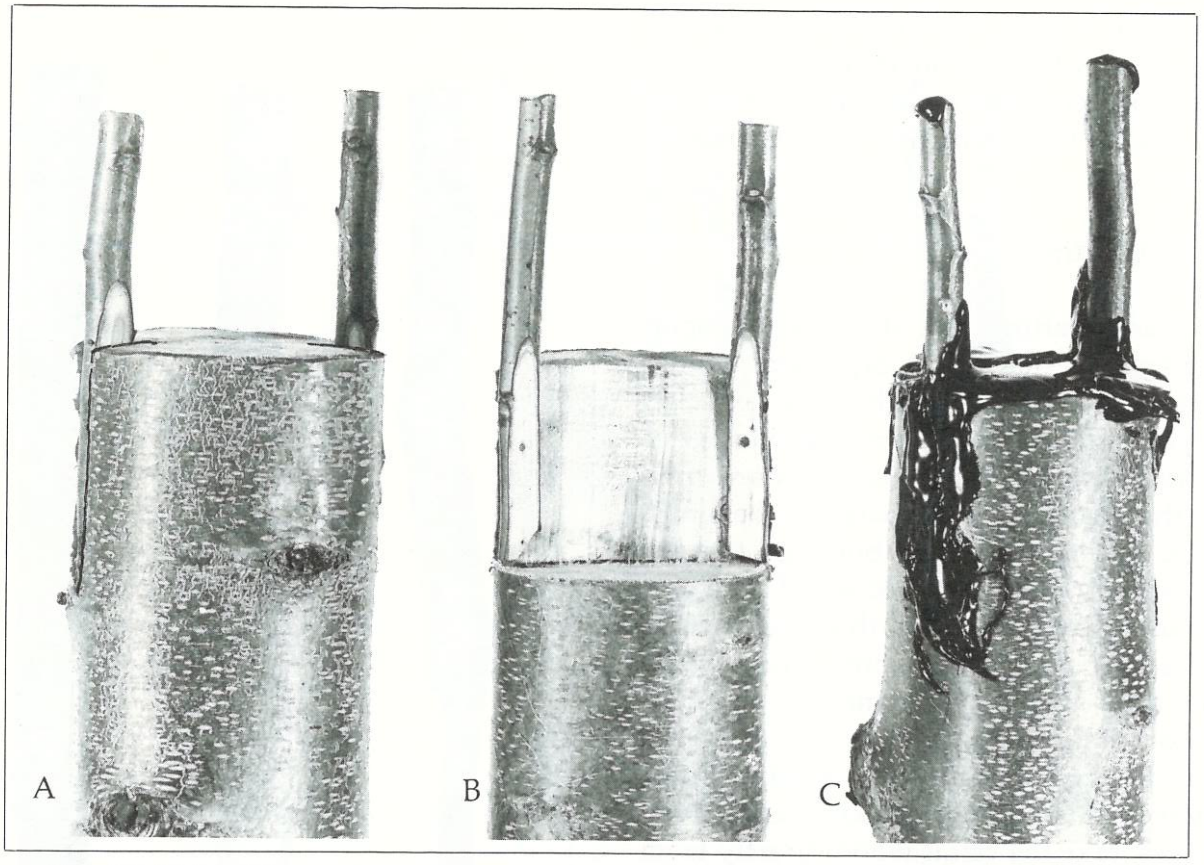

Figure 15. Cleft grafting.

A) The scions inserted in place.

B) Part of the stock removed to show how the cambiums of the stock and the scion are brought into contact with each other. The scions are placed at a slight outward slant to make sure the cambiums touch in at least one place.

C) The completed graft covered with wax.

cambium of the scion and that of the stock. If scions are correctly placed in thick-barked limbs, they are not flush with the surface of the stock branch; they are inside the branch a distance almost equal to the thickness of the bark of the stock so the cambium layers make contact.

Figure 15 (A) shows the wedge removed and the two scions in place. All cut surfaces, including the tops of the scions, are then waxed over (figure 15, C). By making more than one cleft, it is possible to place more than two scions in one stock branch. However, this is rarely done because it tends to reduce the tension placed on the scions. If more than two scions seem desirable, use the bark graft or the saw-kerf graft method.

Cleft grafting has several advantages: it is easy to do; it holds the scions tightly in place; it may be done successfully over a period of 2 to 3 months; and it is done when the scion material is dormant, which allows collection of scion wood at the time of grafting. The main disadvantage of cleft grafting is that wood-decay organisms may get into the cleft.

Cleft grafting results in scions that are more strongly attached to the stock during the first year than occurs when bark

grafting is used. However, after several years' growth, both methods result in the development of new wood at the graft union, so the scions are held securely in place.

Bark Grafting

In bark grafting, the stock is not split. This means that decay organisms cannot enter the wood as easily as when cleft grafting is used. The main disadvantage of bark grafting is that it can be done only in the spring after the bark has begun to slip. By that time, the buds are usually opening on the 1-year-old wood commonly used for scions. For this reason, it is necessary to gather scion wood while the trees are still dormant and store the wood moist at a temperature of 32° to 36° F. (0° to 2° C) until grafting time. However, when topworking citrus and olives, take the scion wood directly from the tree at the time of grafting—March and April in California.

Several variations of the bark grafting method are in use, but only three of these methods are discussed in this section. However, if the work is carefully done, all methods give satisfactory results.

Method 1. When using this bark grafting method, cut the scions as illustrated in figure 16. However, you can make slight modifications in the way you cut the scion, especially in the size of the shoulder. If you use nails to hold the scion in place, cut a narrow shoulder on the scion to reduce the thickness. This procedure prevents the stock bark from being pushed out too far when you insert the scion. If you use waxed cloth, tape, or string to hold the scion in place, the shoulder may help keep the scion in position. Small scions may be made with

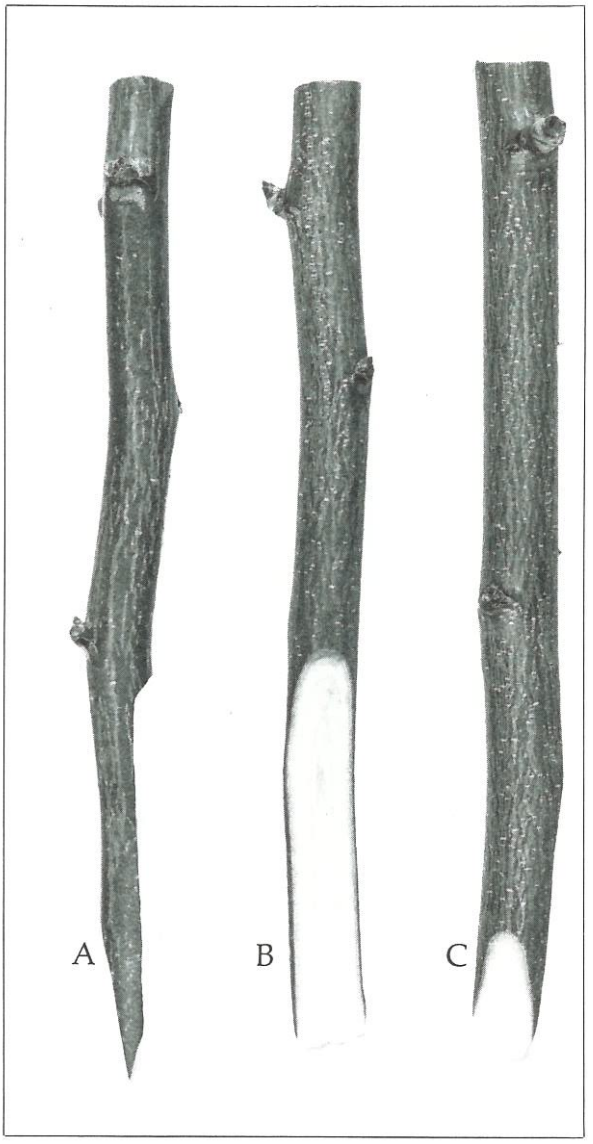

Figure 16. Bark grafting.
A) Side view of a prepared scion.
B) The side of the scion that rests against the wood of the stock.
C) The side of the scion opposite to that shown in view B.

little or no shoulder; large ones require a shoulder larger than that illustrated. Be careful not to make the scions too thin; they may break off after growth begins.

Make the slit in the bark of the stock just long enough so you can push the scion into place without splitting the bark. (See figure 17.) Place the scion in the center of

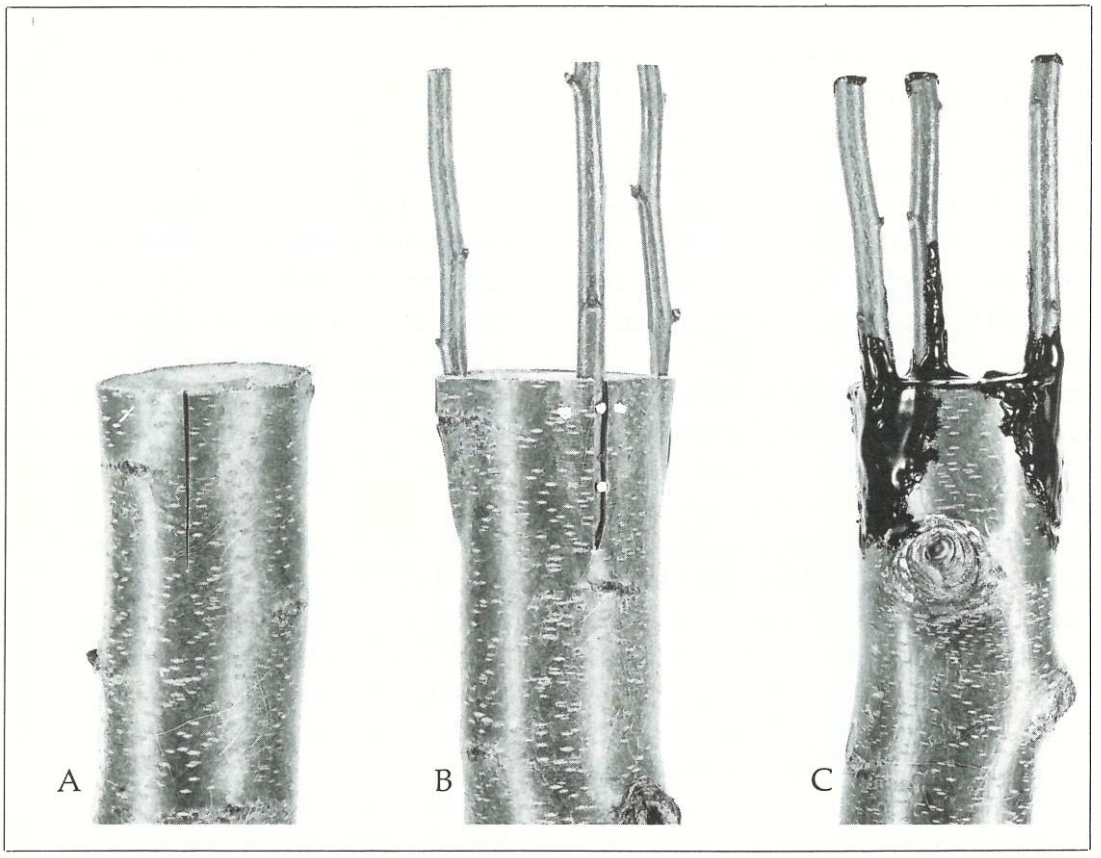

Figure 17. Bark grafting.
A) A vertical cut made through the bark and into the wood.
B) The scions placed directly under the cuts and nailed in place.
C) The completed graft covered with wax.

the slit. As a rule, drive one nail through the scion and one through the bark of the stock on each side of the scion. Then insert an additional nail through the lower part of the scion.

It is recommended that you use nails in bark grafting. The size nails to use depends on the size of the scion wood. When bark grafting most deciduous fruit trees, except walnut, #20 flat-headed, wire nails 5/8 to 3/4 inch long are satisfactory. The large walnut scions usually require #19 flat-headed, wire nails that are 1 inch long.

If desired, you can use waxed cloth, tape, or string wrapped tightly around the stock to hold the scions in place. After completing the graft, immediately cover all cut surfaces, including the tops of the scions, with hot or cold grafting wax.

Method 2. Cut the scions as illustrated in figure 16, except do not center the shorter cut on the back of the scion. Make the shorter cut near the edge of the scion opposite the side that rests against the undisturbed bark of the stock. This uneven cutting allows the raised flap of bark to fit more smoothly on top of the scion.

Make the slit in the bark of the stock just long enough to allow you to push the scion into place. Raise the bark on only

one side of the slit, as shown in figure 18. Insert the scion under the raised bark so that one edge rests against the undisturbed edge of the slit. Place two nails through the scion and the raised flap of bark to hold the scion in place. Then drive one or two more nails through the bark into the wood of the stock near the scion to pull the bark tightly into place.

You can sometimes substitute a heavy staple, put in vertically, for the nails. The use of staples can increase speed, but do not place them horizontally across the scion because it will girdle the scion. On occasion, you may accidentally loosen the bark after grafting has been completed. If this occurs, fasten it with a nail or two.

Method 3. There is evidence that this method, which does not require a shoulder on the scion, is the most satisfactory one, since both edges of the scion rest against undisturbed cambium. You can prepare the scions for this method more rapidly than for the first two methods because you do not need to make a shoulder. However, it takes more time to make the two cuts in the bark the correct distance apart than it does to make one cut. (See figure 19.)

Make two vertical cuts in the bark of the stock. Make the cuts the width of the scion apart and just long enough so you can push the scion into place without splitting the bark. Raise the strip of bark between the two cuts and remove the upper one-third to one-half. However, if you use small scions, retain the entire strip of bark to protect them. If the bark of the stock is unusually thick, you can sometimes force small scions under the bark without making the two vertical cuts in the bark.

Insert the scion far enough under the bark so that only a little of the cut surface extends above the top of the stock. Place the scion so the lower bud is on the outside of the stock only a short distance above the top. The shoots that arise at this point are favorably located for strong attachment and will grow in the correct position. Use two nails to hold the scion in place. Drive the upper nail directly into the scion; drive the lower one through the strip of bark first, then through the scion and into the stock.

Most bark grafting is done on moderate size stock branches, but this method can be adapted to quite small branches. When bark grafting small branches, use a curved chisel to make the inner surface of the scion concave so it fits around a small branch.

Saw-Kerf (Notch) Grafting

Saw-kerf grafting has the same advantage as cleft grafting: you can do the work during a considerable length of time. However, it is best to do most notch grafting in January, February, and March. Since the stock is not split, there is less danger of wood-decay organisms entering the stock than when cleft grafting is used. In addition, you can use this method to graft curly grained stock branches, which you cannot split correctly for cleft grafting. Despite these advantages, saw-kerf grafting is used less commonly than are cleft and bark grafting, probably because the saw-kerf graft requires somewhat more skill than do the other methods.

To make a saw-kerf graft, cut a rather deep notch that extends approximately to the center of the stock branch. (See figure 20.) Use a fine-toothed saw to make the cut. Then use a round-bladed knife

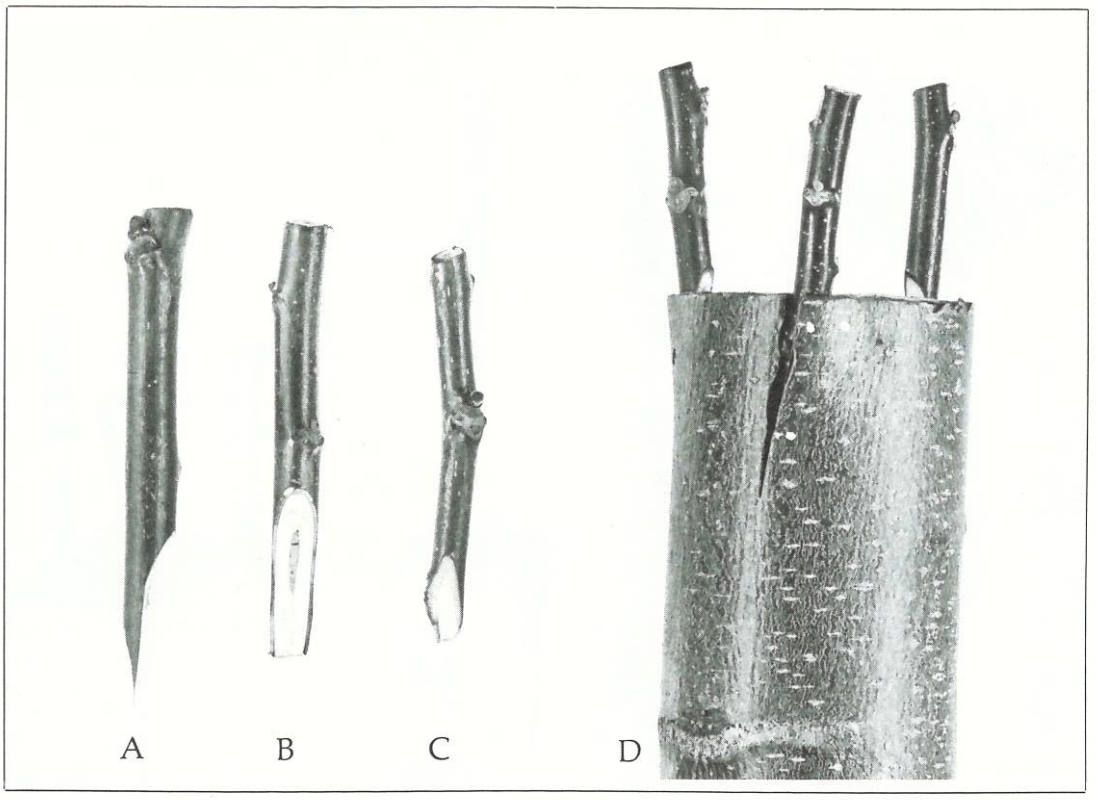

Figure 18. A second method of bark grafting.
A) Side view of a prepared scion.
B) The side of the scion that rests against the wood of the stock.
C) The side of the scion opposite to that shown in view B.
D) Scions inserted and nailed in place. After inserting the scions, thoroughly wax all exposed cut surfaces, including the tops of the scions.

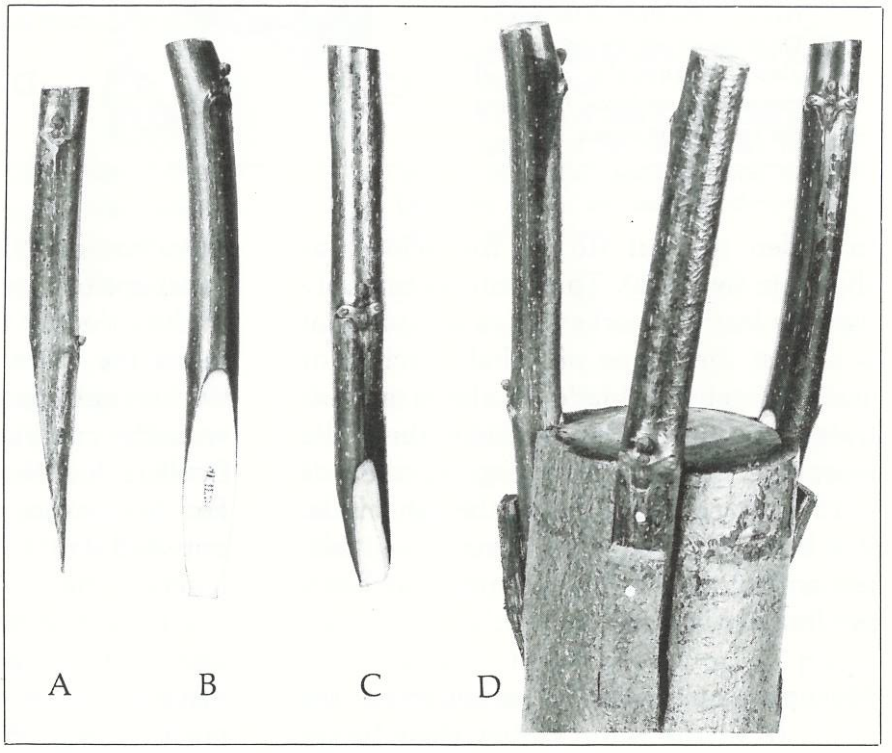

Figure 19. A third method of bark grafting.
A) Side view of a prepared scion.
B) The side of the scion that rests against the wood of the stock.
C) The side of the scion opposite to that shown in view B.
D) After the scions are inserted, thoroughly wax all exposed cut surfaces, including the tops of the scions.

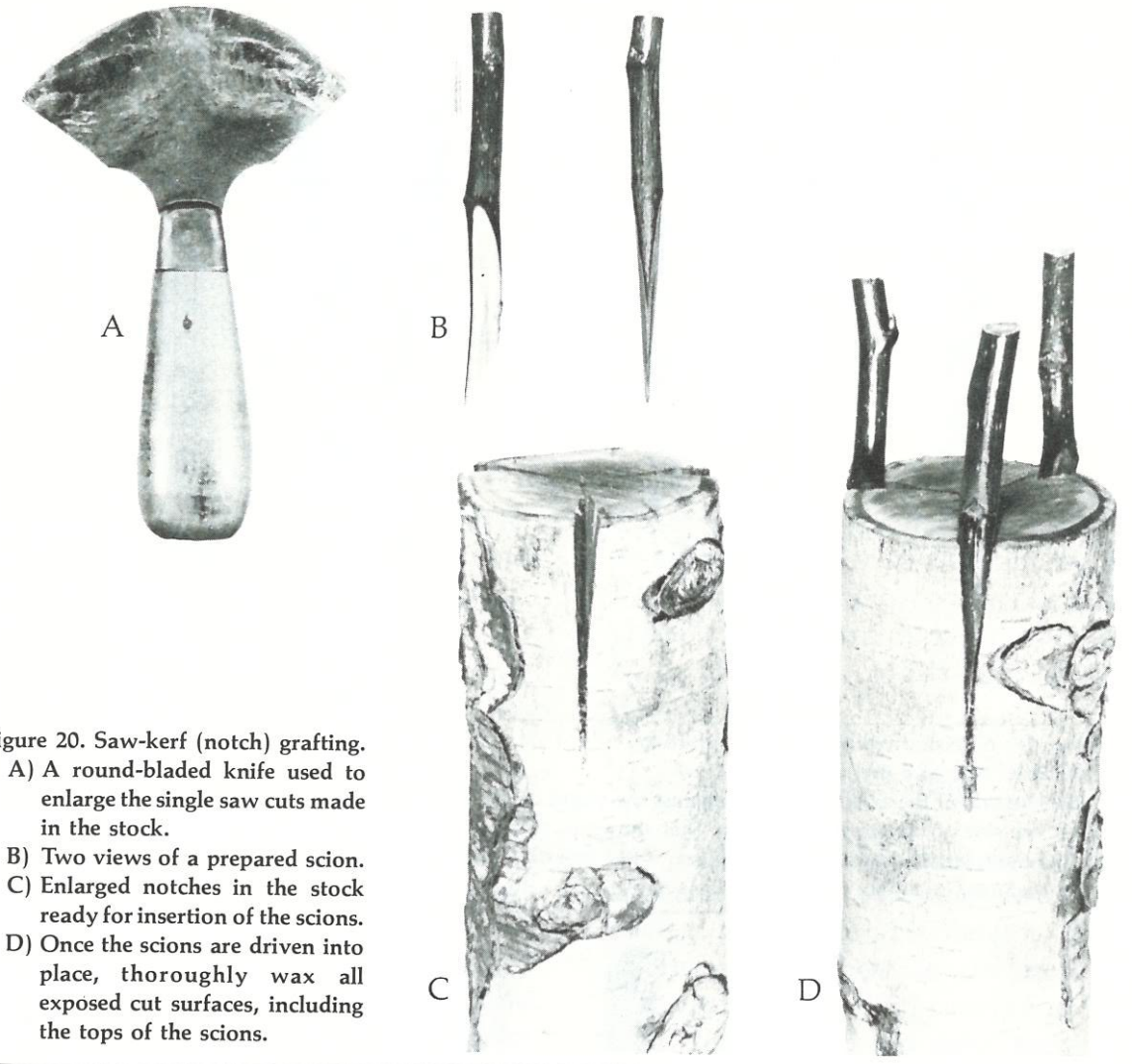

Figure 20. Saw-kerf (notch) grafting.
A) A round-bladed knife used to enlarge the single saw cuts made in the stock.
B) Two views of a prepared scion.
C) Enlarged notches in the stock ready for insertion of the scions.
D) Once the scions are driven into place, thoroughly wax all exposed cut surfaces, including the tops of the scions.

to widen the cut (to fit the scion), as shown in figure 20. This knife, commonly used by leather workers, has a blade that is almost the shape of a half circle. For grafting, cut the blade to the size illustrated in figure 20. To make the knife more effective for grafting, grind one side of the blade flat and bevel the other side. If a round-bladed tool is not available, use an ordinary grafting knife that has a moderately large blade.

Most propagators find it easier to cut the notch to fit the scion rather than to cut the scion to fit the notch. Cut the scion in the shape of a wedge; make the outer edge slightly thicker than the inner edge. Then insert the scion so the cambium on the thicker, outer edge is brought into contact with the cambium of the stock. It is difficult to line the cambiums up perfectly. For this reason, place the scion on a slight outward slant to ensure that the cambium layers of the scion and the stock cross and touch each other in at least one place. Use a small, plastic-tipped hammer to drive the scion carefully but firmly into position by tapping the top of the scion.

Wedge Grafting

Wedge grafting is used for the same reasons as cleft or saw-kerf grafting. Wedge grafting is easier than saw-kerf grafting and gives good results.

Remove a piece of wood the shape of a long, tapering wedge from the top of the stock. (See figure 21.) Drive a heavy bladed, strong, sharp knife into the stock from the side to make two slanting cuts that come to a point at the back, or inside, of the stock. Remove this wedge of wood and bark by tapping a sharpened screwdriver downward between the two cuts at a depth a little greater than the size of the scion to be inserted. Cut the base of the scion to a pointed wedge the same size and angle as the wedge you remove from the stock. (See figure 21.) Make the wedge cuts long enough so that, when you tap the scion into place, the scion is held securely. If the wedge is correctly made, you can tightly wedge the scion into place without using nails. After inserting the scion, cover it with grafting wax.

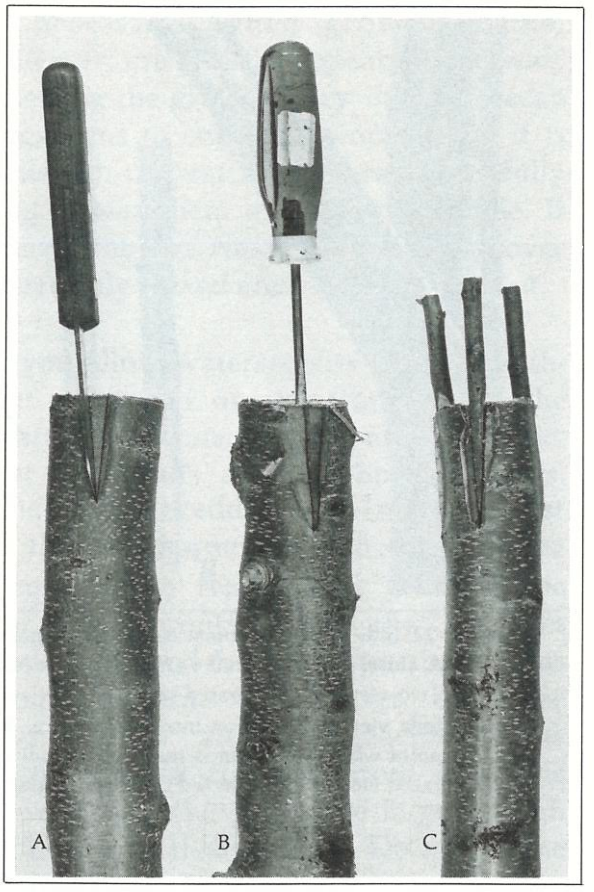

Figure 21. Wedge grafting.

A) A heavy, sharp knife pounded into the side of the stock to form a wedge-shaped piece of wood.

B) A screwdriver driven downward to knock out the wood piece.

C) The scions, each of which has a long, tapering wedge cut at the bottom, are tapped into place so the cambium layers match. Once the scions are inserted, thoroughly wax the graft union.

Side Grafting

Side grafting is used less commonly than are those methods already discussed. However, side grafting is easy to do and gives good success. The graft is usually made as shown in figure 22, but there are many possible modifications, including some that require special tools. Side grafting is most useful for branches about 1 inch in diameter—branches too large for satisfactory whip grafting, but too small for cleft, bark, saw-kerf, or wedge grafting.

Use a chisel or heavy knife to make the slanting cut in the stock. Make a wedge-shaped cut at the base of the scion; make the cut similar to, but shorter than, the cut you would make for the cleft graft. For best contact of the cambium layers of the stock and the scion, insert the scion as shown in figure 22. Bend the stock branch to open the cut and insert the scion. Although the tension of the wood usually holds the scion in place, you can use small nails or string for added support.

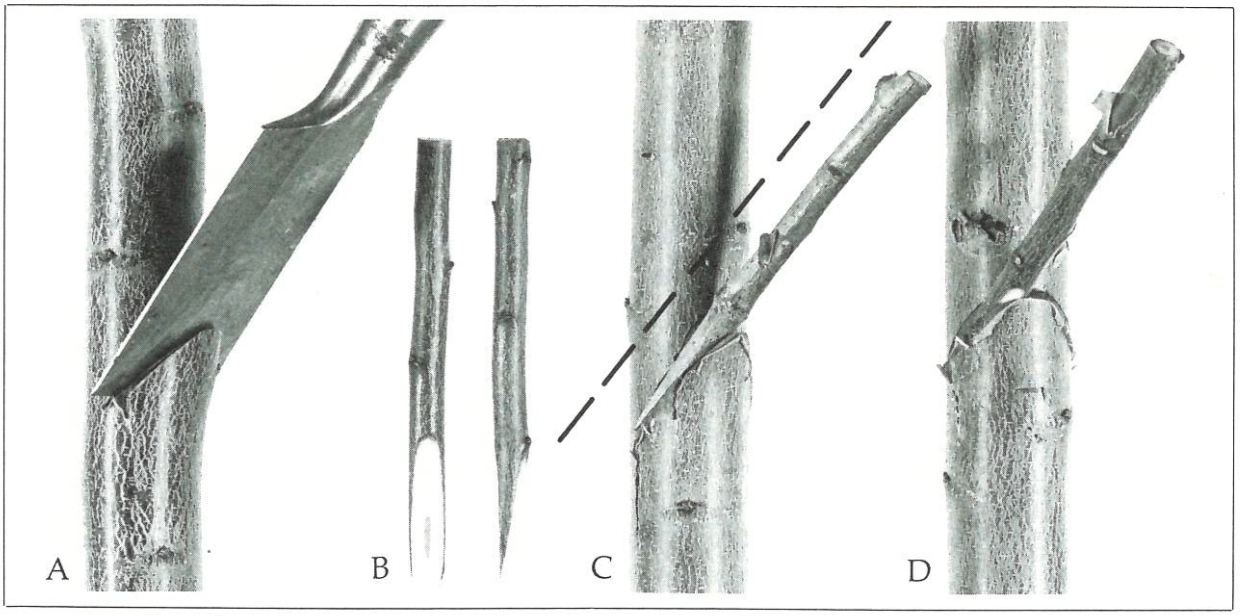

Figure 22. Side grafting is most useful on branches about 1 inch in diameter.

A) A chisel is used to make an oblique cut in the stock.

B) Two views of a prepared scion.

C) Side view of the scion inserted in place. To remove the branch above the graft, cut just above the point where the scion is inserted, as indicated by the broken line.

D) Front view of the inserted scion. After the scion is in place, thoroughly wax all exposed cut surfaces.

Cut off the stock branch at an angle just above the point where you inserted the scion. (See dotted line in figure 22, C.) Carefully cut off the top of the stock branch to avoid dislodging the scion. After removing the top of the stock, wax all cut surfaces on the stock and the scion.

Sometimes the propagator may prefer to place a side graft on the side of a rather large branch. Use a chisel or saw to cut a diagonal slit through the bark of the stock and a short distance into the wood. Drive the scion into place at an angle to the vertical, similar to the angle shown in figure 22 (D). By inserting the scion at an angle, it allows the cambium layers of the stock and the scion to touch.

Three to four weeks after side grafting, severely cut back the grafted branch or tree to force the buds on the scion into growth after the union has healed.

CARE OF TOPWORKED TREES

The care of the tree during the first few years after grafting is as important as the grafting operation itself. Once grafting is completed and the graft union thoroughly covered with grafting wax, use a white, interior, water-base paint diluted 1:1 with water to paint the entire area around the graft union, including the scions, waxed areas, and the exposed trunk below the graft union. White paint prevents sunburning and is more satisfactory for that use than is a whitewash compound. Do not use oil-base paints; they injure the trees. If you use a water emulsion of asphalt instead of a hot wax, allow it to dry before applying the paint.

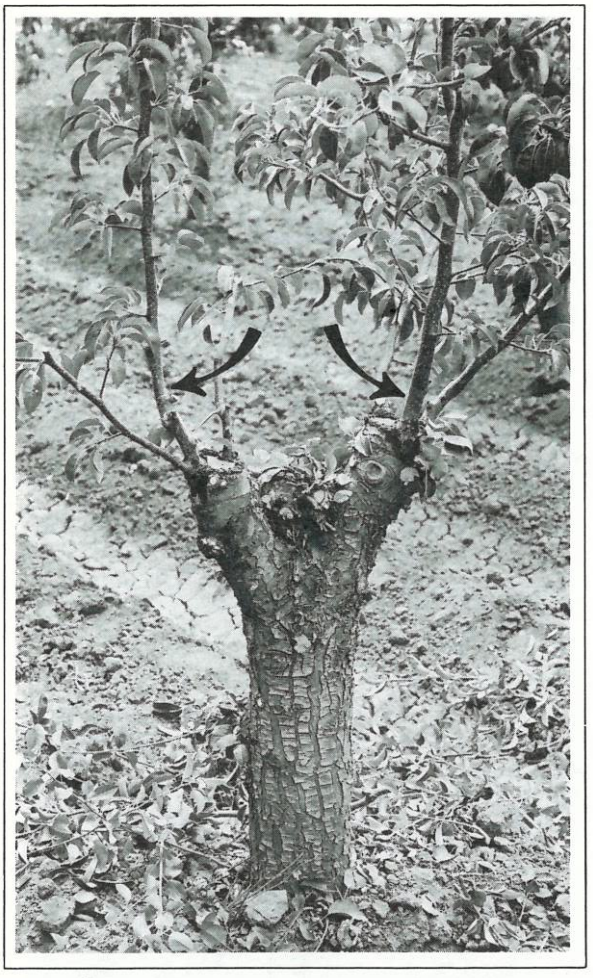

Figure 23. A top grafted tree. On each of the two grafted limbs, one shoot is selected to become the permanent branch (as indicated by the arrows). All other shoots that arise from the scions are pruned back to retard growth. Extra shoots are allowed to remain temporarily to aid in the healing of the graft union; then these shoots are removed.

To protect the scions from the sun, you can place paper bags with holes cut in the corners for ventilation over the grafts. However, experiments have demonstrated that a coating of white water-base paint provides more effective protection than does the use of paper bags.

From the time the grafts are completed until the trees start growing, all you need to do is to inspect the grafts from time to time and re-wax cracked areas if necessary. When growth begins, however, cracks will appear in the wax, allowing the grafts to dry out and decay organisms to enter the wood. Then it is essential to watch the grafts carefully and re-wax them as soon as possible. If considerable re-waxing is required, cover the freshly waxed areas with white paint.

If you allow watersprouts to grow without restriction on the trunk below the grafts, the watersprouts usually choke out the shoots arising from the grafts. The best procedure is to remove most of the watersprouts and to cut back the remainder to retard their growth. The cut watersprouts shade the branches and trunk and help protect these areas from sunburn. The leaves on these watersprouts also manufacture some carbohydrates for the roots until the shoots from the grafts are large enough to take over this function. Do not let the watersprouts become too large; remove them completely when the scions are growing vigorously.

If more than one scion grows on a grafted branch, it is probably best to retain only one permanent scion. If more than one permanent scion is allowed to grow, it is likely to lead to the formation of a weak crotch. To encourage growth, lightly prune, or do not prune at all, the shoots from the scion you want to keep. Heavily prune scions you plan to remove later to prevent them from becoming too large. (See figure 23.) The suppressed shoots from the growing scions help the stock (grafted limbs) heal over. Once healing of the graft union has taken place, remove the scions you do not want.

If only one of two or three scions grows, the tissues on the square shoulder of the stock opposite the growing graft will die

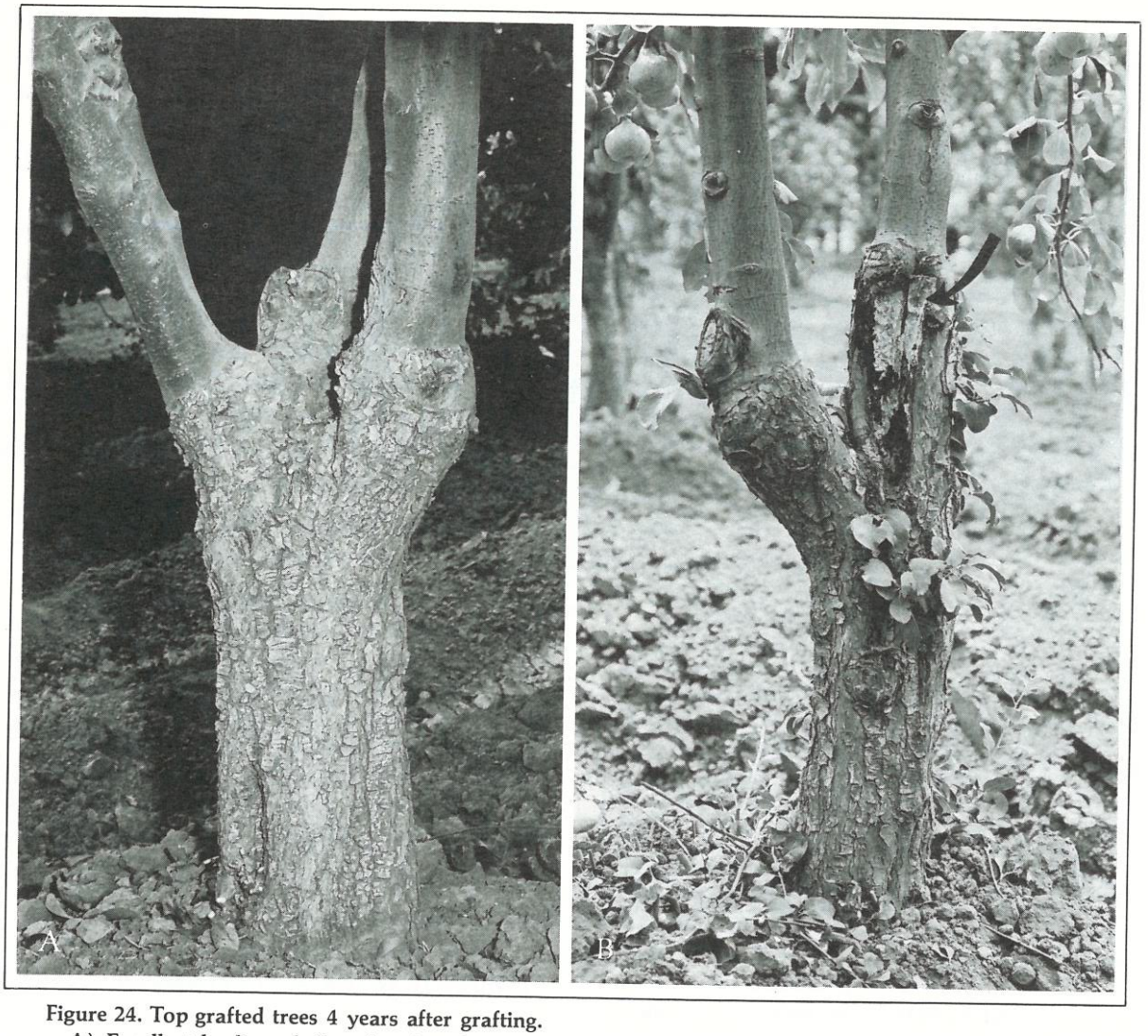

Figure 24. Top grafted trees 4 years after grafting.
A) Excellent healing of all graft unions has occurred.
B) On this tree, the graft union of one of the limbs healed poorly (see arrow) and considerable decay developed in the center of the tree just below the graft union.

and probably decay before healing over. (See figure 24.)

You can promote more rapid healing by making a cut that slopes downward and away from the side where the scion is growing. Thoroughly wax the cut surface. If shoots develop on the stock where grafts fail to grow, cut back the shoots, but use them (as discussed for extra scions) to encourage healing of the stump. Completely remove extra shoots when they are no longer needed.

During the first few years, it is often necessary to provide support for vigorously growing young shoots that arise from the scions. To provide this support, use strips of wood nailed to the tree. (See figure 25.) You may not need to provide support for grafts that have made only a small or moderate amount of growth. If the use of supports is considered uneconomical, and the shoots from the grafts are extremely vigorous, the best procedure is to remove a few inches from the ends of the shoots after

Figure 25. Young shoots that arise from the grafts are supported by tying them to wooden stakes nailed to the trunk. This support prevents the shoots from breaking in strong winds.

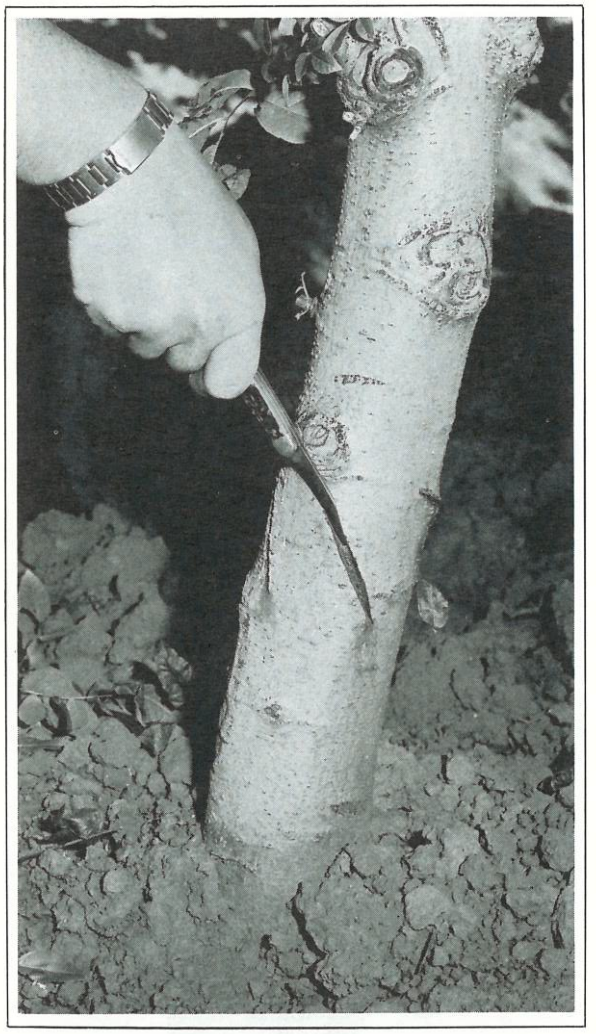

Figure 26. Top grafting trees of some species, such as walnuts, may lead to profuse bleeding at the graft union. Bleeding is most likely to occur when grafting is done in the spring, the period of active tree growth. Bleeding inhibits the production of callus and the healing of the graft union. To prevent bleeding, use a saw or knife to make a series of diagonal, slashing cuts into the wood around the base of the tree. These cuts cause the bleeding to take place in the cut area rather than at the graft union.

they have grown about 18 inches. Pinching back at a later date may also be desirable, as it retards terminal growth and induces branching. Pinching back also allows the succulent shoots to mature somewhat and thus keeps them from breaking or bending. If necessary, thin out some of the shoots to reduce wind resistance.

Bleeding at the graft union is a problem in some species, such as walnuts and grapes. You can prevent bleeding by using the procedure illustrated in figure 26.

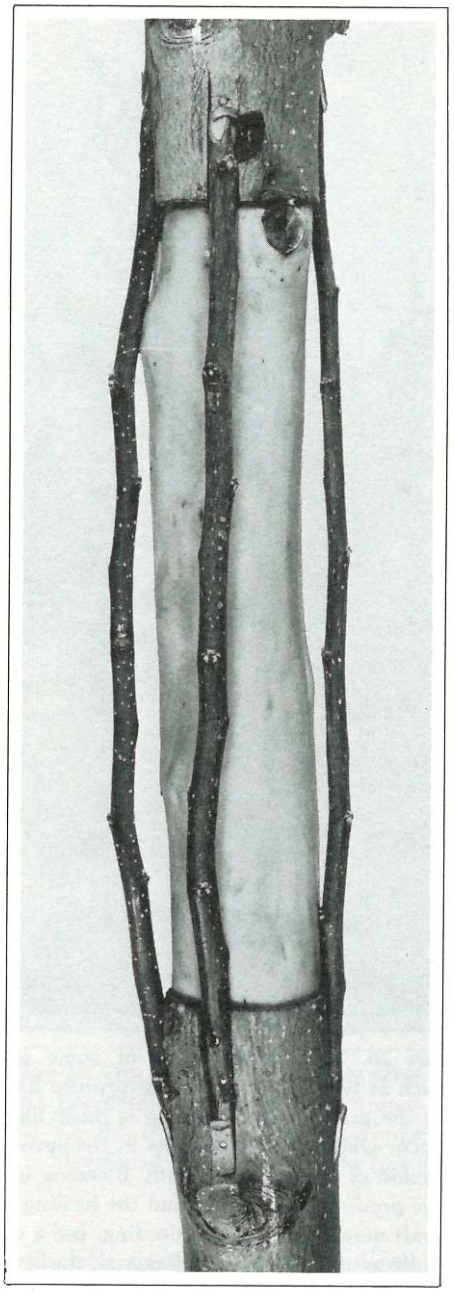

Figure 27. Bridge grafting scions in place. The graft unions at the top and the bottom of the injured area are prepared as described for bark grafting (page 36). The area where the scions are inserted into the bark must be thoroughly waxed. It is essential that the scions are inserted with correct polarity—with the buds pointing upward.

BRIDGE GRAFTING

On occasion, rodents or mechanical equipment cause injury that partly or completely girdles fruit trees just above the soil level. Often the tree can be saved by bridging over the injured area. In the early spring, as soon as the bark of the injured tree will slip, insert scions into the live tissue above and below the wound. (See figures 27 and 28.)

For bridge grafting, it is best to gather the scion wood while it is still dormant. Store the wood in moist peat moss, sawdust, or a similar material under refrigeration at 32° to 36° F. (0° to 2° C) to keep it dormant. However, in some cases, you can gather scion wood at the time of grafting. If you do this, remove any lateral shoots growing on the scion wood and wax over the resulting cuts.

When bridge grafting, insert a scion every 2 or 3 inches around the tree. Cut the scions so they are wedge shaped at both ends; make the cut on one side only about half as long as the cut on the opposite side. Then insert the wedge-shaped ends under the bark so the surface that has the longest cut on it is next to the wood of the tree. Make two slits in the bark of the tree to receive the scion, as described for the third bark grafting method (figure 19). Next nail the scions in place.

If you make the scions slightly longer than the space to be bridged, they bow out slightly so the flat, cut surfaces rest squarely against the wood of the stock. Wax over that part of the graft where you inserted the scions under the bark. It is recommended that you also wax the exposed wood in the girdled area. Remove all buds that start to grow on the scions. Do not insert the scions in

an inverted position—with the buds pointing downward. If you do this, the bridging will not be successful.

INARCHING

Inarching is used to unite plants growing on their own roots. To inarch fruit trees, plant young seedlings or rooted cuttings beside an older tree in late winter and graft them into the trunk in the spring. (See figures 29 and 30.) Results are better if three to five seedlings are inarched because more new roots develop than if only one seedling is used.

The usual procedure is to remove a strip of bark—as wide as the seedling stem and 4 to 6 inches long—from the trunk of the larger tree and then lay the seedling stem in this opening. Before laying the seedling stem in the opening, cut away about half of the part of the seedling stem that lies next to the wood of the tree; otherwise contact of the cambium layers does not occur. In additon, cut the end of the seedling in a wedge shape, as in bark grafting, and shove it under the bark at the top of the slit. (See figure 29, A.) Drive nails about 1½ inches apart to hold the seedling in place. Place one nail through the flap of bark at the top of the seedling. Use flat-headed nails, either 20 gauge, ¾ inch or 19 gauge, 1 inch. Select the nails to use according to the thickness of the seedling stem.

Save some of the shoots that appear on the inarches the first growing season, but suppress the shoots by pinching back the tips. After the union is well established, remove all shoots. It is best to do inarching in the early spring as soon as the bark of the injured trees will slip.

Figure 28. Bridge grafting saved this tree, which was damaged by a tractor. If suckers or watersprouts appear below the injury, graft them in above the injury.

When inarching walnuts, allow a portion of the seedling (usually a section containing three or four buds) to extend above the graft. (See figure 29, B.) Allow leaves to develop on this section during the first growing season. If the union appears to be well established, remove the part above the graft at the end of the first growing season.

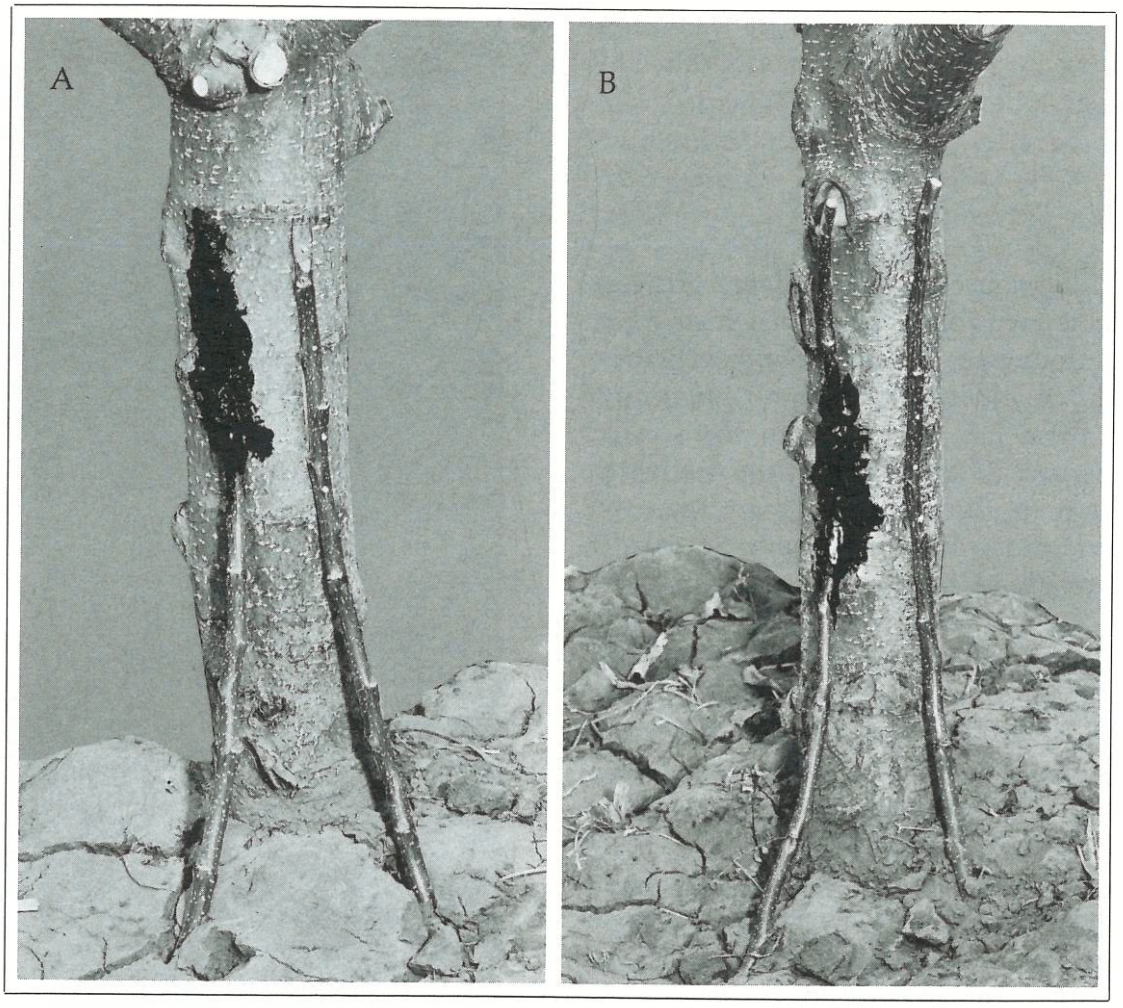

Figure 29. Inarching seedlings into the trunks of older trees whose root systems have been damaged.

A) The top end of the seedling shoot made into a wedge and inserted under the flap of bark.

B) An alternative method, as shown here, is to allow the top end of the seedling above the grafted area to curve outward. This practice often permits more active initial growth of the seedling and promotes healing of the graft union. After the union is well healed, cut off the seedling just above the graft union. The graft union must be thoroughly waxed, as shown for one of the graft unions in each of the above cases.

Inarching is used to save trees whose roots have been damaged by cultivation equipment, fireblight, or gophers, or when there are graft union problems and new rootstock is needed. If the tree has been girdled and the roots are alive, use bridge grafting rather than inarching.

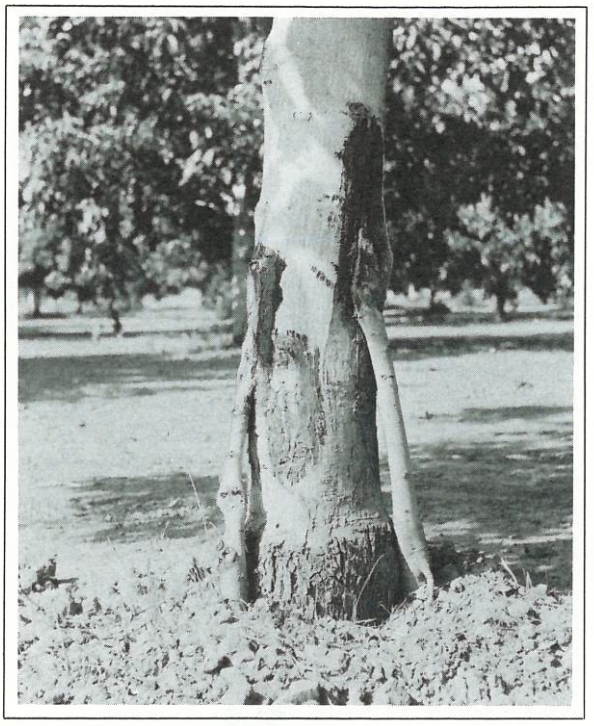

Figure 30. This walnut tree was successfully inarched with seedlings planted around its base.

WAXES AND OTHER GRAFTING MATERIALS

There are various kinds of grafting waxes available. You can prepare one type, a hot wax, by heating a mixture of resin, beeswax, lampblack, and either linseed oil or tallow. Some of these combinations are soft enough to be applied by hand, but it is better to make the wax fairly hard and then to melt it in a special burner at the time you want to cover the graft. Apply the liquid wax with a brush. The use of a liquid wax ensures a better sealing and covering of the graft union than does the use of a soft wax applied by hand.

A satisfactory hot wax consists of 5 pounds of resin, ¾ pound of beeswax, ½ pint of raw linseed oil, 1 ounce of lampblack, and 1½ ounces of flake glue. Melt the resin first, then add and melt the beeswax. Remove the mixture from the heat and stir in the linseed oil and lampblack. Use a double boiler to heat the glue; use just enough water to dissolve the glue. Then add the glue slowly (while stirring) to the wax, which has cooled somewhat but is still liquid. If you add the glue too rapidly while the wax is still warm, the entire mass will boil over.

Most grafting waxes contain lampblack (or, occasionally, a red pigment); the different color makes it easy to determine when grafts are covered. The dark color absorbs heat from the sun and tends to keep the wax pliable, reducing the amount of cracking.

If you need only a small amount of wax, it is usually more convenient to buy a prepared product. Water emulsions of asphalt, often called pruning or grafting compounds, are available under various trade names, such as Treheal or Tree Seal. These products are easy to apply cold and are usually satisfactory, although rains may wash them off if they are not thoroughly dried. These materials may crack after hardening so check 1 or 2 days after grafting and re-wax if necessary. When covering pruning cuts, do not use compounds that come in aerosol cans; these products are not thick enough to adequately cover graft unions. Do not use roofing materials that contain mineral solvents for covering grafts.

Nurseryman's tape or budding tape usually comes in rolls ½ inch wide. Use it when available, but masking tape, which is manufactured for use by painters, also gives good results.

LAYERING

Layering is the process whereby stems are rooted while the stems are still attached to the parent plant.

SIMPLE LAYERING

Simple layering consists of laying down a branch and covering part of its length with soil, leaving the tip uncovered. Roots often form more rapidly if you girdle or notch the buried portion of the branch. During the dormant season, sever the rooted shoot from the parent plant. You can use this method for propagating small numbers of plants of various shrubs and of grapes that have long branches or canes. For propagation of filberts, you can use suckers that arise from the bases of the trees by bending them down to make layers.

TIP LAYERING

Tip layering is the usual method for the propagation of trailing blackberries, dewberries, and black raspberries. During the latter part of the summer, cover the ends of the canes with several inches of soil. The covered portion produces roots and shoots to form a plant that can be detached and planted the following spring. (See figure 31.) Leave about 6 inches of the original layered cane attached to serve as a handle and to act as a marker or guide in cultivating until the new shoots appear.

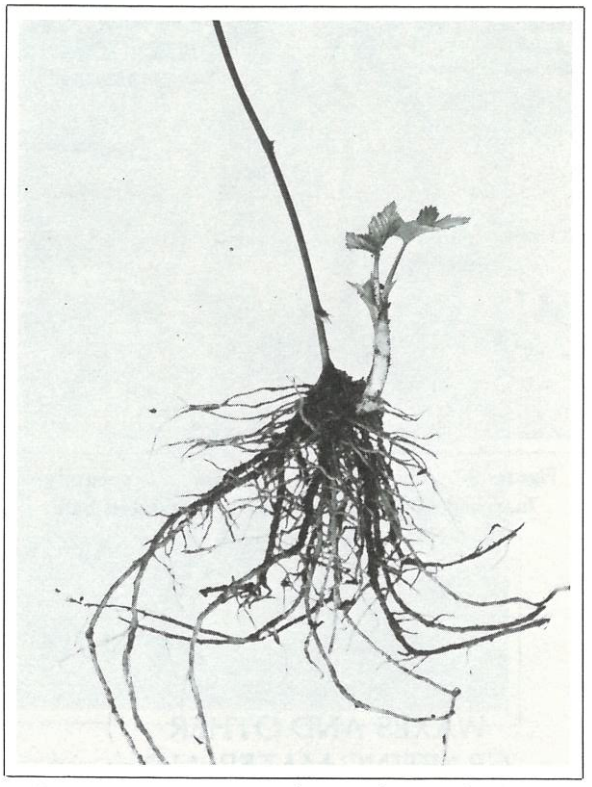

Figure 31. Tip layering of Boysenberry. The shoot tip was buried in the soil in late summer or fall where it rooted and developed a new shoot. Grow the plant in the nursery row another year so it will be ready for setting out in a permanent location. You can also use tip layering to propagate black raspberries. (Reprinted, by permission, from H. T. Hartmann and D. E. Kester, *Plant Propagation: Principles and Practices*, 3rd ed., Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1975.)

STOOLING OR MOUND LAYERING

Mound layering is commonly used to propagate clonal apple and plum rootstocks, gooseberries, and currants. (See figure 32.) Prepare mound layers as described.

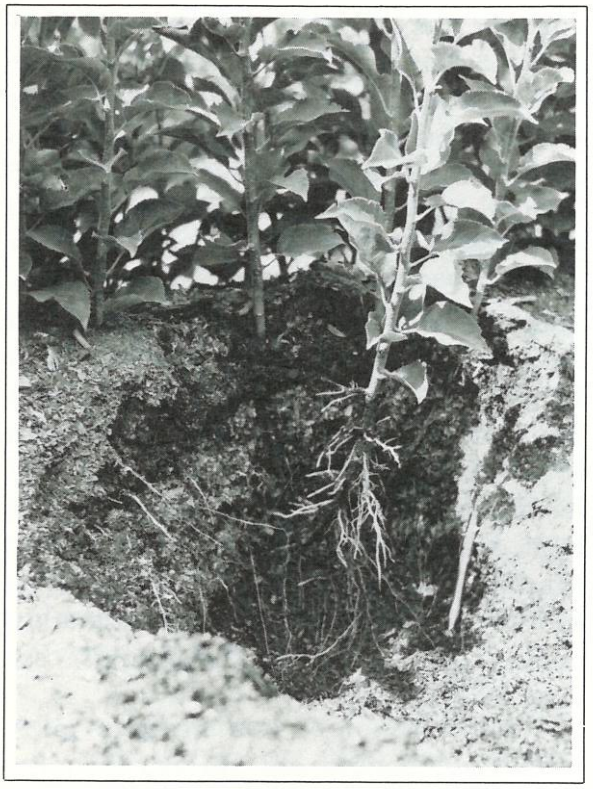

Figure 32. Stooling (mound layering) can be used to propagate clonal apple rootstock plants, such as M 106. This photograph shows the root system that has developed by late summer. During the dormant season, each of these rooted shoots can be cut from the parent plant and set out in nursery rows where, in late summer, the shoots can be budded, using buds from named apple cultivars.

Before growth starts in the spring, cut back the parent plants close to the ground. Mound soil or a soil-sawdust mix around the bases of the new shoots as they develop during the spring; do not completely cover the tips of the shoots. Build up the mound to a height of 8 to 12 inches as the shoots grow during the spring. Roots arise from the bases of the new shoots and grow into the mound if the soil is kept moist throughout the summer. The shoots are usually well rooted by winter.

Remove the soil and cut off the rooted shoots in late winter or early spring. Line out the layers in the nursery row to grow them an additional year to produce stronger plants.

TRENCH LAYERING

Trench layering consists of bending over the entire top of a young plant and pegging it down in a trench 2 or 3 inches deep. The usual practice is to plant trees with 1-year-old tops in late winter. Plant the trees so the trunks are at an angle of 30 to 45 degrees from the horizontal. The next winter, after one season's growth, layer the top. Remove any branches that do not lie flat against the bottom of the trench. In the spring when the new shoots are about 3 inches tall, shovel fine soil around the bases of the shoots. Repeat this process at intervals until you have covered the layered plant to a depth of about 6 inches.

When layering difficult-to-root species, cover all parts of the layer with fine soil to a depth of about 1 inch before the buds start to open. Then, as the new shoots develop, they grow up through the soil.

The winter after the shoots have grown one season, pull the soil away from the layers, cut off the rooted shoots, and transplant them to the nursery row to grow another season. A few shoots fail to root each year. You can lay these down during the winter to supplement the original layered tree. Leave old layers uncovered until the following spring, then repeat the program of the previous year.

AIR LAYERING

Air layering—sometimes called Chinese layering, pot layering, or marcottage—is an ancient method that is sometimes used

to propagate plants that are difficult to start as cuttings and that have an upright growth habit not adaptable to other types of layering. This method has been used to propagate some cultivars of fig, lichee, persimmon, crabapple, highbush blueberry, kola, and plum. However, air layering is not used commercially except for the lichee, kola, and some other tropical plants.

In the modern procedure of air layering, girdle a section of the stem. Then place a ball of some moisture-holding material, such as shredded sphagnum moss, around this section of the stem and wrap tightly with polyethylene sheeting or aluminum foil. Roots initiate at this point and grow into the moss.

You can prepare air layers on 1-year-old wood in the spring when growth starts or in mid-summer when the current season's growth is mature. Some plants form roots during the first summer; others do not develop a good root system until the end of the second year.

Make the layer about 18 inches back from the terminal end on shoots that are ½ to 1 inch in diameter. Girdle the branch at this point by removing a section of bark about ½ inch in width. Stimulate root formation on the cut surfaces by rubbing with a root-promoting powder or by brushing with a concentrated dip of a root-promoting solution. (For information about root-promoting compounds, see page 59.)

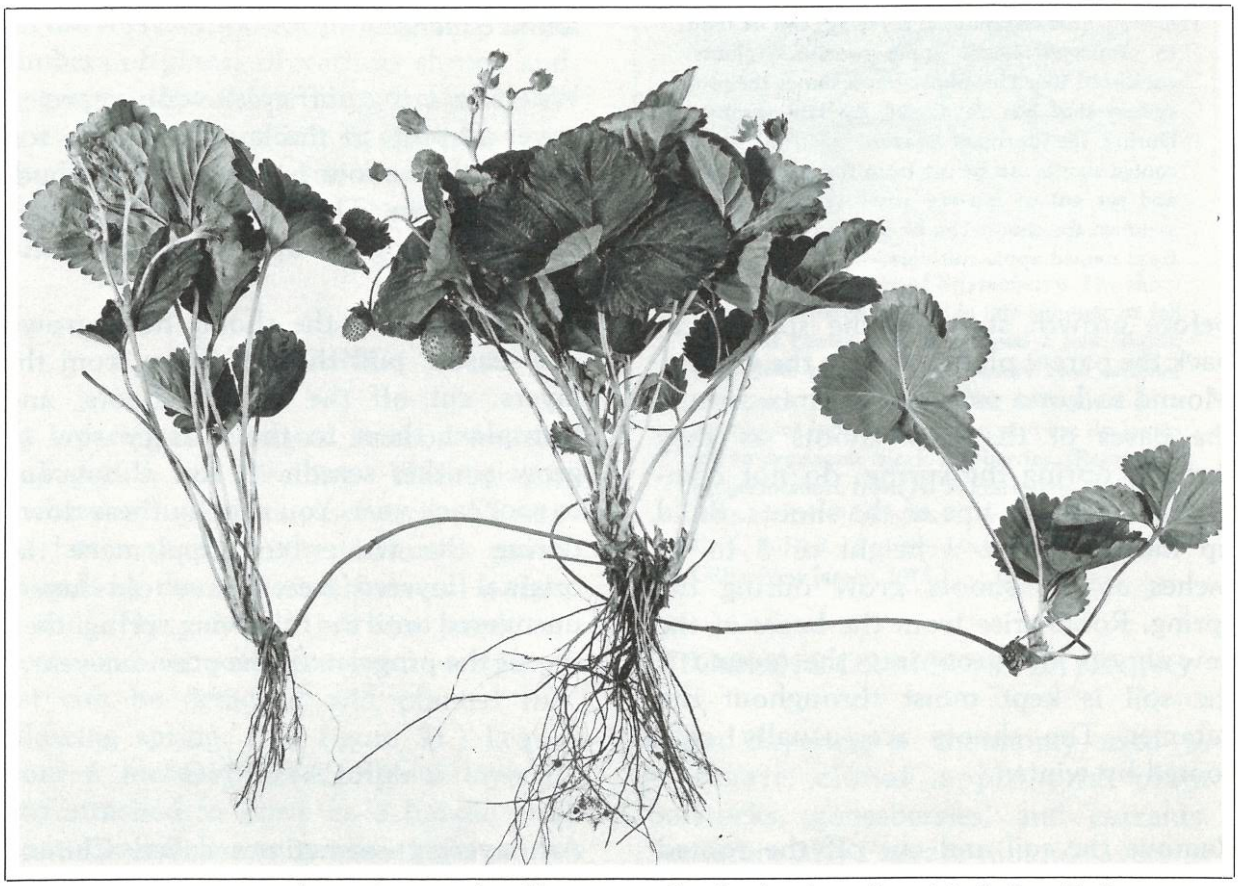

Figure 33. New strawberry plants produced by runners that develop from the original plant. Each new runner can, in turn, produce many additional plants.

Shape the slightly damp, but not wet, moss into a compact ball about 4 inches wide and 6 inches long. Place the ball on the branch and center it over the girdling cut. Then wrap a sheet of polyethylene or aluminum foil securely about the ball and tie at each end. Electrical tape makes a satisfactory tying material because you can lap it at the upper end to keep rain from seeping down the branch into the layer. Lap the plastic on the underside so that the rain cannot penetrate and make the moss excessively wet, which can lead to bark decay. You need not do anything more until roots form. In general, it is not necessary to add water because the polyethylene or aluminum foil effectively prevents water loss.

After a substantial root system has developed, cut off the branch just below the ball of moss, remove the covering, and plant the layer. For deciduous species, do not remove the covering until the dormant season when you can safely plant the layer in a container. Do not disturb the ball of moss that contains the roots. Remove some of the leaves and hold the new plant for a time under cool, humid conditions until it becomes re-established.

RUNNERS

Propagation by runners is a natural type of layering. If you keep the soil moist, runners of strawberry, which is commonly propagated by this technique, root at every other node. (See figure 33.) Buds at the rooted nodes send out leaves to form a new plant, which produces runners and additional runner plants. As many as 50 or more runner plants may originate from one strawberry plant.

Some ever-bearing strawberry cultivars, such as the Rockhill, seldom produce any runners. These cultivars must be propagated by dividing the crown into several pieces, each of which is capable of developing into a new plant.

SUCKERS

Fruit and nut species that you can propagate by suckers include red raspberries, upright blackberries, filberts, olives, and 'Stockton Morello' cherry (a rootstock for cherries). During the winter, remove the suckers, together with some roots, from the parent plant. (See figure 34.) If the suckers are well rooted and larger than ¼ inch in diameter, you can transplant them immediately to a permanent location. Otherwise, line them out in the nursery row for another season's growth.

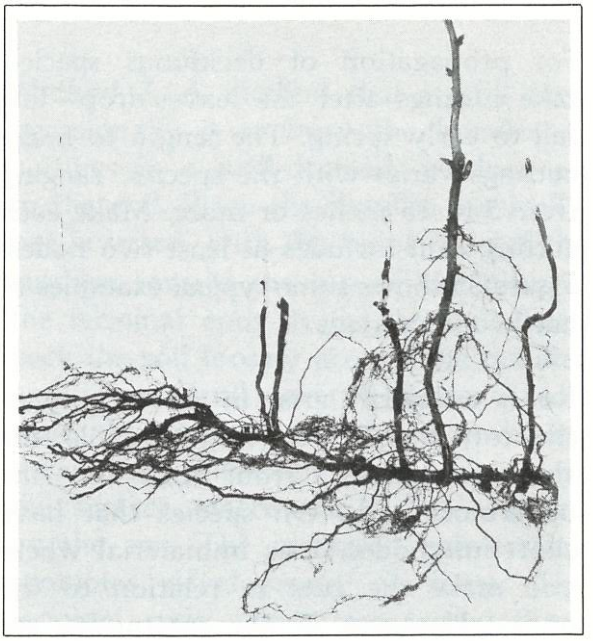

Figure 34. Suckers growing from the root of a red raspberry plant. Cut the suckers apart, including a piece of the old root, to obtain new plants. Grow the plants another year in the nursery row to develop strong plants for setting out in a permanent location.

CUTTINGS

Propagation by the use of cuttings consists of placing a detached piece, such as a stem, root, or leaf, of the parent plant under conditions favorable for root and shoot development. The most important type of cuttings is stem cuttings, which include the hardwood, semi-hardwood, and softwood types.

HARDWOOD CUTTINGS

Hardwood cuttings consist of sections of the stem, which are usually taken from the previous season's growth. However, with some species, such as fig and olive, you can use wood up to 2 or 3 years old.

For propagation of deciduous species, take cuttings after the leaves drop—late fall to early spring. The length to make cuttings varies with the species, ranging from 5 to 15 inches or more. Make each cutting so it includes at least two nodes. Figure 35 shows some typical examples of hardwood cuttings.

Roots ordinarily arise in the vicinity of the lower node, or nodes, while the shoot originates from one of the uppermost buds. On species that have short internodes, it is immaterial where you make the cuts in relation to the nodes. However, if the internodes are long, make the basal cut about ½ inch below a node and the top cut about ½ to 1 inch above a node.

Commercial propagation of several fruit species, including cultivars of grape, currant, gooseberry, fig, quince, mulberry, pomegranate, and olive, is done by using hardwood cuttings. No graft or bud union is involved and the plants that develop are on their own roots. In addition, several kinds of rootstocks are propagated by hardwood cuttings and then later have a fruiting cultivar budded or grafted on them. Rootstocks propagated by this method include some plum rootstocks, such as 'Myrobalan 29C' and 'Marianna 2624'; nematode- and phylloxera-resistant grape rootstocks; some types of quince used as a dwarfing stock for pears; and apple rootstocks, such as M 9 and M 111; pear rootstocks, such as 'Old Home' and 'Old Home' × 'Farmingdale' clones; and some Verticillium-resistant olive rootstocks, such as 'Oblonga' and 'Allegra'.

There are several methods of handling hardwood cuttings of deciduous fruit species. Seven of these methods are discussed in this section.

Method 1. Gather the cutting material in the fall—about mid-November. Make the material into cuttings, dip in a root-promoting chemical, and immediately plant in soil in the nursery. It is usually advantageous to treat hardwood cuttings with a root-promoting chemical before planting. (See page 59.)

In areas of California where the winters are mild, better rooting of most plants can be obtained if the cuttings are planted in the fall instead of in the spring.

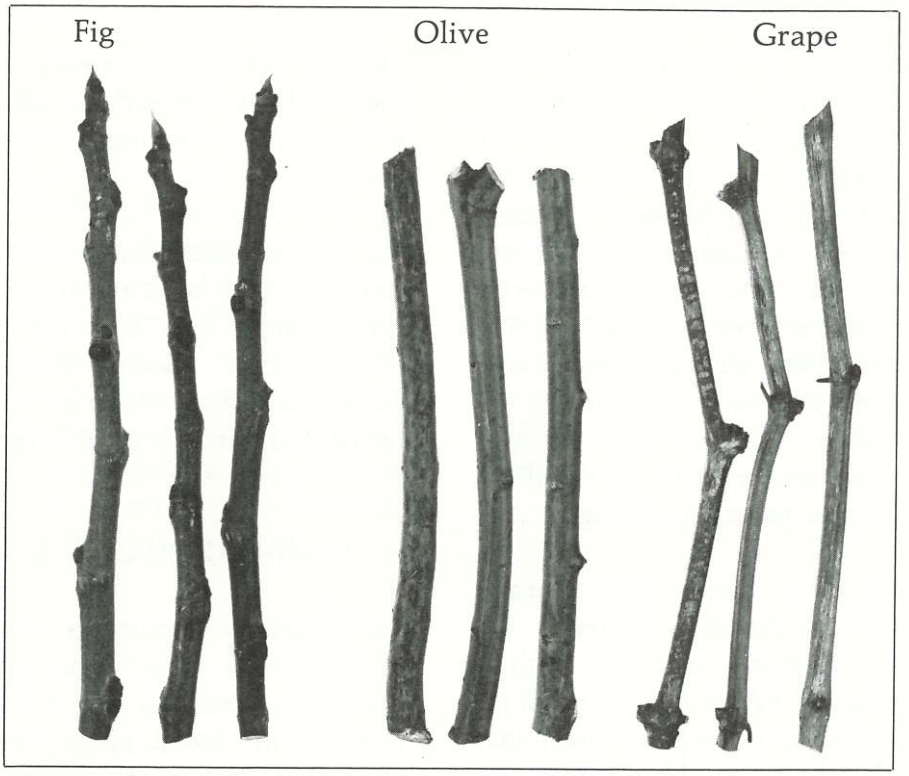

Figure 35. Dormant hardwood cuttings that are ready for planting. Be sure to make the basal cut just below a node (bud). On grapes, make a slanting cut at the top to distinguish the top of the cutting from the base.

However, in areas where winters are severe, the cold may damage cuttings planted in the fall. In addition, freezing and thawing of the soil may cause the cuttings to heave out of the ground. Injury due to rodents and weed control may become problems during the winter if cuttings are planted in the fall.

Method 2. When planting cuttings in the spring, a good procedure is to prepare the cuttings in the late fall or early winter and to store them in callusing beds until the cuttings are ready for planting. Pack bundles of cuttings in moist materials, such as sawdust, shingle tow, or peat moss, in large boxes and keep in an unheated outdoor building or a cool cellar until planting time. Store the cuttings at a temperature of 40° to 60° F. (4° to 16° C).

Method 3. A method that is still used occasionally is to bury the bundles of cuttings in a well-drained, outdoor pit in the soil. Place the bundles vertically, but inverted—with the basal ends of the cuttings toward the top of the pit and the terminal ends at the bottom. Then pack the soil loosely around the bundles and fill in until several inches of soil cover the bases of the cuttings. Inverting the cuttings places the basal ends nearer the surface where the soil is warmed by the sun. The increased temperature promotes development of roots. The terminal ends, which are buried more deeply, presumably remain cooler—and this has the desirable effect of retarding activity of the buds.

Closely watch cuttings stored in any type of callusing beds, especially as the days

become warmer in the spring. If root and shoot activity develops, remove the cuttings immediately and plant them.

Method 4. Another practice that is used for propagating easy-to-root species, especially in areas where the winters are mild, is to gather the cutting material in the late winter before bud growth begins. Prepare the cuttings and plant them in the nursery row immediately. It is only possible to use this method during the winter when the soil is sufficiently dry to permit planting.

Method 5. If you have cold storage facilities, gather cutting material of easy-to-root species at any time during the winter. Wrap the material in packages containing some moisture-holding material, such as peat moss or sphagnum moss, and store at 32° F. (0° C) until spring. At that time, make the cuttings and plant them immediately.

Method 6. In areas where the winters are mild, good results have been obtained with difficult-to-root species, such as 'Old Home' pear, by taking the cuttings in the late fall. Treat the cuttings with 100 parts per million (ppm) indolebutyric acid for 24 hours, store in slightly damp peat moss at about 70° F. (21° C) until roots first appear (about 3 weeks), and then plant the cuttings in the nursery. (See page 60.)

Method 7. Another method that is successful for rooting difficult-to-root species is to treat the dormant hardwood cuttings with indolebutyric acid, as mentioned for method 6. Then place the cuttings upright in boxes of damp peat moss over bottom heat at 70° to 75° F. (21° to 24° C) in an unheated, open shed. This method keeps the bases of the cuttings warm, but exposes the top buds to the cold. Plant the cuttings in the nursery before many roots appear. This method has increased survival percentages of hardwood cuttings of fig, pear, and walnut.

As a rule, plant hardwood cuttings so only one bud is above the ground. Place the cuttings 3 to 4 inches apart in the nursery row. Figure 36 shows typical quince cuttings before rooting and similar rooted cuttings after 1 year's growth.

SEMI-HARDWOOD CUTTINGS

Semi-hardwood cuttings consist of leafy material that must be rooted under high humidity, such as in mist-propagating beds or in closed glass-covered frames. (See page 58.) Ordinarily, you can root semi-hardwood cuttings at any time of the year, but it is best to take cuttings of plants that have distinct flushes of growth after a period of growth activity when the wood has become partly matured. (See figure 37.) For example, cuttings of olive or kiwifruit root best when taken in mid to late summer. You can usually greatly improve rooting of semi-hardwood cuttings by treating the cuttings with root-promoting hormones. (See page 59.)

SOFTWOOD CUTTINGS

Softwood cuttings consist of leafy stem cuttings made from the young, succulent spring growth of deciduous plants. Although propagation by softwood cuttings is not a common commercial practice, you can root softwood cuttings of many fruit species if you treat them with root-promoting hormones and start them in mist-propagating beds. Cuttings that have

been successfully rooted in this manner include some cultivars of peach, pear, plum, apple, apricot, cherry, walnut, and grape. In fact, you can start several species of plants that are commonly considered difficult to propagate by using softwood cuttings under mist.

Many European grape *(Vitis vinifera)* cultivars are commercially propagated by softwood cuttings when large quantities of plants are needed in a short time. Rooting occurs in 2 to 3 weeks and propagation can continue all summer if done under mist in a greenhouse.

Cut leafy softwood cuttings 3 to 4 inches long. Remove the basal one to two leaves; keep one to three of the upper leaves. Dip the base of the cutting in a root-promoting hormone, either liquid or powder, and plant in coarse, well-drained media in pots, flats, or beds under mist. If there is a limited amount of cutting material available, a single node may be sufficient for rooting some softwood cuttings.

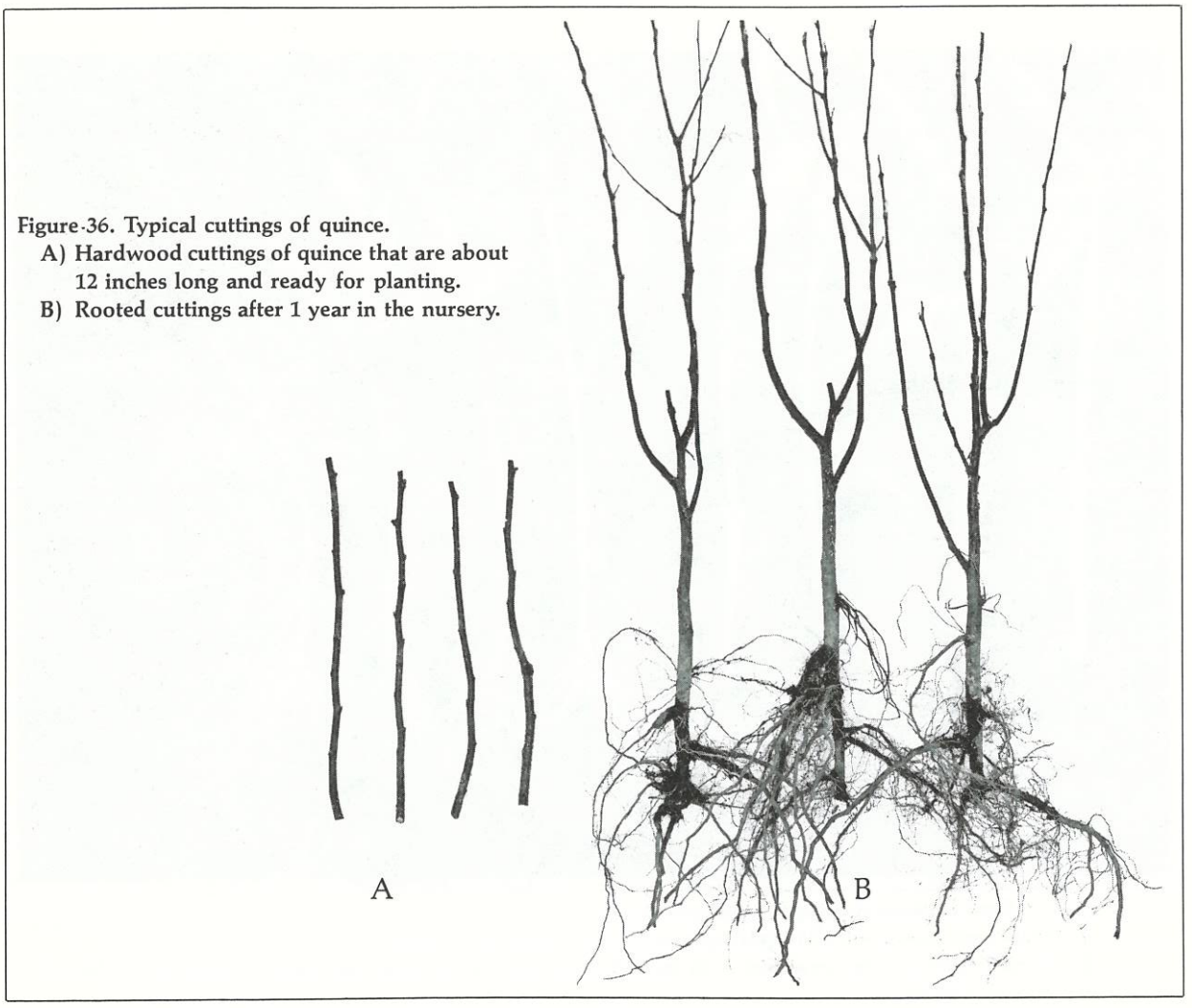

Figure 36. Typical cuttings of quince.
A) Hardwood cuttings of quince that are about 12 inches long and ready for planting.
B) Rooted cuttings after 1 year in the nursery.

LEAF BUD CUTTINGS

A leaf bud cutting consists of an entire leaf and a short section of the stem to which the leaf is attached, including the axillary bud at the base of the petiole. Root leaf bud cuttings under high humidity, such as in a glass-covered frame or under mist. You can use this procedure to start various types of blackberries. However, it is not possible to successfully propagate the red raspberry by leaf bud cuttings.

ROOT CUTTINGS

Root cuttings are small sections of roots. In some kinds of plants, root cuttings, when correctly planted, can develop buds and shoots and thereby produce new plants. Success is more likely if you take root cuttings from young plants. Ordinarily, you can use root cuttings to propagate plants that produce suckers from the roots. Fruit species that you can start in this manner include red raspberry, trailing and upright blackberries, quince, and some pear and apple rootstocks.

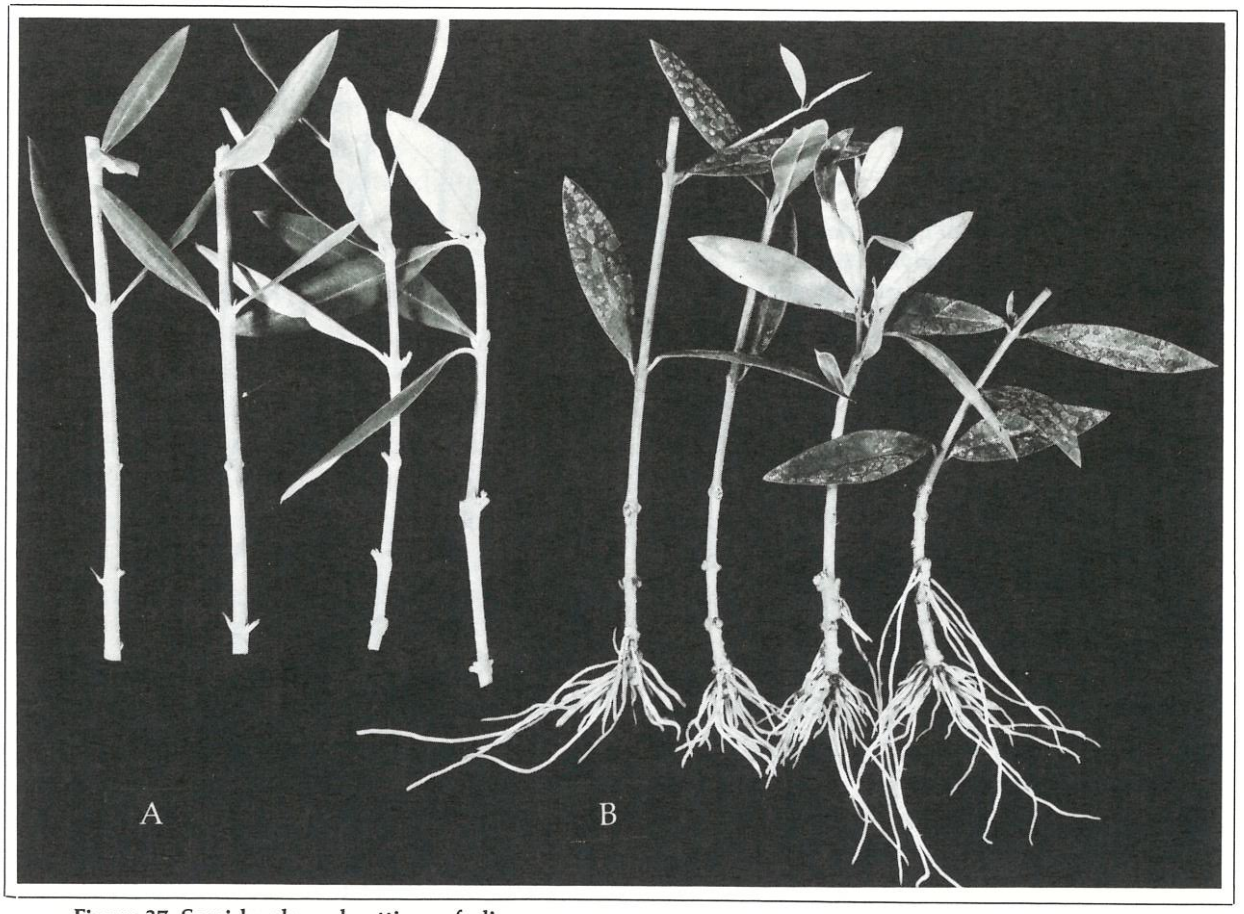

Figure 37. Semi-hardwood cuttings of olive.

A) Leafy semi-hardwood olive cuttings prepared and ready for rooting.

B) Rooted cuttings after treatment with indolebutyric acid (4,000 ppm) and after 8 weeks in a mist-propagating bed.

Make cuttings from roots of various sizes, even tiny roots. Cut the roots into sections 2 to 4 inches long and plant them either horizontally, about 2 inches deep in the nursery row, or vertically with the top just below the surface of the soil. Plant root cuttings of red raspberry and blackberry horizontally. When planting cuttings vertically, always be sure the end of the root piece that was nearest the crown of the plant is up. The best time to take the cuttings is in late winter or early spring before growth starts. You can plant the cuttings immediately or store them in a cool, moist callusing bed until spring.

ROOTING MEDIA

Plant hardwood cuttings in a nursery established in a fertile sandy loam soil that is free of nematodes and other pests, such as crown gall bacteria, oak root fungus, or *Phytophthora.* Commercial nurseries usually fumigate the soil with a nematicide or an all-purpose fumigant to be sure the nursery stock does not become infested with nematodes or pathogens. A sandy soil is desirable as a rooting medium because it is usually well aerated—a condition that promotes good rooting of the cuttings. In addition, the soil can be worked soon after rains, thereby facilitating planting and digging operations.

If you wish to start leafy types of cuttings in special propagating beds, you need a rooting medium that is well aerated, has good drainage yet holds moisture fairly well, and is free of decaying organic matter, which harbors disease-producing organisms.

Several materials or mixtures of materials are widely used for rooting media and have given satisfactory results.

Sand

Use a medium grade, washed sand, such as that used in the building trade. Sand is heavy, has a rather poor water-holding capacity, requires frequent watering, and must be fumigated before use because it may contain nematodes and pathogens. Sand is not as popular a rooting medium now as it was in the past.

Vermiculite

Vermiculite is useful as a rooting medium and is available in several particle sizes. It is a micaceous mineral—chemically, a hydrated magnesium-aluminum-iron silicate—that expands under high temperatures to form porous, light weight, sterile particles that have a high water-holding capacity. Do not compress vermiculite in any way when it is wet; you will destroy its porous structure. Mixtures of vermiculite and sand, or vermiculite and perlite, make a satisfactory rooting medium, especially in mist-propagating beds. (See page 58.)

Perlite

Perlite is a gray-white material of volcanic origin, which has proved useful for rooting cuttings, especially when mixed with vermiculite or with peat moss. It is very light in weight, but has a good water-holding capacity and is practically sterile as a result of the high temperatures under which it is processed. It is best to use perlite in combination with either vermiculite or peat moss.

Peat Moss

Peat moss, when used by itself, retains too much water to make a satisfactory rooting medium. When peat moss is mixed with perlite in varying proportions, such as 1:1 to 1:3, it makes an excellent rooting medium that is widely used for mist propagation.

MIST PROPAGATION OF LEAFY CUTTINGS

The practice of rooting cuttings under water mist sprays not only keeps the humidity around the cuttings at a high level, but also lowers the temperature of the leaves, thus helping reduce undesirable water loss. Propagation beds with mist equipment are ordinarily set up in the greenhouse for summer and winter use, but outdoor installations shielded from the wind have also been satisfactory for rooting cuttings in the summer. Nozzles over the beds are spaced to produce a fine, fog-like spray that completely covers the bed.

Provide only enough mist to keep a film of water on the leaves; use an intermittent mist controlled by time clocks and magnetic solenoid valves. For most plants, the best practice is to apply mist only during daylight hours and completely shut it off at night. The on-and-off intervals can be short: allow the mist to wet the leaves and then shut off the mist until the leaves start to dry, at which time the mist automatically turns on again.

There are several types of spray nozzles available for use in mist propagation. Two types of nozzles that are commonly used

Figure 38. Mist propagation unit in an outdoor Saran-covered lath house in a southern California nursery. The mist is on just long enough to wet the leaves; then it is shut off until the leaves start to dry. Usually the mist is completely off during the night.

are the oil-burner, whirling-action type and the deflection type. The first type of nozzle produces an evenly distributed, fine spray and uses a relatively small amount of water. The mist is produced by water passing through small grooves set at an angle to each other. The deflection nozzle develops a mist by means of a fine stream of water striking a flat surface. The larger aperture of this nozzle reduces clogging, but uses more water than does the whirling-action type of nozzle.

There are several methods of placing the water pipes to which nozzles are attached. One practice is to lay the main feeder pipe down the center of the bed below, level with, or above the surface of the rooting medium. Place the nozzles on the ends of risers from the feeder pipe. This method eliminates dripping because excess water runs back down the riser pipe. Another method is to place the feeder pipe well above the cuttings—usually one pipe down the center of the

bed—with the nozzles directed downward into the bed. Whatever arrangement is used, place the nozzles close enough together and make sure the water pressure is high enough to ensure that the entire bed is under the mist. Rooting is likely to be unsatisfactory unless the mist actually wets the leaves.

The frequent operation of the water line to supply an intermittent mist requires the use of an electrically operated, magnetic solenoid valve, preferably the type that is normally open. When this type of valve is used, a power failure simply results in a continuous mist; when a normally closed type of solenoid valve is used, a power failure, if not detected soon, cuts off the mist entirely and can result in the death of the cuttings.

An electrically operated control uses two timers acting together. One timer turns the entire system on in the morning and off at night. The second timer (connected in series with the first timer) operates the system during the daylight hours to produce an intermittent mist at any desired combination of timing intervals, such as 5 seconds on and 90 seconds off. This type of control mechanism is relatively foolproof and, although it does not automatically compensate for variations in humidity conditions, it can be adjusted to give satisfactory results.

If there is much sand in the water, it is advisable to install 50 to 100 mesh filters in the supply line to reduce clogging of the nozzles.

When propagating cuttings under mist, it is essential to use a well-drained rooting medium. In addition, raise the bed so that all excess water rapidly drains from the rooting medium.

As soon as the cuttings are rooted, move them promptly, but carefully, from the extremely moist conditions of the mist to a drier environment. One way of preparing the cuttings for transplanting is to gradually reduce the mist; decrease the on periods and increase the off periods until the cuttings are able to survive without mist. Then pot the rooted cuttings or leave them in the rooting medium for transplanting during the dormant season. Cuttings of some species whose roots cannot tolerate disturbance can be rooted directly in containers, such as milk cartons, that have had the bottoms removed. After rooting, set out the cutting and container in the nursery for further growth of the plant.

USE OF GROWTH REGULATORS IN ROOTING CUTTINGS

In some cases, use of chemicals, such as indolebutyric acid and naphthaleneacetic acid, promotes root initiation on hardwood, semi-hardwood, and softwood stem cuttings as well as on leafy and leaf bud cuttings. Treatments with these chemicals, while not always effective, often cause a greater percentage of the cuttings to root, speed root formation, and produce a higher number of roots per cutting. Excessive concentrations can be injurious. Do not use these chemicals on root cuttings.

Commercial preparations are available in powder form in which the active ingredients are dispersed in talc. Pure crystals of these chemicals are available so you can prepare your own rooting solutions by dissolving the crystals in alcohol.

Powder Dip

Powders are available commercially in various strengths; use them according to the directions on the container label. Dip the basal ends of the cuttings into the powder, enough of which usually adheres to be absorbed and effective.

Dilute Solution, 24-Hour Soak

Prepare relatively dilute solutions of the chemicals, soak the bundles of cuttings for 24 hours, and then set the cuttings in the rooting or callusing medium. Immerse the basal ends of the cuttings in the solution to a depth of ½ to 1 inch. The chemical concentration to use can range from 15 to 200 ppm, depending on the species. Use these solutions only on hardwood cuttings; softwood cuttings are usually injured by this soaking method.

To prepare 1 liter of a 100 ppm solution of a root-promoting material, dissolve 100 mg of the pure chemical in about 10 ml of alcohol (ethyl or isopropyl). Then dilute the mixture with water to make 1 liter.

To prepare 1 gallon of an approximate 100 ppm solution of indolebutyric acid, measure out ¼ level teaspoon (about ½ gram) of the chemical. Dissolve the chemical in a small amount of alcohol and add to the water, stirring thoroughly. If a white precipitate forms, add a few drops of ammonium hydroxide.

Concentrated Solution Dip

Prepare a fairly concentrated solution—500 to 10,000 ppm—and immerse the basal ½ inch of the cutting for about 5 seconds. Dip large bundles of cuttings at one time and then set them immediately in the rooting bed. It is always advisable to make fresh basal cuts at the time the cuttings are dipped. For hardwood cuttings, a concentration of about 2,000 ppm is recommended; for softwood and semi-hardwood cuttings, higher concentrations—4,000 to 6,000 ppm—are usually more effective.

To prepare 100 ml of a 4,000 ppm solution of a root-promoting substance, dissolve 400 mg of the chemical in 100 ml of 50 percent alcohol (ethyl or isopropyl).

To prepare a 4,000 ppm solution of indolebutyric acid, dissolve ¼ level teaspoon of the pure crystals in 3⅓ fluid ounces of 50 percent alcohol.

SUMMARY OF METHODS OF PROPAGATING VARIOUS FRUIT PLANTS

Use hardwood cuttings to propagate quince, fig, grape, olive, mulberry, currant, gooseberry, pomegranate, some plum rootstocks, such as 'Myrobalan 29C' and 'Marianna 2624', some apple rootstocks, and quince rootstocks used for dwarfing pear trees. Use semi-hardwood cuttings for the propagation of olive and kiwifruit. Use the mound layer technique to propagate currant, gooseberry, and some apple rootstocks.

Grapes can be propagated by hardwood cuttings or, if it is necessary to increase stock rapidly, by softwood cuttings under mist. If root-knot nematodes or phylloxera are present in the soil, whip or machine bench graft the desired cultivars to resistant rootstocks for later planting in the nursery. In the vineyard, use chip budding or field grafting to change vines to other cultivars.

Tip layering is the common method used for the propagation of trailing blackberries, dewberries, and black raspberries, although these species can also be started by leaf bud cuttings. Use simple layering of root suckers for the propagation of filberts.

Propagate red raspberries and upright blackberries by suckers or, if suckers are not plentiful enough, by root cuttings. Use runners to propagate the common strawberry cultivars.

Propagate apple, cherry, pear, almond, apricot, nectarine, peach, and plum by T budding on seedling or vegetatively propagated rootstocks. Bud apple, cherry, and pear in the late summer or fall. Propagate almond, apricot, nectarine, peach, and plum by June or spring budding.

Use patch budding or crown grafting to propagate walnuts and pecans on seedling rootstocks.

There are various reasons for topworking (top grafting or top budding) fruit trees. Sometimes there is not a satisfactory market for the cultivar planted, even though the tree is growing well. In addition, undesirable seedling trees may exist in orchards, pollenizers are sometimes needed in the orchard, and, on occasion, the home gardener desires to graft or bud several cultivars of fruit on one tree. (See table 1, page 26, for the various grafting combinations possible.) Top bud small branches of pear, cherry, apple, peach, nectarine, apricot, almond, plum, and fig in the summer by the T (shield) bud method. When topworking walnut and pecan trees, use the patch bud or whip graft method. In February, you can also whip or tongue graft small branches of the common deciduous fruit and nut trees. For topworking branches that are about 1 inch in diameter, the side graft method is satisfactory.

Use the cleft, bark, saw-kerf, or wedge graft for large branches, those up to 3 or 4 inches in diameter. All these methods give good results with apple, pear, cherry,

olive, apricot, almond, plum, persimmon, and fig. Each method has advantages and disadvantages; weigh these factors before selecting the method to use.

Some propagators have successfully made cleft and saw-kerf grafts on walnuts and pecans, but the average worker has better results with the bark graft method. It is recommended that you use the third method of bark grafting (described on page 36) for grafting walnuts and pecans.

Do not expect good results when grafting old, weak trees or trees on which growth has been seriously hampered by lack of water, nitrogen, or other essential nutrients.

Use the bark grafting method to top graft grapes. It is also the most suitable method for top grafting olives.

Bridge grafting and inarching are methods for saving fruit trees and other species whose trunks or roots have been injured. However, these are expensive, time-consuming procedures and it may be more economical to pull out damaged trees and replace them with new nursery trees.

FRONT COVER
Top right. Rooted grape cuttings.
Bottom left. T budded nursery stock.
Bottom right. Old top-grafted walnut tree.

BACK COVER
Top left. Rooted olive cuttings.
Top right. Undercutting budded fruit tree nursery stock.
Bottom left. Row of planted hardwood cuttings.
Bottom right. T budding, a unique method of budding walnuts.