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PROPAGATING FRUIT TREES IN NEW YORK

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ABSTRACT

Appropriate rootstocks are discussed for use with various species and varieties of deciduous tree fruits. Methods are described for growing rootstocks from seeds, and for propagating clonal rootstocks by means of stooling beds and cuttings. Budding and grafting techniques are described, and directions are given for converting bearing trees from one variety to another by top grafting and for repairing injury to the trunks by bridge grafting and inarching.

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PROPAGATING FRUIT TREES IN NEW YORK

R. D. WAY, F. G. DENNIS, and R. M. GILMER

INTRODUCTION

The seedlings of most fruit trees differ markedly from the parent varieties. Seeds of McIntosh apple, for example, do not grow into trees of McIntosh, but instead produce trees that differ not only from their parent but from each other. New trees of a fruit variety therefore must be propagated from buds or grafts of the variety. These buds or grafts are called *scions* and are commonly propagated on a rooted seedling or rooted shoot, the *rootstock*. The young nursery tree is thus a composite of two different plants with individual genetic backgrounds. Sometimes, a third plant member, the *interstem*, may be interposed between the scion and the rootstock for special purposes.

Each portion of the composite tree is important in determining the performance of the tree in the orchard. The scion variety is obviously chosen because of the desirable characteristics of its fruits. But, the rootstock is no less important, for it may influence tree size, habit of growth, earliness of fruiting, and ability to withstand drought or heavy, poorly drained soils.

VIRUS DISEASES AND NURSERY PROPAGATION

Fruit trees are perennial plants with a long life expectancy, and the cumulative injury caused by virus infections contracted in the nursery during propagation may be very damaging. Once a nursery tree becomes infected with a virus disease, it remains diseased for the rest of its life.

The most common way in which nursery trees become infected is by propagation with infected scions or rootstocks. If scion wood is obtained from an infected tree, most or all of the buds will be infected and will produce infected nursery trees. Viruses may also be carried in infected clonal rootstocks, and a few virus diseases, like sour cherry yellows and necrotic ring spot, are commonly transmitted directly through seeds to seedling rootstocks. Even if healthy scions are budded or grafted on infected clonal or seedling rootstocks, the nursery trees will be infected. All components of the nursery tree, rootstock as well as scion, should be derived from virus-indexed materials.

The use of indexed propagating materials often results in better nursery stands of more vigorous trees. The consistent failure of many ornamental flowering crabapples to grow when propagated on certain clonal apple rootstocks is caused by the occurrence of latent viruses in these rootstocks. The erratic performance of some apple varieties on Virginia Crab or Spy 227 rootstocks is directly related to the presence of latent viruses in the scions.

Even viruses that cause apparently mild diseases may markedly reduce nursery stands and tree vigor. When Montmorency cherry buds infected with necrotic ring spot virus were propagated on mazzard seedlings, only 72 per cent of the buds produced nursery trees, and of these trees less than half (47 per cent) graded No. 1 or better. With healthy Montmorency buds propagated at the same time on rootstocks from the same lot, 84 per cent of the buds produced trees, of which 59 per cent graded No. 1 or better.

Several states maintain or support nursery certification programs with the aim of producing virus-indexed nursery trees of the important commercial fruit varieties. These programs distribute limited amounts of virus-indexed propagating materials, obtained from foundation trees having desirable horticultural characteristics, to cooperating nurseries for further multiplication. Such certification programs are usually supervised by the nursery regulatory agencies of the various states.

SEEDLING ROOTSTOCKS

Until about 1950 nearly all of the fruit trees produced in the United States were propagated on seedling rootstocks. Almost all cherries, peaches, and plums, and many apples and pears are still propagated in this way. As the name implies, seedling rootstocks are grown from seeds. With few exceptions, trees propagated on such rootstocks grow vigorously and produce "standard-sized" trees in the orchard.

Apple. Seedling rootstocks for apple are commonly grown from seeds of commercial apple varieties used in processing or for juice. Seeds of Delicious are most commonly available and produce acceptable seedlings, but seedlings of many other varieties (McIntosh, Winesap, Rome, or Lodi) are equally satisfactory. Seeds of triploid varieties (Baldwin, Gravenstein, and R.I. Greening) should be avoided because they germinate poorly and produce nonuniform seedlings. In areas of extreme cold, seedlings of Siberian crab (*Malus baccata*) or very hardy varieties like Antonovka are preferred.

Pear. Pear seedlings are commonly grown from seeds of Winter Nelis or Bartlett pear, which are available in quantity from commercial canneries. Seedlings of several woolly-aphid and fire-blight resistant species of oriental pear have been widely tested, but are not satisfactory rootstocks, because varieties propagated on them often produce fruits with black-end. The use of oriental pear seedlings as pear rootstocks in California, Oregon, and Washington has resulted in severe damage from pear decline, a lethal virus disease transmitted by the pear psylla. The importation of oriental pear seedlings into New York is prohibited by State regulatory authorities.

Cherry. Mazzard (*Prunus avium*) and mahaleb (*Prunus mahaleb*) cherry seedlings are widely used as rootstocks for sweet and sour

cherries. Mazzard seedlings are susceptible to injury from the cherry leafspot fungus and black cherry aphid, and do not become established in the nursery as readily as mahaleb. They are more difficult to bud successfully, so that good stands of nursery trees are difficult to obtain. Mazzard rootstocks are also subject to low-temperature injury ("black-heart"). Trees on mazzard rootstocks are, however, larger and longer-lived than those on mahaleb, and mazzard rootstocks tolerate heavy, poorly drained soils. Mazzard is the preferred rootstock for sweet cherries.

Mahaleb seedlings are easier to establish in the nursery, require less care, and are more easily budded successfully. This rootstock is deep-rooted and is thus suited for well-drained soils. It withstands drought better than mazzard but is short-lived on poorly drained soils. Mahaleb is the rootstock generally preferred for sour cherry varieties and, in general, produces a more dwarfed, earlier-fruiting tree than does mazzard.

Seedlings of the dwarf cherry (*Prunus fruticosa*) have received limited experimental testing as rootstocks for cherries. Both sweet and sour cherry trees propagated on these rootstocks are very dwarfed and very early in fruiting, often producing fruits by the third year after propagation. This rootstock makes a brittle union with many cherry varieties, and suckers excessively in the orchard, so that it cannot be recommended for commercial use at present.

Peach and nectarine. Peach and nectarine are almost universally propagated on peach seedlings. Seeds are commonly obtained from canneries or drying yards, but seeds of certain red-leaved selections (Tennessee Redleaf, Rutgers Redleaf) are sometimes available commercially. These red-leaved selections are sometimes preferred because of ease in distinguishing between rootstock sprouts and new shoots growing from inserted buds. They appear to be somewhat more subject to cold injury than common peach seedlings.

Plum and prune. The cherry plum or myrobalan (*Prunus cerasifera*) is the most common rootstock for plums and prunes in the Northeast. Myrobalan can be grown on a wide range of soils, including those that are heavy and poorly drained. In California, plums are commonly propagated on peach rootstocks, but this combination can be used only in sandy, well-drained soils in the Northeast, and the trees usually are short-lived. Seedlings of certain European plum varieties (*Prunus domestica*), particularly Ackermann and Pershore, are useful as plum rootstocks, but sometimes sucker excessively in the orchard. They are slightly more dwarfing than myrobalan.

Seedlings of the American plum (*Prunus americana*) are very hardy and are sometimes used as rootstocks for certain American or American-Japanese hybrid plum varieties. They should not be used as rootstocks for most European or Japanese plums because of incompatibility.

The western sand cherry (*Prunus besseyi*) and Nanking cherry (*Prunus tomentosa*) are used as rootstocks for plum and peach where very dwarfed trees are desired. Nursery stands on these rootstocks are often poor because of partial or complete incompatibility between stock and scion. Many trees break at the point of union at digging or after planting in the orchard.

Apricot. Apricot seedlings are the preferred rootstock for apricot, since they are fully compatible and induce early fruiting of the scion variety. Myrobalan seedlings are often used as rootstocks for apricot, but they tend to delay fruiting. Peach seedlings are also sometimes used, but the resulting trees are short-lived and can be grown only on well-drained soils.

SEED GERMINATION

Newly matured seeds of deciduous fruits grown in the temperate zone do not germinate immediately, but first require conditioning by a period of cool, moist storage at temperatures slightly above freezing ("after-ripening" or "pre-chilling" period). The duration of the after-ripening period varies with the individual species of fruit.

At harvest, all fruit pulp should be removed from the seeds to prevent fermentation and heating, which reduce germination. The seeds may be planted immediately after harvest, or they may be dried and stored for later planting in the autumn or the following spring. Planting in late summer or early autumn is the most economical method, as after-ripening is accomplished in the field over winter.

If spring planting is preferred, the seeds must be after-ripened before planting. The dry seeds are soaked in water for 12 to 24 hours and then placed in damp peat moss or sawdust. To prevent seed decay, the storage medium should be moist, but not wet. Polyethylene bags are convenient containers for small lots of seeds. The plastic prevents loss of moisture, and the beginning of germination can be observed without opening the bag. After-ripening seeds should be maintained at temperatures between 33° and 45° F. for periods of 12 to 20 weeks, depending on the species (Table 1). As soon as sprouting begins, the seeds should be planted, or stored at a lower temperature (30 to 32° F.) until planting is possible (Fig. 1). Germinating seeds must be planted carefully, since the young sprouts are brittle and easily broken.

Fig. 1—Germinating cherry (top) and apple (bottom) seeds. Seeds on the right are ready for spring planting, while those on the left are too far advanced for good survival.



Table 1. After-ripening period required for seeds of deciduous fruit trees. Seeds should be placed in a moist medium at temperatures of 33° to 45°F (40° suggested) for number of days indicated.

Species	Time required (days)
Apple, commercial varieties.....	60-80
Pear, commercial varieties.....	45-90
Apricot, commercial varieties.....	30-70
Peach, commercial varieties.....	90-130
Plum	
Myrobalan (<i>Prunus cerasifera</i>).....	90-120
Ackermann (<i>Prunus domestica</i>).....	120-130
Cherry	
Mazzard (<i>Prunus avium</i>).....	100-140
Mahaleb (<i>Prunus mahaleb</i>).....	90-100
Sand cherry (<i>Prunus besseyi</i>).....	60-90
Nanking cherry (<i>Prunus tomentosa</i>).....	60-75

Various treatments improve the germination of seeds of stone fruits. Dry pits may be soaked in concentrated sulfuric acid for a short time (a few minutes to a few hours, depending upon pit thickness), followed by a thorough rinsing in water to remove the excess acid. The seeds are then after-ripened in the usual manner. Germination may also improve if moist pits are initially stored at warm temperatures (65 to 70° F.) for 3 to 8 weeks before after-ripening at low temperatures. Mechanical removal of the stony endocarp (pit) following after-ripening increases germination, but removal of the pit before the after-ripening period may lead to excessive seed decay. These special measures to improve germination are usually not necessary if freshly harvested seeds are properly handled.

For field planting, a shallow, narrow furrow is made with a tractor-mounted trenching tool (Fig. 2). In heavy soils with a tendency to crust, the planting furrow is lined with peat moss or sawdust and the seeds lightly covered with the same materials. The furrow should be mounded over with soil to prevent heaving and seed exposure over winter, but the soil mound must be carefully removed in early spring to allow the seedlings to emerge. For seeds of the stone fruits (peach, cherry, apricot, and plum), planting before mid-September is recommended in New York, since the warm soil temperatures favor weakening of the stony endocarp by soil microorganisms, leading to better germination the following spring.

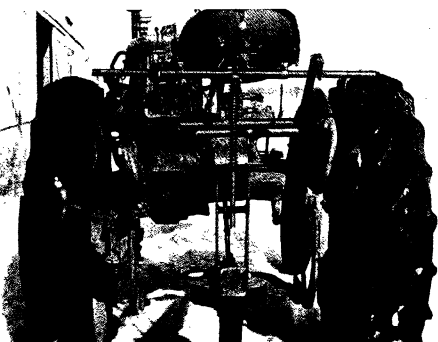


Fig. 2—Tractor-mounted trenching tool for preparing a furrow in which seeds are planted or whip grafts are lined out. Depth of trench can be controlled hydraulically.

The rate of seeding in the nursery row is determined by the expected germination of the seeds, the species of seedling being grown, and the size of the seedling desired. For fall planting of apple, pear, mazzard and mahaleb cherry, and myrobalan plum, the rate of seeding should approximate 15 to 25 seeds per foot of row. The rate should be reduced to 8 to 10 seeds per foot when germinated seeds are planted in the spring.

Seedling rootstocks of these fruits are usually dug after one season's growth and lined out the following year for budding. Under normal conditions in New York, the stem diameter of lining-out stock should be about $\frac{3}{16}$ to $\frac{1}{4}$ inch; seedlings of greater size will grow too large to bud the following August.

Peach and apricot seedlings usually grow vigorously enough to be budded during their first growing season. In this case, a larger seedling is desired, so the fall seeding rate should be reduced to 8 to 12 seeds per foot of row, and the spring seeding rate (germinated seeds) to 4 to 6 seeds per foot. If poor germination is expected, a proportionately larger number of seeds should be planted per unit length of row.

CLONAL ROOTSTOCKS

Clonal rootstocks are propagated vegetatively from one original parent plant; thus each rootstock is identical in character to every other rootstock grown from the same clone. Such clones are selected for special attributes.

Although clonal rootstocks for cherries and plums have been developed and are used commonly in Europe, the only such rootstocks widely used in the United States are those for apples and pears. Apple trees propagated on clonal rootstocks are commonly termed "dwarf," "semidwarf," or "compact" trees. This terminology is not strictly accurate, for some rootstocks reduce tree size appreciably, while others reduce size only moderately, if at all. The amount of dwarfing or size-controlling obtained with any given clonal rootstock depends not only on the rootstock, but on growth characteristics of the scion variety, soil fertility and type, and general orchard practice. Certain clonal rootstocks possess valuable attributes other than size-control. Some of them induce early fruiting, and others are particularly useful for certain soil types and moisture levels.

Because of labor shortages and rising costs since the end of World War II, American fruit growers have become increasingly interested in controlling tree size. The use of seedling rootstocks results in relatively large trees, but certain clonal rootstocks are capable of limiting the size attained by the scion variety propagated upon them. In New York, the increasing tendency toward size-control of apple trees is evident from the following data on the percentage of new apple plantings on clonal rootstocks: 1940-49 - 0.3; 1950-54 - 10.8; 1955-59 - 29.8; 1960-64 - 47.4; 1965 - 61.0.

In order to retain the individual characteristics of a rootstock clone, it must be propagated vegetatively. Any of several methods of vegetative propagation may be used.

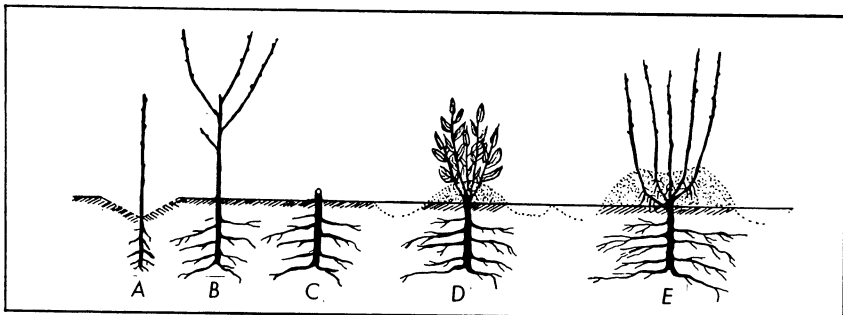


Fig. 3—Steps in establishing mother plants for stooling. (A) rooted shoot after planting in early spring, (B) same at end of first growing season, (C) shoot after cutting back in early spring of second growing season, (D) first hilling up during second growing season, (E) mother stool before rooted shoots are cut off in spring of third growing season.

Stooling. Stooling is the most common method of propagating clonal rootstocks (Fig. 3). The stooling bed is established by planting rooted shoots of the clone about 12 to 15 inches apart in the row. If hilling is performed by hand, the distance between rows may be 3 feet, but when machinery is used, the distance between rows should be at least 8 feet.



Fig. 4—Tractor-mounted hoe used in hilling stooling beds (photo taken in spring before removal of rooted shoots).

The rooted shoots are permitted to grow for 1 year and are then cut back in the early spring to 1 to 2 inches above the ground line. Several new shoots will develop from the crown; when these are 3 to 5 inches in height, loose soil is drawn up around their bases (Fig. 4).

Fig. 5—EM VII stooling bed in late July, after completion of last of three hilling operations.



The soil cover excludes light and stimulates rooting. As the shoots continue to grow, additional soil is hilled up around the bases. A total of three hilling operations is generally required before shoot growth stops in late July (Fig. 5). At this time the basal 6 to 8 inches of each shoot will have been covered with soil. Proper hilling operations will result in a shallow trough in the center of the row to collect and conduct rain to the roots below.

By the following spring, many of the shoots will have formed roots along the basal portions beneath the soil cover. After danger from severe cold is past, the soil is carefully raked away and the individual shoots separated from the mother plant (Fig. 6). The cuts should be made as close as possible to the crown of the mother plant to avoid leaving stubs. All except the very smallest shoots should be removed, whether they are rooted or not. Any unrooted or poorly rooted shoots may be treated as hardwood cuttings (see below).



Fig. 6—Cutting rooted stooling bed shoots in early spring after removal of soil and sawdust cover.

The crowns of the mother plants are left exposed until new growth starts. As the new shoots develop to a height of 3 to 5 inches, hilling is again commenced.

Stooling beds should be located on soils that are light in texture, yet capable of holding adequate moisture. Irrigation may be advisable during prolonged dry periods. The presence of stones or large clods during hilling will break or damage many of the tender shoots. In heavy soils, sawdust or peat moss may be substituted for the soil cover, or mixed with the soil to improve the texture. When sawdust is used in hilling, a side dressing of ammonium nitrate should be applied to both sides of each row at the rate of about one pound per 40 linear feet of row.

Rooted shoots may be removed in the late autumn rather than in early spring. If shoots are harvested in the autumn, the mother plants must be recovered with soil to protect them from injury by low temperatures, and this soil covering must be removed early the following spring before growth of new shoots begins. Spring harvests are, therefore, more economical of time and labor.

Yields from well-established stooling beds range from 20,000 to 60,000 rooted shoots per acre, depending on the clone and growing conditions. About 50 to 60 per cent of these shoots are of saleable size, but the remainder will be too small for immediate use as lining-out stocks. The smaller shoots may be lined out in the nursery and grown for another season to reach marketable size.

A well-managed stooling bed will remain productive for many years. Some of the beds at the Geneva Experiment Station were established during 1932-35 and are still productive in 1967.

Hardwood cuttings. Inducing rooting of hardwood cuttings of some clones is a relatively simple procedure. In New York, cuttings of the clonal apple rootstocks MM 106, EM I, EM VII, and EM IX root more freely than those of MM 111 or EM II. With careful handling, field stands of 50 to 60 per cent can be obtained. Quince cuttings root more readily and are more easily established than clonal apple rootstocks.

Hardwood cuttings are prepared during the dormant season when no leaves are present. Shoots that have failed to root in the stooling bed or shoots harvested from mother trees that have been trained as low hedges are used. The shoots are cut into 6 to 8-inch lengths and stored upright in moist sawdust or peat moss at a cool temperature (35 to 40°F.) until planted.

Cuttings from the bases of 1-year old shoots root more freely than those from the mid-portions; cuttings from the tip sections root very poorly and are usually discarded. Cuttings from shoots 3/16 to 1/4 inch in diameter root more readily than those from shoots of larger diameter.

The development of roots on hardwood cuttings often can be enhanced by treating with indole-3-butyric acid (IBA). The base of the

cutting is dipped momentarily into a concentrated solution of IBA dissolved in 50 per cent ethyl alcohol (1 to 8 grams per liter) or it is soaked in a weaker aqueous solution (25 to 100 milligrams per liter) for 24 hours (Table 2). IBA is also available in powder form mixed with talc; the base of the cutting is dipped in the powder and gently tapped to remove the excess.

Although cuttings harvested from stooling beds or hedges in late winter generally root well, cuttings taken from mature trees usually root very poorly regardless of treatment. Recent experiments in Oregon and California indicate that apple or pear cuttings from mature trees can be successfully rooted if they are collected in October or November. The cuttings are treated with IBA and their bases placed for 3 to 5



Fig. 7—Hardwood MM 106 cuttings ready for planting after being cut in late February, treated with IBA, and held over bottom heat for 3 weeks with tops exposed in unheated barn. Bases have callused, but roots have not yet emerged, and buds are still dormant.

weeks in a moist, well-aerated medium heated to 65 to 70°F. Under West Coast conditions, the cuttings may be planted in the field in the winter where they complete their chilling requirement and root the following spring. Fall planting would not be advisable in New York, but the method may prove useful when the cuttings can be held in cold storage until spring. Bottom heat may also improve rooting of cuttings taken in late winter in New York. Heating of the bases of the cuttings should be discontinued and the cuttings lined out before extensive rooting occurs (Fig. 7).

At planting, the cuttings should be spaced about 3 to 6 inches apart in the row and inserted in deep trenches so that only the top 1 to 2 inches is exposed above the soil. The soil must be carefully firmed to eliminate any air pockets around the bases.

Many failures of cuttings in field plantings are caused by poor soil preparation and late planting. The major part of root development occurs after planting, and good root development must occur before any significant amount of leafy growth appears. The soil should be worked into a friable condition that will retain moisture well, and plantings should be made as early in the spring as the soil can be properly fitted. In New York, plantings can sometimes be made as early as April 1, and should not be attempted after the first or second week of May. In general, the earlier the planting, the better the field stand.

Table 2. Methods of preparing solutions of indole-3-butyric acid (IBA) for treating cuttings.

Stock solution: (8000 parts per million):

Dissolve 1 level teaspoon IBA crystals in 1 cup 50 per cent ethyl alcohol. Keep tightly stoppered, and refrigerate when not in use.

Concentrated dips

Concentration desired	Mix indicated volumes of:	
	Stock solution	50% ethyl alcohol
(parts per million)	(cups)	(cups)
1000	1	7
2000	1	3
4000	1	1
8000	(Use stock solution)	

Aqueous solutions

Concentration desired	Mix indicated volumes of:	
	Stock solution	Water
(parts per million)	(cups)	(quarts)
25	$\frac{1}{4}$	20
50	$\frac{1}{4}$	10
100	$\frac{1}{4}$	5

Root cuttings. Multiplication of clonal rootstocks by root cuttings is possible, but the procedures are laborious and generally used only when material is in short supply or with materials difficult to multiply by other methods.

Root sections about 4 inches in length are removed from young plants (1 or 2 years of age). Root sections from older plants often fail

to develop the necessary leaf buds. The root sections should be about one-quarter to three-quarters of an inch in diameter. A square cut is made at the upper end and a slanting cut at the bottom. The cuttings may be made during the winter and stored in moist sawdust at cool temperatures until planted.

Root cuttings should be set upright (square end up) in a shallow furrow and barely covered with soil. A number of shoots often develop from each cutting, and when these attain a height of 2 to 3 inches, all but the strongest shoot should be removed.

Softwood cuttings. Still another method of propagation is to induce rooting on leafy cuttings made from the terminals of rapidly growing shoots in early summer. Cuttings taken from stool beds or low hedges root more easily than do similar cuttings from mature trees. Disadvantages are that special care is needed to induce rooting before the succulent cuttings dry out and die, and that cuttings are somewhat difficult to establish even after rooting has occurred.

Maximum rooting is obtained by collecting the softwood cuttings during the period of most active terminal growth, which occurs from early June to early July in New York. If growing conditions are favorable, a second harvest is sometimes possible from terminals that develop to replace those removed earlier. As the leafy terminals are collected, they are placed in plastic bags or moist burlap to prevent wilting. They must never be allowed to wilt during trimming. Individual cuttings should be 4 to 6 inches in length with one or two of the basal leaves removed to permit inserting the base of the cutting in the rooting medium. However, as much leaf surface should be left as possible, since the amount of rooting is generally proportional to the amount of leaf surface. Although good results in rooting softwood cuttings of apple have been obtained without using rooting compounds, rooting is generally improved by the use of IBA, as described previously for hardwood cuttings.

The rooting medium may be composed of any material that retains moisture without becoming waterlogged. A commonly used medium is clean plaster sand mixed with an equal volume of peat moss. This medium drains well but remains moist and is sufficiently stiff to hold the cuttings erect.

The bases of the cuttings are inserted 1 to 2 inches deep in the medium and spaced so that shading is not excessive. Glass frames may be placed over the cuttings to reduce wilting, but this method requires constant and tedious watering, shading, and ventilating. A more economical method is to use intermittent misting with fine water droplets to keep the cuttings cool and moist. Mist systems are commercially available and consist of a series of nozzles delivering a fine spray of water, a solenoid valve to control the flow of water, and a device to activate the solenoid valve (Fig. 8). The activating device may be a simple time switch, or it may be a mechanism activated by the mist

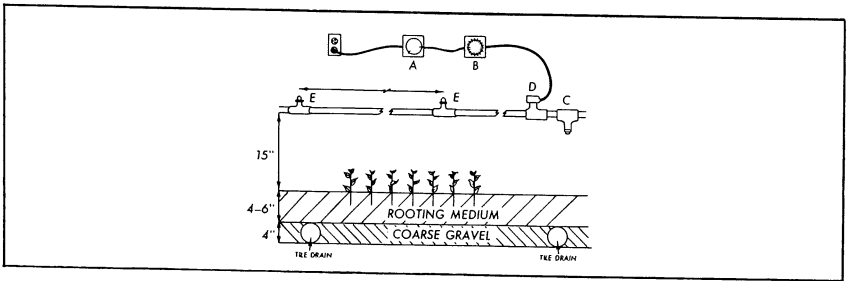


Fig. 8—Diagram of essential parts of a misting system for rooting softwood cuttings. (A) time clock set to turn power on in morning, off in evening, (B) time clock with 10 to 15-second intervals to control mist during day, (C) strainer to remove solid particles from water and prevent plugging of nozzles, (D) solenoid valve, controlled by time clock (B), to open water line during misting cycle, (E) misting nozzles spaced 3-3½ feet apart.

itself. In the latter type, called an “electronic leaf,” two electrodes are separated by a nonconductor, which when wet will permit a current to flow between the electrodes, activating a relay which closes the solenoid valve. As the water film evaporates, the circuit is broken, and water flows through the nozzles. This type of mechanism often works poorly with hard water, because a mineral deposit may permanently short the electrodes and prevent misting. With either type of control device a second timer is needed to turn off the mist at night, when humidity is high.

The system should be adjusted to limit the amount of mist to the minimum needed to prevent wilting of the cuttings. Ideally, a misting cycle should begin just as the mist applied in the previous cycle evaporates. Excessive amounts of water may not only leach the leaves severely, but may saturate the rooting medium and cause the bases of the cuttings to die from lack of aeration.

Recent experiments suggest that the adverse effect of leaching by mist may be partially overcome by applying a small amount of soluble fertilizer in the mist. Leaching and wilting of very succulent cuttings may be reduced by dipping the foliage in a weak solution of polyvinyl latex (“Wilt-Pruf”) or water soluble wax (Carbowax 2000). These practices cannot yet be recommended unreservedly, but are worthy of further trial.

Rooting should occur within 3 to 4 weeks after the cuttings have been placed in the medium. As roots develop, the amount of mist should be gradually reduced and the periods between misting cycles slowly lengthened to harden the cuttings. The cuttings must be shaded during this critical period to compensate for the decreased misting. With some species, notably cherry, immediate removal from the mist after rooting may be required to prevent defoliation, which is lethal to the cuttings. In addition to the greater amount of care required to prevent loss, softwood cuttings must usually be grown for two seasons in order to reach a size suitable for budding.

Other methods of propagation. Other methods of propagating fruit or rootstock clones are occasionally used. In general, these methods require special manipulations that are expensive and time-consuming, but they may succeed where the common methods do not.

Layering is, in essence, a modified method of stooling, but it is often used with materials very difficult to propagate, such as filberts. The mother plants are set at a 45° angle along the nursery row. Before growth begins the following spring, a shallow trench 4 to 6 inches in depth is dug on each side of the row, and the dormant plants are bent down to the ground and held in place with wooden pegs or U-shaped wires. Any weak lateral growth should be pruned out at this time, but strong laterals should be cut back lightly and also pegged down. The layered shoots are then covered with fine soil or sawdust, 1 to 2 inches in depth, before growth starts. As the young shoots push through the soil or sawdust covering, additional layers of covering are applied. Care must be taken not to cover too deeply areas where shoot growth has not yet appeared.

The following spring the covering soil is carefully removed and the rooted shoots are cut off. Any unrooted shoots may either be pegged down again to renew the layered plant, or used as hardwood cuttings.

Air layering. This method is of value when the amount of material available for propagation is in very short supply. One or 2-year old branches are partially girdled by removing a complete section of bark about 1 inch wide just before growth starts. The girdled area, and the bark 2 to 3 inches above and below it, are surrounded with a loose wrapping of moist sphagnum moss, and the entire area is then covered with a piece of polyethylene film (2 to 3 mil thickness), which is tied securely to prevent water loss (Fig. 9). Rooting will occur just above the girdled area. At the end of the growing season when the shoots are dormant, the polyethylene may be removed and the rooted shoot cut off.

Fig. 9—Air layered shoots on a mazzard rootstock plant.



INCOMPATIBILITY

Incompatibility is the failure of the scion and rootstock to form a functional union. In the nursery, incompatibility may be so pronounced that the scion dies or breaks at the point of union with the rootstock. In some instances, serious incompatibility may not develop until several years after the tree has been established in the orchard. The affected trees initially appear to grow quite normally, but when they are subjected to some stress, such as drought or heavy fruiting, they break at the union or decline and die.

Certain scion-rootstock combinations are notoriously incompatible: peach on *Prunus tomentosa* or *P. besseyi*, Bartlett pear on quince, Stanley prune on myrobalan, and Van sweet cherry on mahaleb. Many myrobalan seedlings are sufficiently compatible with Stanley prune to make desirable orchard trees, but others will not support the growth of Stanley scions for more than 3 to 5 years. In this instance, incompatibility appears to be a heritable characteristic present in some myrobalan seed source trees.

The adverse effects of scion-rootstock incompatibility can be avoided by using an interstem capable of making strong unions with both the scion and the rootstock. Decline of Stanley prune does not occur on the myrobalan rootstock if Italian prune is used as an interstem. Similarly, the use of Hardy or Old Home pear interstems avoids the brittle union of Bartlett pear with quince rootstocks.

BUDDING

The scion variety is established on the rootstock by either budding or grafting. In commercial practice, most nursery trees are propagated by budding to conserve labor and materials. This method of propagation is generally less expensive than grafting and produces a larger number of saleable trees in a shorter period of time.

The rootstocks are first established in the nursery by planting ("lining-out") in the early spring. Nursery rows are commonly spaced 42 to 60 inches apart, with the individual rootstocks spaced 8 to 10 inches in the row. The rootstocks are cultivated to suppress weed growth and should be fertilized and irrigated as necessary to ensure vigorous growth.

The budding operation is performed when the scion wood supplying the buds is mature and when the rootstocks are growing vigorously so that the bark "slips" or peels easily. In New York, budding is usually commenced in mid-July and may continue until early September. The growing season is too short for June budding to be practical. In June budding, the buds grow in the same season that budding is done.

The sequence in which the various kinds of fruit trees are propagated depends largely on the individual nurseryman. Seedlings of sand cherry and Nanking cherry (dwarfing rootstocks for peach or plum) cease growth relatively early and are usually budded first (mid-July). Other fruits are usually budded in the following sequence: pear on seedling pear; apple on apple; sweet or sour cherry on mazzard; pear on quince; plum or apricot on myrobalan; sweet or sour cherry on mahaleb; peach on peach.

The scion wood that supplies the buds for propagation should be collected only from vigorous, healthy trees of known variety. Mature shoots are selected from branches well exposed to light (Fig. 10A). Water sprouts growing on the inside branches are often immature and are not a desirable source of buds. Terminals from young nursery trees are a very satisfactory source.

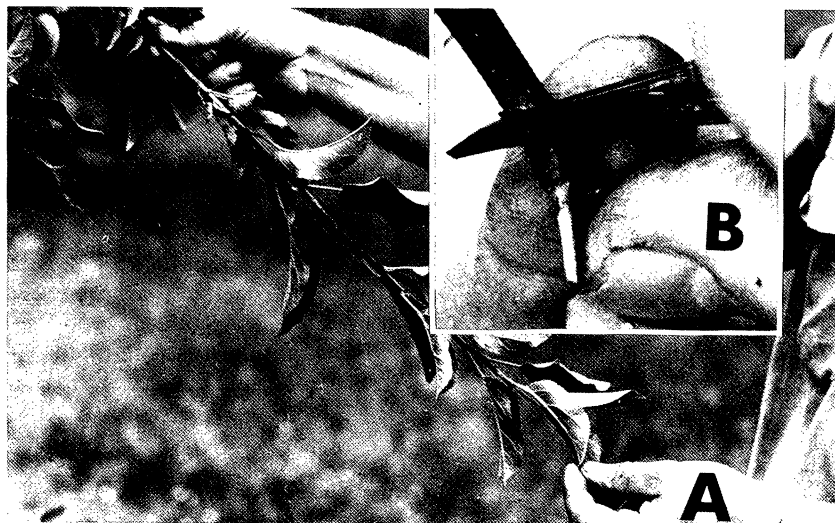


Fig. 10—(A) selection of bud stick, (B) cutting the bud shield.

After the shoots are removed, the leaves are trimmed off by cutting through the leaf petiole (stem) about 1/2 inch above its juncture with the bud stick. The base of the petiole is left attached to serve as a handle for inserting the bud and bud shield into the rootstock (Fig. 10B). Any stipules (small leafy structures at the base of the petiole) should be trimmed away. The terminal 3 or 4 buds at the end of the bud stick are often too immature for use and are discarded.

The bud sticks must be prevented from drying out during collection. They should be trimmed immediately, wrapped in wet burlap, and temporarily stored in a shady place. Preferably, bud sticks should be collected fresh every day. Any bud sticks not used immediately should be stored at 35°F.

The buds are usually inserted into the rootstocks about 2 or 3 inches above the soil line. However, insertion at a 10-inch height is recommended for apple buds propagated on the clonal rootstocks EM VII and EM IX, where deep planting to improve anchorage is desirable.

All buds should be placed on the same side of the nursery row to facilitate future nursery operations and to assist in locating any buds that failed to unite with the rootstock.

Successful budding requires speed and a sharp knife. Specially designed budding knives are available, constructed of hard steel to hold a sharp edge. However, a pocket knife is quite suitable if kept sharp.

First, a T-shaped cut is made in the bark of the rootstock (Fig. 11B) at the desired height. The horizontal portion covers about $1/3$ of the circumference of the rootstock, and the vertical portion is about an inch in length. The cuts should penetrate the bark completely, but should not pierce the wood beneath. If the bark is slipping properly, the two flaps formed by the T-cut are easily loosened from the wood beneath by twisting the knife blade slightly as the vertical cut is completed, or by inserting the point of the knife beneath the bark.

Next, the bud and bud shield are removed from the bud stick which is held with the terminal end toward the body (Fig. 10B). A slicing cut is made, beginning half an inch below the bud to be removed, by drawing the knife toward the terminal (Fig. 11C). The knife stroke should penetrate the bark completely and cut slightly into the wood beneath. The completed shield is about an inch long and $1/4$ inch wide, and consists of the bud and an oval section of bark together with a thin section of wood. The wood section may be removed, but is usually retained as part of the shield when budding fruit trees.

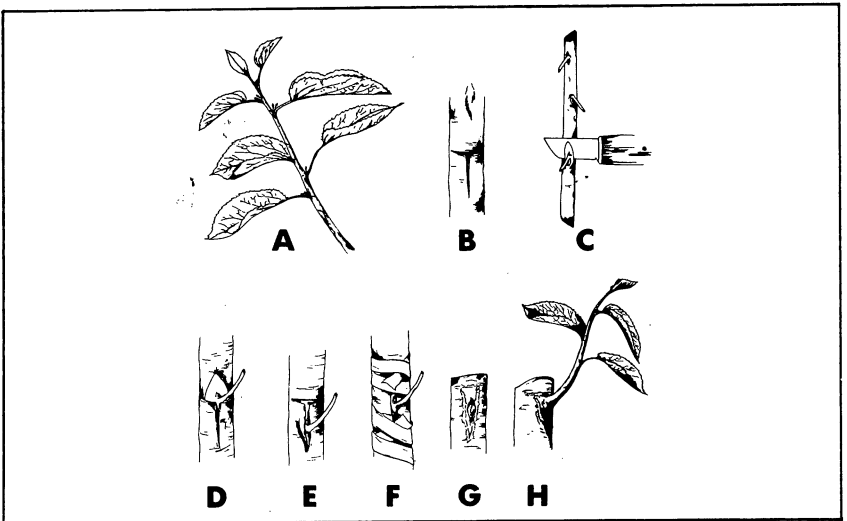


Fig. 11—Steps involved in developing a successful budding procedure.

Using the leaf petiole as a "handle," the bud shield is inserted between the two bark flaps, starting at the junction of the two cuts of the T, and is pushed downward to the base of the vertical cut (Fig. 11D). The point of the knife may be used to force the shield downward until it fits snugly behind the bark flaps. When properly inserted, the bud is upright and about 3/4 inch below the horizontal cut. If the bud shield is too long, it should be cut off level with the top of the T-cut to permit a tight fit (Fig. 11E).

The entire operation from making the T-cut to final insertion of the bud can be completed in 30 seconds or less by a skilled budder. Speed is essential to prevent drying of the bud shield between its removal from the bud stick and its insertion into the rootstock.

After the bud shield is inserted into the T-cut, it is tied in place with a bud-tie to ensure contact between the cambiums of the bud shield and the rootstock. Bud-ties are rubber bands of varying thicknesses. For New York, .010 gauge (.01 inch) ties about 5 inches long are recommended. The bud-tie is wrapped several times around the rootstock to hold the bud firmly in place (Fig. 12). It need not cover the entire area of the cut and spaces between the laps are permissible (Fig. 11F). The bud itself should not be covered. Waxing of the tie and T-cut is unnecessary.

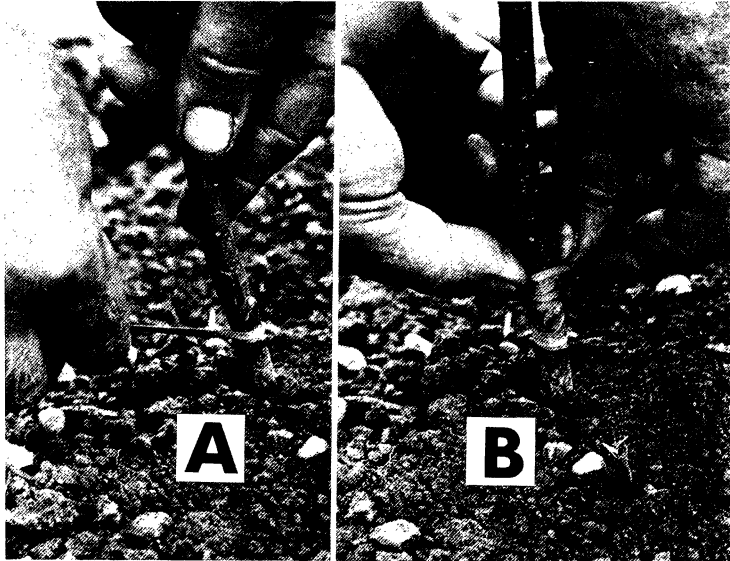


Fig. 12—(A) tying the bud,
(B) completion of tying.

In large-scale budding operations, weeds and obstructions in the rootstock row are first removed. Leaves and side branches are stripped from the bases of the stocks. Then, the budding is done by a team of two workers: the first cuts and inserts the buds, and the second follows, tying the buds in place.

The rubber tie disintegrates and drops off in 3 or 4 weeks. In the intervening period, the bud and the stock grow together and the bud is held firmly in place. Separation of the leaf petiole from the shield within 2 or 3 weeks of budding indicates a successful union. If the petiole fails to drop off, the bud has failed to unite with the stock. In case of bud failure, a new bud can be inserted into the stock the same season.

At the time of budding, each variety should be carefully marked in the nursery row with weatherproof labels. A map showing the location of each variety in the nursery should also be made.

When budding is done in late summer, the buds usually remain dormant for the remainder of the year. An occasional bud may make a short growth in the fall. Such shoots are pruned back to the most desirable side bud the following spring.



Fig. 13—Cutting off the top of the rootstock just above the bud in early spring.

As the buds begin to turn green the following spring, the tops of the rootstocks are cut off with sharp pruning shears just above the inserted buds (Fig. 11G and Fig. 13). The cut is slanting with the high side of the cut toward the bud. For most kinds of fruit trees, the tops should be cut before the buds break fully into growth. However, wounds may heal better in peaches if top cutting is delayed until a short time after leaf growth starts.

The removal of the tops stimulates the growth of both inserted buds and buds on the rootstocks. These growths from the stocks (suckers) should be removed as they develop by rubbing them off with the fingers. Removal is necessary two or three times at 2-week intervals following top cutting. The inserted buds grow vigorously (Fig. 11H) and eventually suppress the emergence of new suckers.



The nursery must be kept free of weeds with a tractor-mounted row cultivator and supplemental hand hoeing and chemical weed control. Budded trees must be hoed with great care in order to prevent injury to the new shoots.

Apple scions on the hardy stock, Robusta No. 5, make weak unions and the young shoots are easily broken by the wind. Wind damage is prevented by tying the young shoots to wire stakes inserted beside the trees.

Herbicides are often used in fruit tree nurseries to reduce the need for expensive hand hoeing. Generally, weeds are easily controlled by row cultivators and light hand hoeing in the first year after planting lining-out stocks. In the spring following budding, weeds can become well established in the spring while the soil is still too wet to permit cultivation. Simazine or a combination of simazine and diphenamid sprays applied in late fall or in early spring controls weeds adequately without injury to the nursery trees. Materials and local recommendations for rates and timing of applications can be obtained from county agents or from agricultural experiment stations.

Several insects and diseases may injure the young trees in the nursery. Disease and insect control recommendations for fruit tree nurseries are provided in New York State Agricultural Experiment Station Bulletin 776.

WHIP GRAFTING

Fruit trees can also be propagated by whip grafting, often called bench grafting or tongue grafting. Whip grafts may be made indoors during the winter when work schedules are generally less pressing than they are in summer. Grafting has the disadvantage of requiring more scion wood than is needed in budding. Apple, pear, cherry, plum and grape are often whip grafted, but peaches are difficult to graft and are therefore generally budded.

For whip grafting, scions are cut from the variety source tree during the winter. Vigorous shoots of the previous summer make the best wood for grafting, but water sprouts are satisfactory. Two-year old wood can also be grafted, but is generally less desirable than large, 1-year old shoots.

Whip grafts are usually made on rootstocks which have been dug from the nursery. They can also be made outdoors in the spring, using rootstocks which were lined out in the nursery a year earlier. The best rootstocks for whip grafting are 1/4 to 1/2 inch in diameter. Scions should never be larger than the stocks, but they may be slightly smaller. Best grafts are made when scion and stock have equal dia-

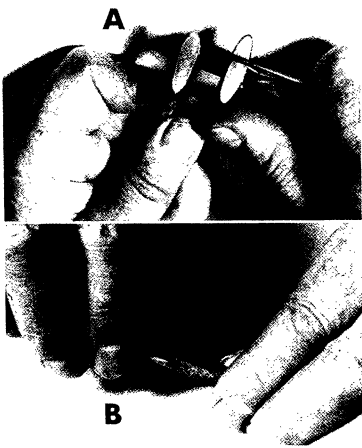


Fig. 14—(A) cutting for whip grafting, (B) uniting stock and scion.

meters. Figures 14 and 15 illustrate the method of making whip grafts. Scions are usually about 4 inches long with three or four buds. At least one bud must be present. The top of the scion is cut on a slant just above a bud so that it will heal smoothly. Slanting cuts about 1-1/2 inches long are made at the top of the rootstock and at the bottom of the scion (Fig. 14A). A cut about 1/2 inch long is made downward through the middle of the long slanting cut on the stock and another upward through the cut on the scion (Fig. 14A). The scion is then joined with the stock by inserting the tongue of the stock into the cut on the scion and the tongue of the scion into the cut on the stock as shown in Figure 14B.

As in budding, the scion cambium and the rootstock cambium must be in line with each other, preferably along most of one side of the graft union. If the stock is larger in diameter than the scion, the cambium layers can be aligned only on one side.

The graft union is wrapped with an adhesive plastic-paper tape, (Fig. 15C) or with a rubber bud-tie. Cloth adhesive tapes made especially for grafting (Fig. 20F) and sold by nursery supply stores can also be used. However, the plastic-paper tape is superior to the cloth tape because it deteriorates more quickly in the nursery row. The more durable cloth grafting tape must be cut about a month after planting to prevent girdling. The graft union need not be covered with grafting compound.

Fig. 15—Whip grafting.

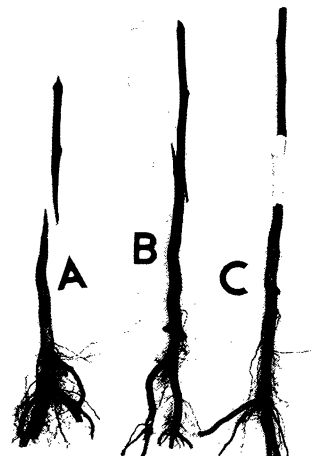




Fig. 16—Whip grafted tree growing in the nursery. Note union of stock and scion.

After the grafts are made and wrapped, they must not dry out. Drying can occur very quickly in a heated workroom in mid-winter. The grafted plants are tied into bundles and stored at about 35°F. with the roots buried in damp sand. They can also be wrapped in plastic bags and stored in a refrigerator, or packed in a box with damp peat or sphagnum moss.

Small lots of plants can be planted by hand, using a spade. For larger lots, a narrow furrow is made with a special trencher drawn by a tractor (Fig. 2). Row width should be adapted to tractor implements; spacings of 40 to 48 inches are satisfactory. The roots are placed into the narrow furrow and the soil is packed firmly around them. Trees are spaced about 6 to 8 inches apart in the row. For very large nursery operations, special 2-row nursery tree planters similar to cabbage planters are used.

During the first few weeks after planting, suckers will develop from the rootstocks. These should be rubbed off as described above for budded trees. As growth begins in the summer, a firm, smooth union forms between the scion and the rootstock (Fig. 16).

During the early summer, the nursery should be cultivated at 10-day intervals using a tractor-mounted row cultivator. A side dressing of ammonium nitrate at 100 pounds per acre is sometimes applied with one or two of the early cultivations. If potassium is deficient in the soil, it also should be applied. It is desirable to keep the planting free of weeds, especially in the early summer when trees are making their most rapid growth. In late summer, a little weed competition may be beneficial in stopping growth so that the trees are matured by digging time.

When rainfall is deficient, irrigation can be very beneficial to the growth of the nursery trees. Each nurseryman must decide for himself whether it will be economical for him to install an irrigating system.

The shoots from buds which were budded in the preceding season make more growth during the summer than shoots from whip grafts planted in the spring. This is because the roots of budded trees have already been established in the soil for a year, and bud growth can begin in the very early spring. Grafted trees, on the other hand, must be planted sometime after the beginning of the growing season, and considerable time is required for the roots to become well established in the soil.

INTERSTEMS

Fruit trees with interstems are sometimes preferred for orchard planting either because of special characteristics of size control or to overcome scion-rootstock incompatibilities (see p. 18). For example, mature apple trees which have 5-inch trunk sections between the roots and tops consisting of the extremely dwarfing clones, EM VIII or EM IX, develop into trees which are about half the size of trees with seedling rootstocks, yet have the advantage of strong root systems. EM VII is rarely used as an interstem because it does not reduce growth enough.

Interstems of apples are generally made by whip grafting 6-inch long scions of EM VIII or EM IX on strong seedling rootstocks. The whip grafts are made during the winter, and the grafted plants are lined-out in early spring in the usual manner. The desired scion variety is budded 5 inches above the graft union the following August. In the spring following budding, the tops are cut back to the buds in the customary manner.

Interstem trees can also be produced by making two whip grafts on each tree in the winter. The 5-inch scion of EM VIII or EM IX is grafted onto the seedling rootstock, and the scion of the desired variety is grafted onto the top of the interstem. The double grafted trees are planted in the nursery and cared for in the usual manner. Because each tree has two grafts, especially careful handling is required.

A third method is to insert the buds of the interstock variety the first summer and bud the scion variety the second summer. A disadvantage of this method is that 2 years are required to obtain saleable trees. Another disadvantage, at least with prune trees, is that rootstocks which have grown in the nursery for 3 years are undesirably thick in diameter and are somewhat difficult to dig from the nursery and plant in the orchard. Because of the extra labor required to produce interstem trees, they are more expensive than trees grown from a single budding. However, in these special cases, the added benefits to the fruit grower are worth the extra costs.

Dwarf Bartlett pears are grown as interstem trees. Bartlett buds or scions do not make strong unions with quince roots, which are used as the dwarfing stock for pears. To overcome this incompatibility, the Old Home pear variety is used as an interstem. Old Home is compatible with both Bartlett pear and quince, and is also resistant to fire blight disease.

The Stanley prune often develops a root constriction and eventually dies when budded directly on myrobalan roots. When virus-tested Italian prune is used as an intermediate stempiece between the myrobalan roots and the Stanley top, the constriction disorder does not occur.

DIGGING AND STORING NURSERY TREES

Because of their vigorous growth, peach and sweet cherry trees are almost always dug 1 year after budding. Their rootstocks have grown during the same season that they were budded and are therefore 2 years of age at the time of digging. Trees of apple, pear, and sour cherry are also generally dug as 1-year olds, but sometimes are left for an additional one or more years. Trees with interstems must always be left in the nursery a second year. When left in the nursery, second-year trees are pruned back to a height of 24 or 30 inches at the beginning of the second growing season. This pruning induces the growth of side branches (Fig. 17) which can be trained into a permanent branch framework after the trees have been planted in the orchard.

Nursery trees are dug in October and November with a U-shaped blade mounted on a large, high-clearance tractor (Fig. 18). The roots are first undercut and then the trees are pulled out by hand. Small lots can be dug with a spade. Trees (Fig. 19) are tied into bundles, care being taken to retain the varietal identity of each lot. In some large nursery operations, a part of the digging is deferred until early spring.



Fig. 18—Nursery tree digger.



Fig. 17—Apple trees in their second summer in the nursery showing growth of side branches.

Fig. 19—Ideal 1-year old nursery tree ready for orchard planting.



Tree roots must not be allowed to dry out in storage. The trees should be put into a cool, damp cellar as soon after digging as possible. Refrigerated nursery storages are sometimes used. The floor is covered with sand, in which trenches are dug, and the tree roots buried. Bins in which bundles of trees are piled horizontally with roots covered with damp sphagnum moss are generally not desirable because the roots are often allowed to dry out. If the roots dry out even for a short time, the trees may not grow after they are planted in the orchard; drying is one of the major causes for failure when the grower plants nursery trees.

In a warm nursery cellar in the early spring, sweet cherry trees are among the first to begin to grow. Apple trees can be stored longer without excessive growth of buds.

TOP GRAFTING ORCHARD TREES

A fruit grower may wish to convert part of his orchard to another variety, perhaps because the first variety was unprofitable or because trees of another variety are needed for cross-pollination. Established trees can be converted by topworking scions of a new variety into them. Trees from 1 to 25 years of age or older can be topworked, although trees between 4 and 10 years of age are most easily top grafted. Topworking should be attempted only on healthy, vigorous trees.

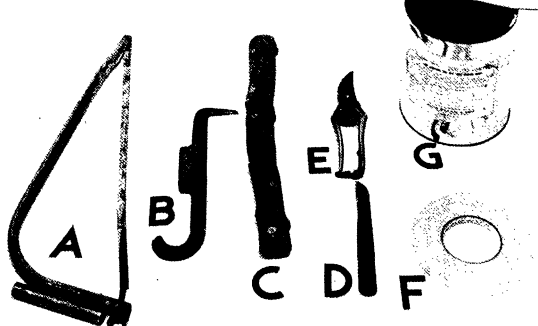
Apple and pear trees can be top grafted without difficulty. Cherry trees are more difficult to graft, and peaches are seldom grafted successfully.

Commercial apple varieties should not be topworked on crab apple trees because the crab apple trunks cannot tolerate certain viruses which commercial varieties sometimes carry. These graft combinations will initially make good unions, but in a few years the trees may become stunted and decline.

Trees are topworked in the spring, preferably about 2 weeks before bloom. However, successful grafts have been made as early as February and as late as mid-summer. Fully dormant scion wood is generally used, but experiments have shown that if grafting is done immediately after the scions are cut, successful grafts can be made using scions which are in full bloom with partially emerged leaves. Some growers erroneously believe that grafting should be done in June, after the bark begins to slip. It is possible to graft in June, but grafts made 2 weeks before bloom are more likely to succeed.

Scions for spring grafting are usually collected in the winter and stored until used. They must not be allowed to dry out during storage. They can be wrapped in damp sphagnum moss or put into plastic bags and held in a refrigerator at 35 or 40°F. Scions which are cut in the spring should be examined carefully for winter injury.

Fig. 20—Tools used in cleft grafting. (A) saw, (B) grafting iron (C) club to drive grafting iron, (D) knife, (E) shears, (F) half-inch wide grafting tape, (G) grafting compound and flat stick used to apply it.



The tools for grafting are illustrated in Figure 20. Several different techniques can be used to make grafts, but cleft grafting (Figs. 21 and 22) is the easiest and most common. Timing is less important because cleft grafts can be made during dormancy, while bark grafts cannot be made until the bark slips.

If 7 or 8-year old apple trees are to be grafted, five or six sturdy branches well spaced around the stock tree are selected (Fig. 23A). These branches should comprise about half the branch surface on the tree. Branches not more than 4 or 5 feet above the ground and those that will make the best shaped framework should be grafted. When very high branches are used, the branches of the new variety will be too high for easy harvesting. The selected branches are sawed off squarely where they are 1-1/2 to 2-1/2 inches in diameter (Fig. 21) and not more than 18 inches away from the trunk or a main branch. Ungrafted branches are retained to sustain the tree's growth during the first summer while the grafts are becoming established (Fig. 23A). By competing for water and nutrients, these sustaining branches also prevent the scions from making too much growth late in the summer.

The sharp-bladed grafting iron is placed across the cut end of the branch to be grafted and driven with the club until a vertical cleft about 4 inches deep is made. The grafting iron is then removed and its wedge end is driven into the center of the cleft until the latter is opened about three-eighths of an inch (Fig. 21A).

Scions are prepared from shoots about 1/4 inch in diameter. One-year old shoots are easy to make into scions and result in very successful grafts; but scions from 2 or even 3-year old wood also may be used. The scions (Fig. 21) should be 3 to 6 inches in length and must carry at least one bud, preferably two or three buds. The base of the scion is trimmed into a long wedge to conform to the size of the split in the branch where it is to be placed. The outer edge of the scion wedge should be slightly thicker than the inner edge.

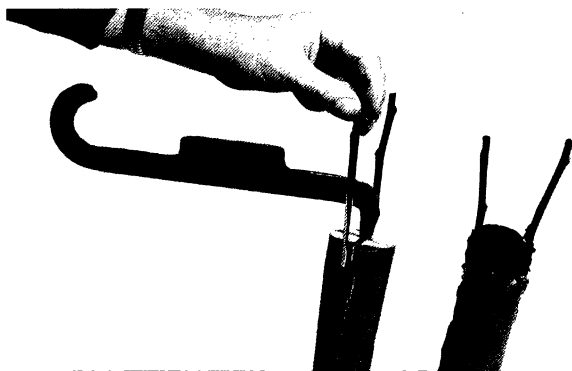


Fig. 21—Cleft grafting.

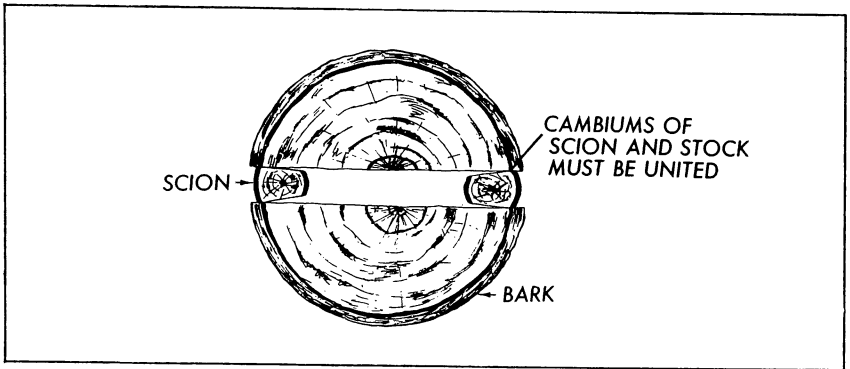


Fig. 22—Cross-section of cleft graft showing matching of scion and stock cambiums.

The prepared scions are inserted into the cleft so that the cambium layers of the scions and branch are in line (Fig. 22). The wedge of the grafting iron is then removed and the pressure of the stock branch holds the scions firmly in place. The exposed cut surface of the stock branch and the vertical cleft are then coated with grafting compound. If the stock branches are less than an inch in diameter, the scions should be held in place by wrapping the stock branch with grafting tape (Fig. 20F) before applying the grafting compound. The grafting tape must be removed later in the season to prevent girdling.

Two scions are usually inserted at the opposite sides of the cleft in the branch. Even though only one graft will eventually be preserved, the second scion ensures against the failure of one of the scions to unite and grow and, additionally, aids in healing both sides of the cleft.

Commercially available water-soluble asphalt grafting compound is very satisfactory for covering grafting wounds to prevent these from drying out before the graft unites and grows. It is relatively inexpensive, adheres firmly, and does not require heating before application as do beeswax-rosin grafting waxes. It is easily thinned to the proper consistency (thick paste) with water, and will adhere and serve as a marker for several years after the graft wounds have healed. If rained on before drying, it may be washed off exposing the wounds and causing the scions to die. Unused grafting compound may be stored indefinitely by protecting it from freezing and covering the surface with a water layer to prevent drying out. Water-insoluble asphalt pastes, such as those used in home building, are very toxic to plants and should not be used as grafting compounds.

The severe pruning associated with cleft grafting stimulates many dormant buds to grow on the branches just below the cuts. These unwanted suckers should be pulled off two or three times, until the grafts are growing vigorously enough to suppress further sucker growth. Failure to remove these suckers may restrict scion growth.



Fig. 23—Apple tree 1 year after grafting. (A) half of branches were retained for 1 year to sustain tree's growth, (B) pruned.

The inserted grafts will grow very vigorously (Fig. 23B). The succulent tissue is very attractive to aphids, and special summer sprays may be required for aphid control.

In the year after grafting, the branches which had been left to sustain tree growth are pruned off (Fig. 23). If desired, additional scions can be grafted at that time. In succeeding years, all suckers and water sprouts emerging from the stock tree should be removed.

When two scions are grafted into a branch, one often grows more vigorously than the other, or one may branch at an undesirable angle (Fig. 24A). In the second and third year after grafting, the less desirable scion should be headed back by about 1/3 of its length (Fig. 24B) in late winter; it should not be removed completely because

Fig. 24—(A) scion grows 1 year after grafting, (B) pruned.





Fig. 25—The less desirable scion is retained 3 or 4 years to aid healing of the pruning wound before it is pruned off.

its growth will aid in healing the cut. However, it should be gradually headed back in succeeding years and finally removed entirely (Fig. 25). The permanent grafts are usually not pruned extensively until they begin to bear fruit (Fig. 26), but side branches with angles less than 30° should be removed.

Instead of grafting only a few large branches, numerous grafts are sometimes placed into smaller branches about an inch in diameter, near the outer surface of the tree head. This method requires a great deal more work than the use of larger limbs. It is also possible to graft even larger branches up to 4 inches, or even to remove the entire tree head and graft into the trunk, which may be 3 inches or more in diameter. However, very large cuts make healing difficult. Extensive wounds often decay, causing a weak tree structure.

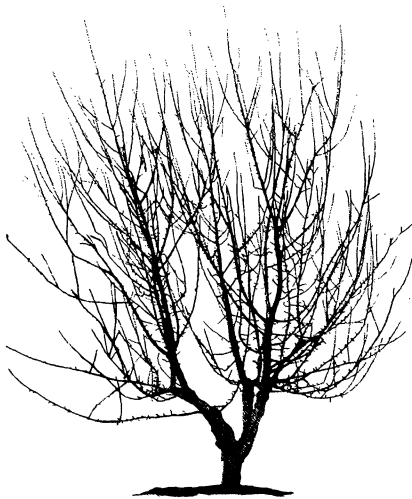


Fig. 26—Apple tree top grafted to a new variety.

Cleft grafting is the most common method of topworking fruit trees, but several other types of grafts can also be used. Some of these are: side graft, bark or inlay graft, patch graft, and stub graft. Each of these has its own special features, but all resemble cleft grafting.

Orchard trees may be budded in early August, instead of top grafted in early May. Buds should be placed on the lower sides of 2 or 3-year old branches; the new branches grow straighter than when budded on the top side. In the spring after budding, branch terminals of the stock tree are cut back to the new buds to stimulate their growth. Over a period of 2 or 3 years, all of the nonbudded branches on the stock tree are removed.

Some fruit growers prefer to plant trees of a hardy variety such as McIntosh to serve as framework trees. Two or 3 years after planting, the McIntosh frames are top budded in early August to the desired variety. Buds can be placed into 1, 2, or 3-year old branches, depending upon the best location for new branches. Robusta No. 5 is sometimes used in northern areas as an extremely hardy stock. Rooted cuttings are planted in permanent orchard locations. After they have developed into trees with well-shaped frames, they are top budded to the desired variety.

BRIDGE GRAFTING

Trunk or root bark on orchard trees is sometimes eaten by rabbits or field mice during the winter. This can occur even when poisoned baits and wire trunk guards have been used. Trees with bark removed completely around the trunk will die, although a narrow vertical strip of continuous bark may prevent death. Completely girdled trees can be kept alive by bridge grafting (Fig. 27) or inarching (Fig. 28). Winter-injured trunks or those with bark injuries from implements also may



Fig. 27—Bridge grafting.



Fig. 28—
Inarching.

require repair. Bridge grafting is most easily done just after bloom when the bark is slipping, so that inlay grafts can be made. Bridge grafting is more successful with apple and pear trees than with stone fruits; injured trees of cherry, peach and plum are seldom bridge grafted.

Bridge grafting consists of implanting long scions to bridge the area of damaged bark (Fig. 27). Hardy varieties such as McIntosh, Wealthy or Duchess should be used as scion sources for apple. Narrow sections the width of the scion and about two inches long are cut out of the trunk bark both below and above the injured area. The scion is whittled down at each end to about half its original thickness so that it can be placed into the prepared bark notches, flat against the wood of the trunk. Scions are made slightly longer than the distance spanned, so that they will bow outward and make secure contact at both ends. Small nails are driven through the ends to hold them in place, and they are then coated with the water-soluble asphalt grafting compound. Usually, scions are grafted 2 inches apart around the injured portion of the trunk. The scions unite with the bark at both ends of the girdled area. During the first summer, suckers must be removed several times from the scions. The scions grow in thickness and may eventually touch each other.

Inarching (Fig. 28) is much like bridge grafting, and is used in an attempt to save a tree whose root system has been injured. Trees over 25 years old are generally not inarched. One or two young nursery trees are planted about a foot from the trunk of the injured tree. The tips of the top branches of these nursery trees are removed with a slanting cut extending on the inner side for a distance of about 3 inches. Using these prepared shoots as a pattern, notches are cut into the bark of the trunk of the injured tree. The shoots are fitted into the notches, nailed, and coated with grafting compound. The tops of the shoots will unite with the trunk of the tree. Suckers must be kept removed from the inarched trees during the first summer. The planted trees quickly assume the normal trunk functions and are retained for the life of the original tree.