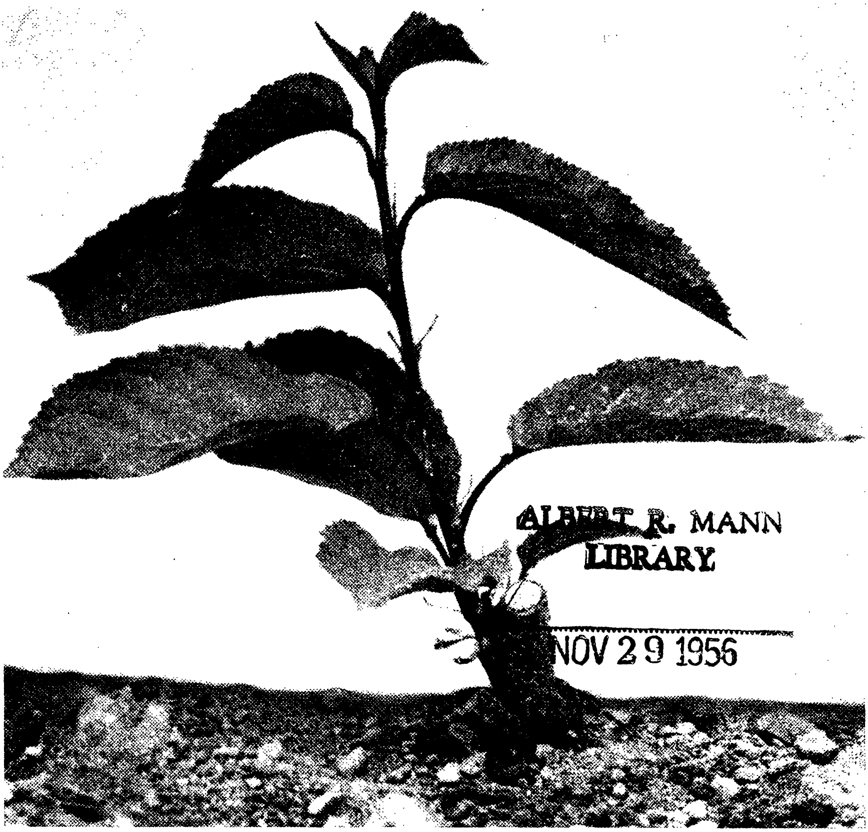
Propagating Fruit Trees

By Karl D. Brase



New York State
Agricultural Experiment Station
Cornell University, Geneva, N. Y.

Bulletin No. 773 March, 1956

Contents

BULLETIN NO. 773

Propagating Fruit Trees

KARL D. BRASE

Abstract

FRUIT tree varieties, although originating from a seed, cannot be propagated from seed but of necessity are composed of two parts, the variety and the rootstock.

Propagation methods as they apply to the northeastern United States are described and observations with various propagation practices discussed in detail.

These practices include handling of seed for rootstock purposes, establishment of mother plantings for clonal rootstock production, propagation methods and cultural practices in the nursery, dwarfing effects by interstocks, establishing scions on their own roots, and various top-working methods applicable to the established orchard planting.

Introduction

MOST varieties of fruit plants do not "come true" from seed and must therefore be propagated by vegetative methods. A severed root may produce a shoot or portions of stems or leaves may be induced to produce roots, thus establishing new plants. Some plants send up suckers from the roots, that can be dug and planted. Strawberries send out runners that root and produce new plants at their tips. Black raspberry canes become rooted at the tip and produce new plants when they make contact with the soil. Woody material which is difficult to progagate by any other method may often be made to root by layering, an operation by which shoots still attached to an established mother plant are made to root.

With most tree fruits, it is customary to utilize an already established seedling plant, called the rootstock, on which to bud or graft the desired variety. Grafting and budding may also be used to advantage to change the variety of an established tree or to repair injury.[1]

Propagation by seed is satisfactory only for plants which come nearly true from seed, with respect to their desirable characters. This is done with many shade and lumber trees. Seedling rootstocks upon which fruit varieties are to be budded or grafted are also produced from seed.

[1]Methods to change varieties by grafting and to repair injury are also described in Cornell Extension Bulletin No. 882 on "Top-Working and Bridge-Grafting Fruit Trees."

Conditioning Rootstock Seeds

Fruit tree seeds, like the seeds of many woody plants, will not germinate immediately after they are mature. They must complete a period of "after-ripening" in which internal changes necessary for germination occur. These changes take place only at temperatures between 33° to 45° F under moist conditions. Freezing is not necessary and in same cases actually harmful.

Freshly harvested seed, particularly that of stone fruits, after it has been cleaned of the pulp can be planted at once so that after-ripening can take place in the soil during fall and early winter. When planting directly in the nursery row the seeds are evenly distributed in a narrow shallow trench and covered with soil. However, in soils where the formation of a hard crust can be expected, it is best to cover the seed first with either moist peat moss or soft wood sawdust before covering with soil. The planted covered rows must be well protected by mounding up additional soil over the rows in a similar way to the hilling of potatoes. This soil mound protects the seed over winter but must be removed in the spring as soon as soil conditions permit, leaving only a thin cover through which the sprouting seed can easily emerge (Fig. 1).

Fall planting is the simpler and most economical way to handle all stone fruit seed. Apple and pear seed can also be handled in this way.

Where fall planting is not possible artificial conditioning is necessary. It can be accomplished by soaking the dry seeds in water for 10 to 12 hours and packing them in containers mixed with a moisture-holding material such as moist soft wood sawdust or moist peat moss. The containers may be buried in

Fig. 1.—Mazzard cherry seed planted directly in the nursery row, Sept. 22, 1955; photographed May 31, 1956.

the ground over winter in a sheltered position or they may be stored in a cool cellar. Refrigerated storage rooms with a constant temperature near 40° F are the most desirable for storage. Under such storage conditions, however, care must be taken that the medium in which the seeds are stored remains moist at all times. Under refrigerated storage near 40° F, use can also be made of polyethylene film made into envelopes in which the wet seeds and a small amount of moist peat moss are placed. Polyethylene film allows air exchange, but prevents moisture loss from the seed and the enclosed peat moss. Polyethylene is transparent and thus it is possible to examine the seed frequently without opening the container. This method is particularly helpful where small seed lots are to be conditioned for germination (Fig. 2).

The moisture and cool temperature bring about changes that act upon the hard shell and the en-

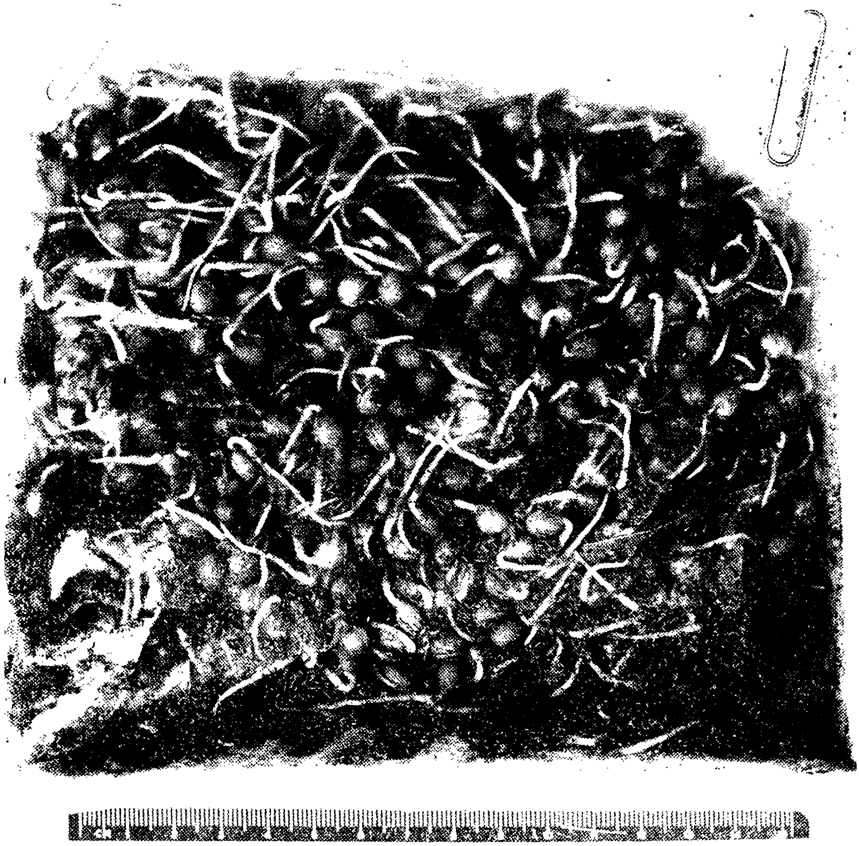


Fig. 2.—Five hundred pits of a Mahaleb cherry seed source after-ripened in a polyethylene envelope at 40° F for 150 days. The seed started to germinate after 120 days of storage and should have been planted at that time.

closed seed. After a definite time, varying in length with different species (Table 1), the hard shell will split apart and the seed will start to sprout. The sprouting seeds are best planted at once, although if soil conditions do not permit immediate planting they can be held in their storing medium just above freezing for a week or more without any apparent harm.

Stone fruit pits, particularly those of peach and plum, which after completing the required after-ripening period have not split open can be cracked by mechanical means. A high percentage of such pits, however, will be found to contain either decayed or nonviable seeds which on planting will fail to grow.

TABLE 1.—DURATION AND EFFECTIVE TEMPERATURE FOR AFTER-RIPENING FRUIT TREE SEED TO BE USED IN PRODUCTION OF SEEDLING ROOTSTOCKS.*

NAME OF SEED AND SPECIES	EFFECTIVE TEMPERATURE °F	BEST TEMPERATURE °F	TIME REQUIRED IN DAYS	REMARKS
Apple, domestic varieties	40°–50°	40°–41°	70–80	Fresh seed taken out of fruit in cold storage will germinate after 30 days of after-ripening
Apricot, domestic varieties	40°–50°	45°	60–70	
Cherry, Mazzard, *Pr. avium*	33°–50°	41°	120–140	Require longest after-ripening period of stone fruit seed
Cherry, Mahaleb, *Pr. mahaleb*	33°–50°	41°	90–100	
Peach, variety Lovell	33°–50°	45°	120–130	Loses viability during dry storage; seed stored for more than 1 year gives low germination
Pear, *Pyrus communis*	33°–41°	40°	60–90	Fresh seed taken out of fruit in cold storage will germinate after 30 days of after-ripening
Sand cherry, *Pr. Besseyi*	33°–50°	40°	60–90	
Nanking cherry, *Pr. tomentosa*	33°–50°	40°	60–75	
Myrobalan plum, *Pr. cerasifera*	40°–50°	40°	100–120	
Ackermann plum, *Pr. domestica*	40°–50°	40°	120–130	

*Seed is best stored dry in sealed containers at a cool temperature. In after-ripening seed one must keep in mind the approximate planting date in the spring. One determines when the after-ripening period should begin by counting back from this date the minimum number of days required for after-ripening.

Rootstocks Used for Fruit Trees

Apples

Seedling rootstocks grown from the seed of certain commercial apple varieties account for almost all rootstocks used in the United States. Ben Davis, Delicious, Columbia, Rome Beauty, Yellow Newtown, and Winesap are good seed sources. Seed from triploid varieties like Baldwin, Rhode Island Greening, and Gravenstein is unsatisfactory for rootstock production.

In the northeastern states where budding in late July and early August gives best results, branch-rooted 1-year-old apple seedlings of $^{3}/_{16}$ to $^{1}/_{4}$ inch diameter are preferred for planting as lining-out stock (Fig. 3). However, in regions with a longer growing period bench grafting during late winter is often practiced. For this method tap-rooted seedlings can be utilized. Rather than use the whole seedling, a 3-inch long portion of the tap root is used and at least two or three grafts are possible from a single tap-rooted seedling.

Fig. 3.—One-year-old apple seedling rootstocks. Tap-rooted seedling (left) and two branch-rooted seedlings. Branch rooting of center seedling was obtained by transplanting young seedling. Branch rooting in seedling on right was obtained by undercutting seedling row in late spring when the seedlings were small.

In addition to seedling rootstocks, clonal apple rootstocks that control the size of the tree and bring about earlier bearing are now used in a limited way. Clonal rootstocks are not propagated from seed, but by such vegetative methods as layering, stooling, hardwood cuttings, and root cuttings. Each individual plant of a given clon is identical in germ plasm to each other plant of that clon.[2]

Best known among clonal apple rootstocks are those of the East Malling series, so named because they were selected and described by the East Malling Research Station in England. Each selected East Malling clon, instead of having a name, is now identified by the letters EM followed by a Roman numeral. The numeral, as for instance "I" has no reference whatever to performance or desirability but merely indicates that it was the first vegetatively propagated rootstock described. This system of numbering has been accepted and has the advantage of meaning the same throughout the world.

Of the existing EM clons the best have been selected to provide a range of performance to cover the needs of American fruit growing (Table 2).

Other clonal rootstocks, known as MM (Malling Merton) stocks, that

[2]A clon is a group of plants composed of individuals reproduced vegetatively from a single "mother" plant.

TABLE 2.—PROPERTIES OF RECOMMENDED APPLE ROOTSTOCKS.

Rootstock	Growth effect upon a variety	Propagation method	Soil requirements	Good properties	Bad properties faults	Remarks
EM VIII French Red Paradise	Very dwarfing	Stooling	Fertile well-drained soil	Induces early bearing; frost hardy	Wood and roots brittle	Should only be used as interstock to obtain dwarfing effects
EM IX Yellow Paradise	Very dwarfing	Stooling and hardwood cuttings; roots readily	Fertile well-drained soil	Induces early bearing	Root system is brittle; tree needs support	Can be used as interstock, as rootstock used for strong-growing varieties; if budded in late July will start to grow; should not be budded until late August
EM VII	Moderately dwarfing	Stooling and hardwood cuttings; roots easily	No special requirements; tolerates heavy soils well	Is frost hardy and well-anchored; shoots free of laterals and spines	Suckers if planted too shallow	The only true semi-dwarfing stock; best used for strong growers that come into bearing late
EM II Drucin or English Paradise	Moderately to slightly dwarfing	Stooling and hardwood cuttings; roots moderately well	Does well on heavy and lighter soils	Induces early bearing if planted deep enough is sufficiently well-anchored	Tender in regions with severe winter temperatures	Best used for varieties that are not strong growers; a good stock for commercial orchards
EM I Broad-leaved English Paradise	Only slightly dwarfing	Stooling and hardwood cuttings; roots easily and profusely	Fertile well-drained soil; in sandy soils more dwarfing	Induces early bearing in satisfactory soils; is well-anchored	Tender to low temperatures and environmental conditions	Does best in fertile soils that are well drained but of sufficient moisture-holding capacities
EM XIII	Very slightly dwarfing	Stooling and hardwood cuttings; roots profusely	Heavy soils with high water table	Will tolerate wet orchard sites; surface rooter; well-anchored	Fails in dry soils	Does not induce early bearing but when bearing influences fruit size favorably; a very good stock for R. I. Greening and Cortland
Domestic apple seedlings	Induce vigor	From seed; resulting seedlings are graded and only those of plantable	No special requirements	Strong growth and good anchorage	Late to come into bearing; susceptible to powdery mildew	Rootstock most commonly used for commercial orchards

are resistant to the woolly aphid, have been developed and are now being tested for their adaptability to American conditions. It will take several years, however, before these stocks will become available in quantities. Of 14 MM clones selected, MM 104, MM 106, MM 109, and MM 111 are no longer under restriction and can be propagated for distribution.

Apricots

Seedlings grown from seed of the Myrobalan or cherry plum *Prunus cerasifera* are the main rootstocks used for apricots. Although this rootstock grows well in heavy soils, it is not entirely satisfactory and apricot trees on this stock tend to be late in fruiting. Preference therefore should be given apricot seedlings. Not only will such seedlings bring the variety budded onto it into bearing sooner, but the apricot seedling rootstocks are also resistant to root-knot nematode injury.[3]

Cherries

One-year-old seedlings grown from seed of the wild sweet cherry *(Prunus avium)* known in North America as the Mazzard cherry and the Mahaleb cherry *(Pr. Mahaleb)* are thus far the only rootstocks on which sweet and sour cherry varieties are propagated. Which of these two should be given the preference depends on certain conditions.

Mahaleb is more easily grown in the nursery because it is less susceptible to cherry leaf spot, furthermore it will withstand lower winter temperatures than Mazzard. It is also more resistant to drought. Mahaleb is a good stock for sour cherry varieties and will give an early bearing tree but requires a well-drained soil. In heavy soils that tend to drain slowly it will give a short-lived tree.

Mazzard is susceptible to cherry leaf spot and is more tender to low winter temperatures, but will tolerate soils that are at certain times too wet for Mahaleb. The Mazzard cherry rootstock gives the larger and longer lived tree. It should be given preference for sweet cherry varieties.

Since certain virus diseases, such as sour cherry yellows and necrotic ring spot, are seed transmissible, it is important that seed of these two cherry rootstocks is harvested only from trees free of these viruses. Seed from virus-infected trees will give some virus-infected seedlings, which when used as rootstocks transmit the disease to the variety.

Nectarines and Peaches

Peach seedlings grown from the seed of a California variety, the Lovell, serve at present as the major rootstock for nectarines and peach varieties. Seedlings grown from seed of selected red-leaved peach varieties have also come into use in eastern nurseries. Since a high percentage of these seedlings have red foliage, they are easily distinguished from the budded variety and thus helping to prevent nonbudded seedlings from becoming mixed with budded varieties. Peach seedling rootstocks, in contrast to other seedling stocks that have to be

---

[3]Day, L. H. Rootstocks for stone fruits. *California Agr. Exp. Sta. Bul. No. 736. 1953.*

grown for one year before they are transplanted to the nursery row, are usable as rootstocks the same season they grow from the seed. Transplanting is not necessary.

Seedlings of the western sand cherry *(Pr. besseyi)* and the Nanking cherry *(Pr. tomentosa)* have a limited use as dwarfing rootstocks for peach varieties. Also, the Beach Plum *Pr. Maritima* can serve as rootstock.

Pears

The common cultivated pear *(Pyrus communis)* is the preferred rootstock for pear varieties. The seedling rootstocks used by commercial nurseries in the eastern states are grown from the abundant seed supply of the Bartlett that can be obtained from canneries. Bartlett seed gives satisfactory germination and seedling vigor; seedlings grown from such seed have good affinity with cultivated pear varieties. Also seed of the varieties Beurre Hardy and Winter Nelis serves as a very satisfactory seed source for pear rootstock production.

Because of their resistance to fire blight and to pear woolly aphis *(Erisoma pyricola),* certain oriental

TABLE 3.—COMPATIBILITY RATING OF PEAR VARIETIES ON ANGERS QUINCE EM TYPE A DWARF ROOTSTOCK BASED ON SHOOT GROWTH AND EASE OF BREAKING OFF AT BUD UNION, 1955.*

Variety	Number of buds growing out of 10	Condition of bud union†	Budling growth†	Number broken off at bud union year after budding
Beurre Giffard	10	S	M	0
Cayuga	10	P	G	1
Chapin	9	P	W	2
Clairgeau	9	VP	M	3
Covert	8	S	M	0
Dumont	9	VP	M	2
Early Seckel	8	VP	W	1
Ewart	9	P	W	3
Flemish Beauty	10	S	M	0
Gorham	9	S	M	0
Kieffer	9	S	G	0
Maxine	10	S	G	0
Ovid	9	S	G	0
Packham's Triumph	10	S	M	0
Passe Crassane	10	S	M	0
Phelps	9	S	G	0
Pulteney	9	S	G	0
Waite	4	VP	W	4
Willard	10	P	M	1
Winter Bartlett	10	S	M	0
Worden Seckel	7	VP	W	1

*Bartlett, Bosc, and Clapp's Favorite make a weak bud union with Angers quince rootstock and should always be double-worked to more compatible varieties such as Anjou, *Beurre Hardy, Duchess d'Angouleme,* Howell, and Flemish Beauty. (Italicized varieties are the preferred ones.)

† S = Strong smooth bud union.
P = Poor with swelling at point of union.
VP = Very poor, bark of stock and variety is separated by dark line.
M = Medium, not as strong as the variety on pear seedling rootstock.
G = Good, as vigorous as the variety on pear seedling rootstock.
W = Weak, short and thin growth as compared with variety on pear seedling rootstock.

pear species, such as *P. calleryana, P. pyrifolia (P. serotina),* and *P. ussuriensis,* have been tried as pear rootstocks but have not proved satisfactory. Varieties on these stocks have developed "black-end" of the fruit. *P. betulaefolia* which in tests carried out in New York proved a satisfactory rootstock for Bartlett, Kieffer, and Seckel has since been found very susceptible to blight[4] and therefore is no longer recommended as a pear rootstock.

To obtain dwarf pear trees quince rootstocks must be used. Three vegetatively propagated quince clons, Angers Quince EM Type A and Common Quince EM Types B and C, can be considered suitable; however, Angers Quince Type A should be given first choice.

Not all pear varieties will make a strong graft union with the quince rootstock (Table 3), but by double working as illustrated in Fig. 33, all important commercial pear varieties can be grown on this dwarfing stock.

Plums and Prunes

The Myrobalan or cherry plum *(Prunus cerasifera)* is the only important rootstock used for plum and prune varieties in New York and other northeastern states. Seedling rootstocks of *Pr. cerasifera* are grown from seed collected in California from seedling trees.

Frequently, on seedlings grown from this seed source, a leaf symptom termed "chlorotic fleck" is found (Fig. 4). Affected seedlings make reduced growth and likewise reduce the growth of varieties grafted or budded to such rootstocks. Experimentally, it has been determined that the Stanley prune develops a constriction at the bud union when budded to Myrobalan seedlings showing "chlorotic fleck".

Fig. 4.—Myrobalan seedling shoots having leaves with chlorotic fleck.

Stanley trees showing this constriction in severe form are often killed after having been planted to the orchard. The causal factor of chlorotic fleck is carried in the seed and symptoms seem to be well developed on the very young seedlings but disappear as the seedling grows older. At present no source of Myrobalan seed known with certainty to be free of this trouble is available. Some trees may be free of chlorotic fleck, but one cannot be certain until seed is planted for study of the seedlings. Until Myrobalan seed sources free of chlorotic

---

[4]Tukey, H. B., and Brase, K. D. An attack of fire blight upon trees of *Pyrus betulaefolia. Proc. Amer. Soc. Hort. Sci.,* 43:*129. 1943.*

fleck can be developed, it is suggested either to rogue out those young seedlings showing chlorotic fleck or at least not use them as rootstocks for Stanley.

Lovell peach seedlings can, in special cases, also serve as rootstocks for plum and prune varieties. Where used as rootstock it must, however, be remembered that the peach root system does not tolerate wet and heavy soils and that plum or prune trees growing on peach seedling rootstocks will be short-lived if planted in unsuitable soils.

Although certain selections of the Marianna plum, a hybrid of *Pr. cerasifera* (Myrobalan) × *Pr. munsoniana* (Munson plum) are used as rootstock for plum and apricot in California, this plum rootstock is not used in the northeast. Where used as a rootstock it is propagated by hard wood cuttings.

Certain European plums, *Pr. domestica* varieties as the Ackerman and Pershore plum, have merit as a rootstock for all *Pr. domestica* varieties. Rootstock tests carried out in New York indicate that seedling stocks of the Ackerman plum also known as Marunke, must be budded earlier in the summer than Myrobalan stocks to insure satisfactory bud take.

Pr. Americana seedlings are only important as rootstock for American-Japanese hybrid varieties like Redcoat, Superior, South Dakota, and others.

Tests carried on at this Station have proved that the Western Sand Cherry *(Pr. besseyi)* can be used as a dwarfing stock for *Pr. domestica* varieties as well as *Pr. triflora* varieties. American Mirabelle and Sweet Damson, both being *Pr. insititia* varieties, did not grow on this stock.

Vegetative Methods of Propagation

The major vegetative propagation methods used for deciduous fruit plants are stooling, layering, budding, grafting, and hard wood, soft wood, leaf bud, and root cuttings. Budding and grafting are primarily relied upon to multiply and perpetuate tree fruit varieties, whereas one resorts to stooling, layering, and cuttings in the propagation of clonal rootstock plants. Grapes, currants, and gooseberries are also grown from hardwood cuttings, whereas with filberts layering is the best propagation method.

Establishing Mother Plants for Stooling

In stooling the soil is hilled up and around the new shoot growth arising from the below-ground portion of the established mother plant. It is the basic propagation practice to mass-produce clonal apple rootstocks.

In establishing a stooling-bed, well-rooted shoots of the clon to be propagated are cut back to a uniform length of from 15 to 18 inches and are planted in the spring as early as soil conditions permit, in an upright position 12 to 15 inches apart in rows. Planting them in a shallow trench (Fig. 5A) will insure that they are set deep enough. Where tractor hilling tools are used, distances between rows must be great enough to allow for cultivating between rows. In such cases it is advisable to plant rows not closer than 8 feet. After planting, the space between rows is kept well cultivated and the plants allowed to grow unchecked for that growing season (Fig. 5B).

The following spring, before new growth begins, all plants are cut back to within 1 inch above the ground level (Fig. 5C). Each young mother plant cut back in this way will produce from two to five new shoots during the second year, depending on the growth characteristics of the clon and growing conditions. As soon as these young shoots are from 3 to 5 inches tall, loose soil is drawn up and around each shoot (Fig. 5D). The hilling operation is repeated as the new shoots reach a height of 10 to 12 inches. In all, three hillings are required and should be completed by the end of July.

Care of stooling bed

Care must be taken that the soil is in good condition and moist when hilling-up operations are carried out. In stooling, root formation on the new shoot growth is influenced by hilling up early in the growing season before the new shoots have become hard and woody at the base and by sufficient soil cover, availability of moisture, and soil texture. Prolonged dry periods during early summer and compacted heavy soils hinder root formation. Stool beds, therefore, are best established where there is sufficient moisture and where the soil can be kept in good physical condition.

The final hilling should bring the soil at least 6 inches above the base of the shoots. Hilling up in such a way forms a shallow trough that will hold rain water (Fig. 5E).

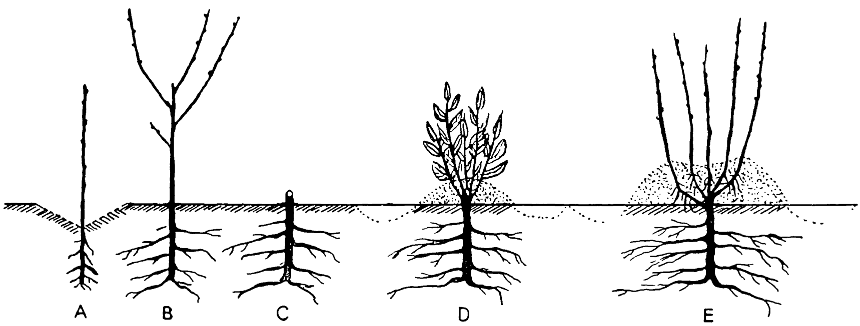


Fig. 5.—Steps in establishing mother plants for stooling. A, rooted shoot after planting in early spring; B, at end of first growing season; C, shoot is cut back in early spring of second growing season; D, first hilling up during second growing season; E, hilled up mother stool before rooted shoots are cut off.

Mixed pine and other soft wood sawdust has been used as the hilling medium in a newly established planting at Geneva, N.Y. (Fig. 6). To prevent the sawdust from being blown away by wind, soil was plowed up to each row from both sides after the last hilling operation (Fig. 7). Rooting under

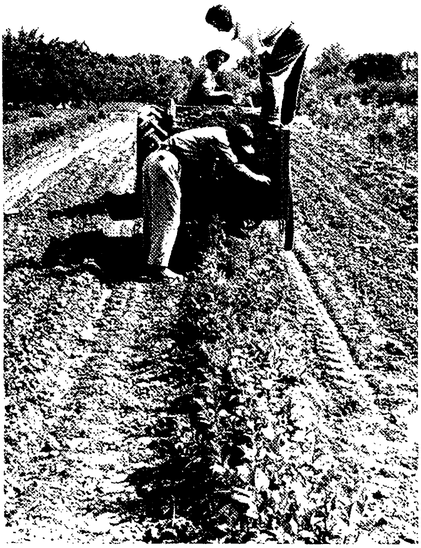


Fig. 6.—Applying sawdust to the mother plant row.

sawdust improved over that obtained where soil alone was used (Fig. 8). Where sawdust is used, a nitrogen fertilizer, such as ammonium nitrate, should be applied as a side-dressing along both sides of the row of mother plants after the rooted shoots have been cut in the spring and where the sawdust applied the previous growing season has become mixed with the soil in cultivation operations. One pound of ammonium nitrate per 40 linear feet of row is sufficient. Heavier applications overstimulate growth of individual shoots.

Removal of rooted shoots

During late winter or early in the spring, before new growth has started, the cover is carefully removed by plowing the soil away from the row and by grubbing out all that remains between shoots. All shoots are then cut as close as possible to the place where they arose on the mother plant (Fig. 9). After removal, the mother stool remains exposed. New shoots will start to grow again and when they have reached 3 to 5 inches in height, the hilling operation is repeated as during the previous year.

Thorough cultivation and maintenance of soil fertility by annual manure applications between the rows, as well as early cutting of the shoots in the spring when the mother plant is completely dormant, will help prolong the productive life of the mother stools. Rooted shoots, however, can also be removed in the fall. If this is done, the mother plant must be re-covered with soil to protect it against winter injury. This protection must then be removed again in the spring. The spring harvest of rooted shoots is therefore more economical in labor and also helps to prolong the life span of each mother

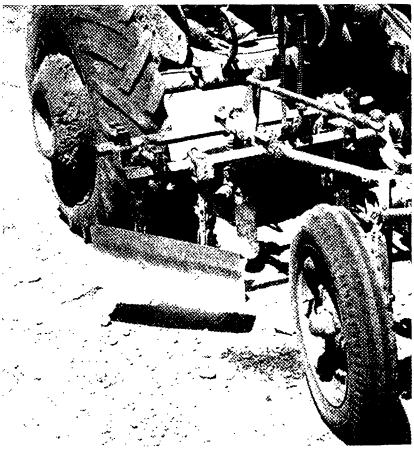


Fig. 7.—Close up of tractor attachment used to push soil up to the row after the sawdust has been spread over the row.

stool. Well-cared-for mother plants will give a continuous annual increase in shoots from each plant and will remain productive for 15 to 20 years. Stooling is a time-consuming operation that must be carried out when conditions are right. Nonrooted 1-year-old shoots produced by established mother plants can be cut from the plant in late winter or early spring and made into hard wood cuttings.

Layering

Layering is an operation by which shoots still attached to an established mother plant are made to root.

The simplest method is tip layering, employed to obtain young blackberry, dewberry, and black raspberry plants by covering the ends of the young canes with soil during late summer. The covered portion will develop roots and the rooted tip, when separated from the mother plant the following spring, will serve as the new plant.

Another method is simple layering that consists of bending and pegging down branches and covering part of each branch with soil, but leaving the tips of the branch uncovered. This method is successful with grapes and filberts.

Trench layering, a method used to multiply rootstocks that do not readily root on stools, demands more care and attention than any of the other methods thus far described.

The mother plants are set at an angle of 45° along the row with 24 to 30 inches between the plants and are customarily pointed toward the south. The rows must be far

Fig. 8.—Three-year-old apple rootstock mother plants after hilling with sawdust and soil in mid-June.

Fig. 9.—Rooted shoots produced by 3-year-old mother plants after uncovering in early spring. Note root development under sawdust cover. All shoots are cut off close to the place where they arise.

enough apart to allow ample room for cultivation and hilling operations. Cultural practices during the season after planting are the same as with stools.

Care of trench layer bed

The year following planting of mother plants a trench 2 to 3 inches deep is made in early spring along both sides of the row and each plant is bent down in alternating directions and secured with wire pegs made out of 15-inch, 10-gauge galvanized steel wire pieces bent in U form. Any weak lateral growth on the pegged down shoot is cut back to about ½ inch of the main stem. Strong lateral shoots are cut back lightly and can also be pegged down. The entire layer is covered with an inch of fine soil or sawdust before bud activity starts. This cover serves to bring about etiolation and better rooting of the newly developing shoot growth. In late May, or as soon as the young shoots push through the thin cover, more soil or sawdust is placed over them, but care must be taken that the layer is not too deep in places where shoots have not appeared. The covering is repeated as shoot growth increases in height, but shoots should not be covered for more than half of their height.

The following spring, before growth starts, the cover is carefully removed and the rooted shoots are cut off (Fig. 10). Shoots that did not root are left and pegged down as before. Such shoots serve to maintain the layered plant. Eventually older parts of the layer will die or may break out, so care must

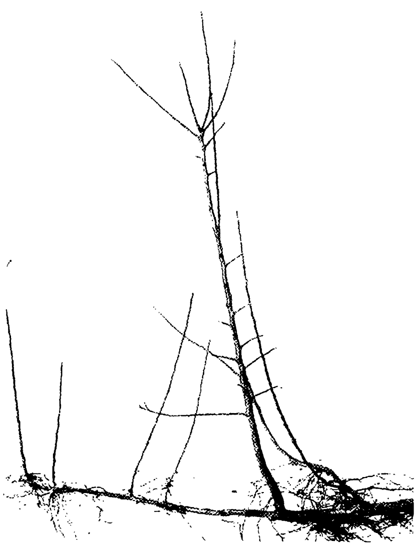


Fig. 10.—Trench-layered apple rootstock shoot.

be taken each year that some new shoots remain to replace those that have been lost.

Air layering

This method is not new, but better results can be obtained with it by the use of polyethylene film as the cover of the rooting medium. The properties of polyethylene film, namely, air passage through the film and prevention of moisture loss, make it an ideal cover for air layering.

In applying air layering, a 1-inch wide ring of bark or only a portion of the bark is removed on the 1-year-old branch to be layered in the spring when growth starts. The wounded area and 2 to 3 inches of the branch above and below it are surrounded with a handful of moist sphagnum moss and wrapped with a piece of polyethylene film which is tied securely at both ends (Fig. 11). During the growing season, roots develop above the wounded area on the shoot where it is covered with the moss. Such shoots can be cut from the mother plant as soon as sufficient rooting has taken place, which is most likely the following fall.

The rooting of shoots by the air layer method is most successful with plants that also can be made to root by stooling or trench layering.

Cuttings

Plants that will root when stooled or layered also will often root when a piece of the mother plant, such as a stem, a root, or even a leaf attached to a short stem portion, is placed under conditions favorable for root development. The important factor that makes rooting possible is the condition of the material used and the time the cuttings are planted.

Fig. 11.—Air-layered cherry shoots on a Mazzard rootstock plant.

Hardwood cuttings

As the name implies, hard wood cuttings are made out of 1-year-old dormant wood by making the basal cut just below and the distal cut just above a bud. Shoots that have failed to root on the stool or shoots cut from mother plants especially grown in hedge rows for the purpose, can be cut into 5- to 6-inch lengths in late winter and early spring and stored in moist sawdust in a cool storage cellar until planting time (Fig. 12).

Cuttings of $^{3}/_{16}$ to $^{1}/_{4}$ inch diameter taken from the basal end of a shoot will root more freely than cuttings of larger diameter or cuttings made from the median portion of a shoot. Cuttings made of tips of 1-year-old shoots will give

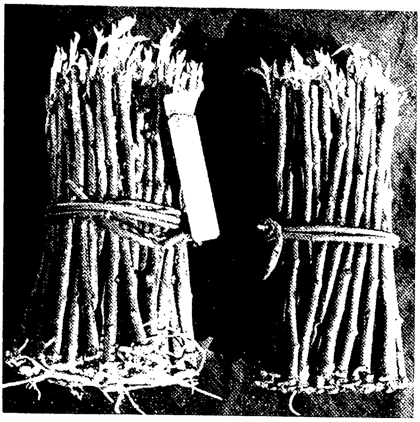


Fig. 12.—Hardwood cuttings of EM II. Bundle at left stored in sawdust; bundle at right stored in sand. Plants in both bundles are too far advanced and should have been lined-out before bud growth started.

few or no rooted plants. Tip portions should therefore be discarded.

The time of planting the cuttings and the soil in which to plant them are important. Satisfactory field stands of rooted cuttings can only be obtained by planting early in the spring and in soils which are friable and of good moisture-holding capacity. Where conditions permit, one might plant as early as mid-March in New York, but not later than the first week in May. In regions with little or no freezing of the soil, hardwood cuttings can also be planted in late fall or early winter.

The cuttings are set upright 2 to 3 inches apart in trenches with only the uppermost bud above ground level and are well firmed in the soil. Rooting responses vary with different plants. Quince cuttings used as dwarfing rootstocks for pear varieties root more readily than clonal apple rootstocks. Hardwood cuttings of the apple rootstock EM II do not root as freely as those of EM I, VII, and IX (Fig. 13). In trials with clonal rootstocks at this Station, average field stands of 50 to 60 per cent have been realized.

Root cuttings

Propagation from root cuttings is only successful with roots taken from 1- to 2-year-old plants. Roots from older plants rarely develop leaf buds and resulting plants.

Plants to furnish the roots for root cuttings are dug in late fall and taken to a storage cellar where roots $^3/_{16}$ to $^3/_4$ inch in diameter are cut into 4-inch sections during

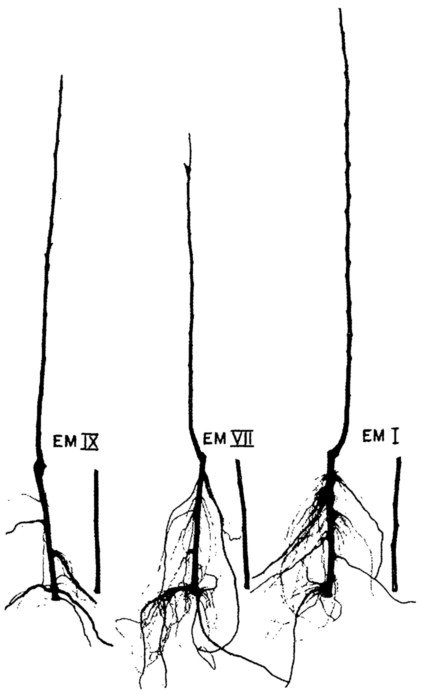


Fig. 13.—EM apple rootstock cuttings. The hardwood cuttings as planted on the right in each case and the rooted plants dug at the end of the growing season.

winter. To make sure that they will be planted in the upright position, the upper end is cut square across and the lower end is cut slanted. The cuttings are stored in moist sawdust until soil conditions permit planting in early spring. At this time they are set upright 2 to 3 inches apart in a shallow trench in such a way that the upper end is just covered with soil. Root cuttings can also be taken from freshly dug plants in the spring before new growth has started. A number of shoots will grow from each cutting, but only the best upright growing shoot is allowed to grow, the others being removed (Fig. 14). In the fall the resulting young plants are dug and any new roots sufficiently large can again be cut off and made into cuttings.

Fig. 14.—Shoot growth in late spring from root cutting taken from a selected Mazzard clone. Small shoots were not removed from plant on left; on the right, only the stronger shoot allowed to grow.

The method is used to propagate certain clonal fruit tree rootstocks that are difficult to multiply by any other method. It is also used for multiplication of blackberries and red raspberries where the cuttings, instead of being planted in an upright position, are placed horizontally in a shallow planting trench and covered with loose soil.

Softwood cuttings

Although propagation by soft wood cuttings is the more commonly used practice to multiply many ornamental plants, it is applicable to relatively few deciduous fruit plants. As the term implies, soft shoots of the current season's growth are taken from late June through July in the northeastern United States and made into cuttings 4 to 6 inches in length, with the lower cut just below a bud or leaf and the top cut a short distance above a bud or leaf. For convenience in handling, the lowest leaf is removed. It has been found, however, that cuttings will root better if the foliage on each cutting is not reduced.

The time required to form roots and the number of roots formed is increased by treating soft wood cuttings with a growth regulator. Powdered preparations of growth regulators are the easier ones to use by simply dipping the basal end into the powder just before planting in the rooting medium.

The most important factor is to keep soft wood cuttings from wilting while subjecting them to as much sunlight as feasible. The old practice consisted of planting them in rows in sand in a glass-covered frame and sprinkling them with water frequently. Under these conditions partial shade had to be provided to moderate the temperature in the frame on sunny days.

A new technic has been developed that dispenses with the glass cover but instead provides at frequent intervals a fine mist of water over the cuttings. The interval at which mist spray occurs can be regulated by electric timing devices. Cuttings rooted under interrupted mist can be subjected to full sunlight and while wilting is prevented in that the leaves are kept moist at all times by the mist spray. Rooting will occur in from 10 to 20 days, depending on the material to be rooted.

Prunus Mahaleb, a cherry rootstock, selected *Pr. cerasifera* and *Pr. domestica* clons, and even peach and Japanese flowering cherries can be rooted successfully by this method, but soft wood cuttings of East Malling apple rootstock clons, apple varieties, and cherry varieties have not responded (Fig. 15).

Leaf-bud cuttings

The method consists in making cuttings of a leaf, together with the bud in the axil of the leaf, and a small attached shield of bark and wood from the shoot. The cutting is not unlike a shield bud used in budding, but with the entire leaf attached (Fig. 16). Leaf-bud cuttings are handled identically as soft wood cuttings either in a glass-covered frame or better under interrupted mist spray.

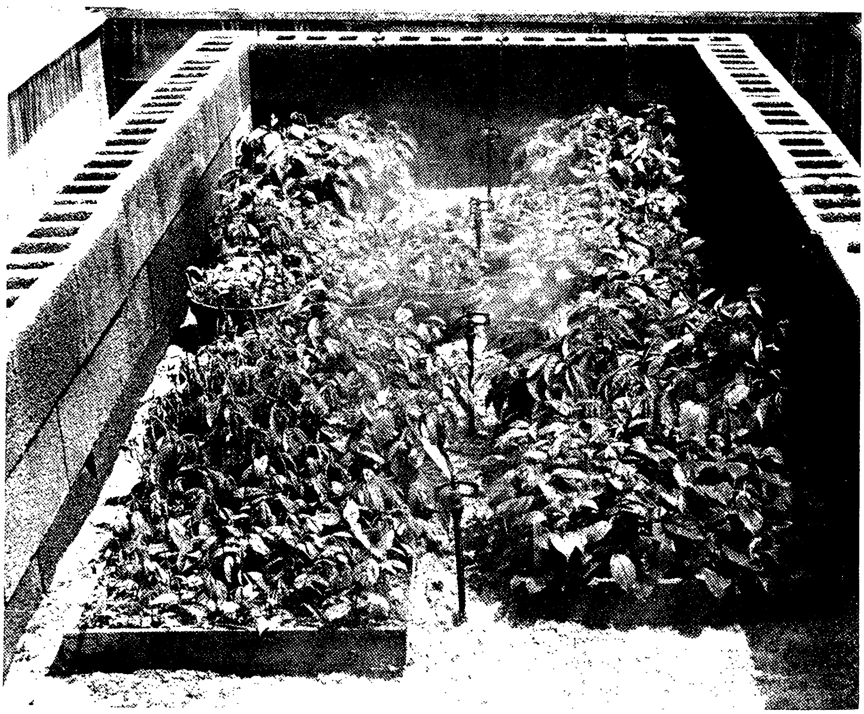


Fig. 15.—Softwood cuttings of *Pr. domestica, Pr. serrulata* (Shirofugen), and *Malus robusta #5* in the propagation bed in early July. Note fine water spray applied at short intervals.

Although a successful propagation method for broad-leaved evergreens, such as rhododendrons, this method has its only application among deciduous fruit plants with purple and black raspberries. In experiments carried out at this Station at different times of the year, cuttings were taken in early April from raspberry canes that had been forced to grow from potted plants in the greenhouse. Those of purple and black raspberry rooted 92 and 93 per cent, respectively, within 8 days, but both failed to produce new shoot growth. Since the cuttings were made from lateral shoot growth of 1-year-old canes, it is not surprising that buds which developed were all fruit buds, since this is normally the fruiting wood. All cuttings taken of red raspberry canes failed to root.

When the experiment was repeated in early and mid-summer, using the current season's suckers growing from the base of plants, both purple and black raspberries rooted 100 per cent and the buds developed into vigorous new shoots. Red raspberry cuttings again failed to root. Apparently the success of this method with purple and black raspberries is to be associated with the presence of root primordia in the cuttings.

Essentials of Budding

Varieties of fruit trees are generally propagated by budding or grafting on another plant that furnishes the rootstock. It is essential that the plants joined together in this way are closely related and compatible and that the cambium of the cion or bud is placed in contact with that of the rootstock.

Fig. 16.—Leaf-bud cutting of black raspberry.

In fruit trees the cambium is found between the bark and wood. It consists of a thin layer of cells from which new bark and wood cells originate. In the spring and summer, the bark readily separates from the wood in the cambium region, some cambium adhering to the lifted bark and some remaining on the wood. In winter the position is not so clearly defined, but close examination of a shoot will reveal its position at the junction of the soft bark and the hard solid wood. Numerous methods to bring about cambium contact between the rootstock and the cion variety have been devised. Budding during the summer months is one of them.

Planting of rootstocks to be budded

When nursery trees are produced by budding, the rootstocks are first trimmed and then planted in early spring. The trimming consists of cutting back the lateral roots, removing all side branches, and cutting the top to a total length of about 15 inches. This trimming is done largely to expedite planting, since the rootstocks are planted by inserting in a narrow vertical trench opened by a special trenching plow (Fig. 17). This planting process is called "lining out," and plant materials so handled are commonly called "lining out stock" (Fig. 18).

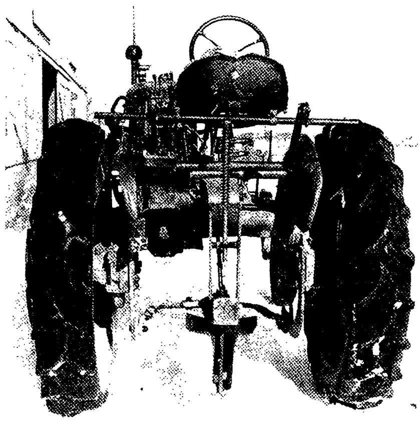


Fig. 17.—Trenching plow used in making trenches in which to line-out rootstocks. Depths of trench can be controlled hydraulically.

Time of budding

The budding operation can be carried out when the bark of the rootstock easily parts from the wood and when sufficiently developed buds of the desired fruit variety are obtainable.

Depending on the region, budding can be carried out from June until September, although the month of August is the time when budding is mostly done in the northeastern United States.

The best time to bud some fruit stocks is dependent on certain growth characteristics of the stock. Fruit plants that complete their growth earlier in the growing season must be budded first. *Prunus Besseyi, Pr. domestica,* pear, apple, Mazzard cherry seedlings, and quince stocks are best budded in the order given from mid-July to mid-August, whereas Myrobalan

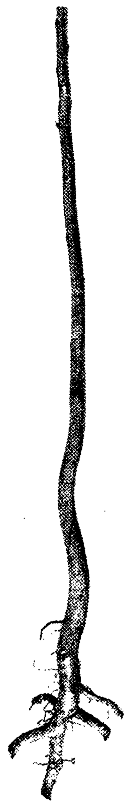


Fig. 18.—One-year-old branch-rooted apple seedling trimmed for lining-out in the nursery row.

plum, Mahaleb cherry, and peach seedling stocks will give a better bud-take when budded from late August to early September under conditions prevailing in most of New York State.

Selection of budsticks

Shoots from which buds are to be taken, commonly called budsticks, must be collected from healthy trees of the desired variety. This is particularly important with cherry varieties. Buds from cherry trees affected by virus diseases will grow, but the resulting trees will be of lesser vigor and will carry the virus. The production of virus-free trees, that is trees propagated only from virus-free sources, therefore is important to the plant propagator and fruit grower. (See Bulletin No. 776 of this Station.)

The current season's shoot growth (Fig. 19) from either a bearing orchard or from nonbearing young nursery trees furnishes the bud source, but the collection of budwood from nonbearing young trees must be done with care to avoid varietal mixtures.

After the budstick has been cut from the parent tree, loss of moisture by evaporation from the leaves must be prevented at all times and can be checked by prompt removal of the leaves and by keeping the sticks moist. With the leaf blades removed (Fig. 19) but leaving the leaf stem in place, the bud sticks are wrapped in moist cloth or are placed with the basal end in water in a container. In this way they can be stored in a cool place for several days, although it is preferable to use them soon after cutting. The soft tip of the shoot and the buds near the base are discarded and only the well-developed plump and hard buds near the middle of the budstick are used.

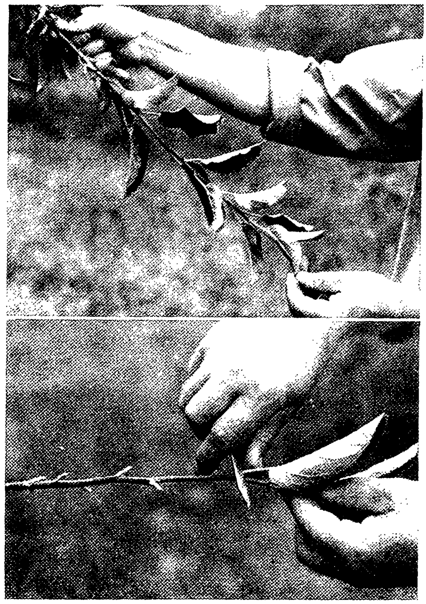


Fig. 19.—Selecting bud sticks. Above, current season's shoot growth furnishes the bud source. Below, bud stick with leaf blades cut away leaving leaf stem.

Budding technic

The buds are inserted into the rootstock 2 to 3 inches above the ground level in the case of seedling rootstocks. Clonal rootstocks, on the other hand, should be budded at least 4 inches above ground level. This insures a long enough rootstock portion on the finished tree capable of giving good anchorage to the tree on transplanting to the orchard without having to plant the bud union below ground level. Trees having too short a clonal rootstock portion often start leaning when planted in wind-exposed locations. As far as possible the buds are placed on the same side of the stock so that they may be readily inspected and manipulated the following season. The side from which prevailing winds come is the preferable one to prevent subsequent breakage. Where established young orchard trees are to be topworked to a new variety by budding, the buds are placed on the lower side of lateral branches (Fig. 20).

At the budding point the stock is wiped clean of soil particles and a T-shaped cut is made through the bark but not into the wood. The upper transverse cut is made first about one-third around the stock, followed by a vertical cut upwards to meet the transverse cut. As it reaches the transverse cut, a twist of the knife blade raises the edges of the bark just enough without tearing so that the bud may be easily inserted (Fig. 21A).

After completing the T-shaped incision on the stock the bud is cut with a shield of bark by holding the budstick by the upper end with the lower end away from the body. The knife is placed half an inch below the first suitable bud and by a shallow slicing movement is passed beneath the bud approaching the surface an inch above it (Fig. 21B).

The shield bearing the bud must be cut fairly thin, but not so thin that the soft growing tissue between the bark and the wood is injured. With fruit plants one may leave the thin strip of wood that was cut with the shield, while with certain ornamental plants, such as roses, it is

Fig. 20.—Two-year-old nursery tree top worked by budding. Notice new growth from the bud (arrows) following spring.

best to remove all the wood. This can be accomplished by cutting a thick shield and severing the bark by a cross cut an inch above the bud.

Grasping the shield firmly between the thumb and forefinger, it can be carefully lifted from the wood without tearing the bud. After cutting, the bud is held by the leaf stem between finger and thumb and is inserted into the T-shaped incision on the stock (Fig. 21C).

With rootstocks of sufficient diameter, in good growing condition, and with the bark separating readily, the insertion of the bud is easy. When properly inserted (Fig. 21D), the bud should be at least three-quarters of an inch below the transverse cut.

Tying the bud

To assure firm cambium contact and to prevent drying out of the severed bark, it is necessary that the cut be wrapped with a rubber budding strip. Waxing is not necessary. If the bud has been properly inserted, the wrapping may either be done downward or upward (Fig. 22). The important point is that the wrapping is tied and that the bud itself is not covered by the rubber band. The rubber band is held in place by placing the free end back under the last turn. Gaps may be left between each turn (Fig. 22).

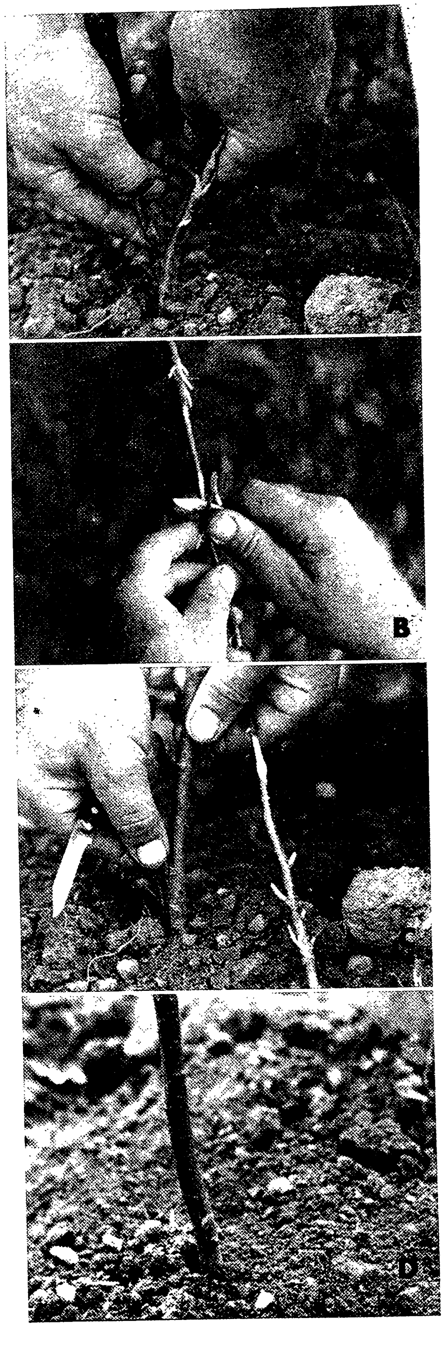


Fig. 21.—Steps in budding operation. A, making T-shaped incision on the stock; B, cutting the bud from the budstick; C, bud is held by leaf stem and is inserted in T-shaped incision; D, bud properly inserted and ready for tying.

Although other tying materials may be used, such as raffia or woollen yarn, the rubber budding strips have the advantage of expanding with growth of the rootstock and after exposure of a month to the sun will rot and fall off. By this time a good union between bud and stock has taken place. In the northeast rubber budding strips of .010 gauge are the better ones to use, whereas in more southern regions strips of .016 gauge should be used.

Care after budding

The first indication that the bud has united with the stock is the dropping off of the leaf stem. Shrivelled adhering leaf-stems often indicate failure. In such a case, provided the bark still separates readily from the wood, a new bud may be inserted in a new position on the stock.

Under New York conditions, buds inserted during late July or later will remain dormant until the following spring. In contrast buds inserted during June or earlier will start growing soon after they have united. The resulting shoot growth will be limited by the growing conditions of the northeastern United States. In order to obtain a strong and straight budling, it may be necessary to cut back June-budded trees the following spring. In more southern regions with longer growing periods, June budding may result in desirable trees. It is practiced primarily in the propagation of peach trees and rose bushes.

The bud properly united with the stock does not require any winter protection. The common practice of plowing up to budded stock in the fall is not necessary and may be harmful. Tests carried on at this

Fig. 22.—Tying the buds. Left, tying inserted bud with rubber budding strip. Right, rubber band is held in place by putting free end back under last turn.

Station have shown that besides eliminating two extra time-consuming operations, namely, covering in the fall and uncovering in the spring, buds that had no soil cover over winter started earlier and more uniformly the following spring than where winter protection had been provided.

when still dormant are slow in developing new growth from the inserted bud and some buds may fail to grow entirely.

Sucker growth will arise on the rootstock during spring and early summer and should be removed by rubbing off as it appears. This rubbing off is known as "sprouting"

Fig. 23.—Cutting tops of budded (arrows) Mahaleb rootstocks in late March to early April.

the budded stock (Figs. 24 and 25). Two to three "sproutings" may be necessary before the growth from the inserted bud is strong enough to be completely dominant. To obtain maximum growth, the soil must be well cultivated during spring and early summer. To insure healthy foliage, aphids, leaf hoppers, and chewing insects, as well as diseases, must be controlled by appropriate sprays.[5]

Good foliage is important because it is, in part, from materials manufactured by the leaves that

Care during the second season

Depending on the locality, rootstocks with successful buds are cut off during mid-March to mid-April immediately above the inserted bud (Fig. 23). The cut surface may be covered with grafting wax. Tests have shown, however, that no particular benefit is obtained from such a cover and that if a clean cut is made, healing will take place without the wax covering. Tests have also shown that the cutting off of stone fruit rootstocks, such as Mazzard and Mahaleb cherry and peach seedlings, should be delayed until new growth begins. Stone fruit rootstocks that are cut off

[5]For disease and insect control measures in the nursery see Bulletin No. 776 of this Station.

the young budded tree now called a "budling" grows and develops. Adequate moisture during the growing season, a well-developed root system, and soil tilth and fertility at the planting location are the factors responsible for vigorous shoot and foliage development.

The 1-year-old budling, if of sufficient size, can be dug in the fall and planted in its permanent location. In nursery practice peach trees are always dug as 1-year budlings. Fruit growers should also give preference to 1-year-old sour and sweet cherry trees as well as plum and prune trees. Stone fruits make a much quicker recovery on transplanting to the orchard when planted as 1-year-olds in comparison with budlings that were left for two growing seasons (2-year-olds) in the nursery row.

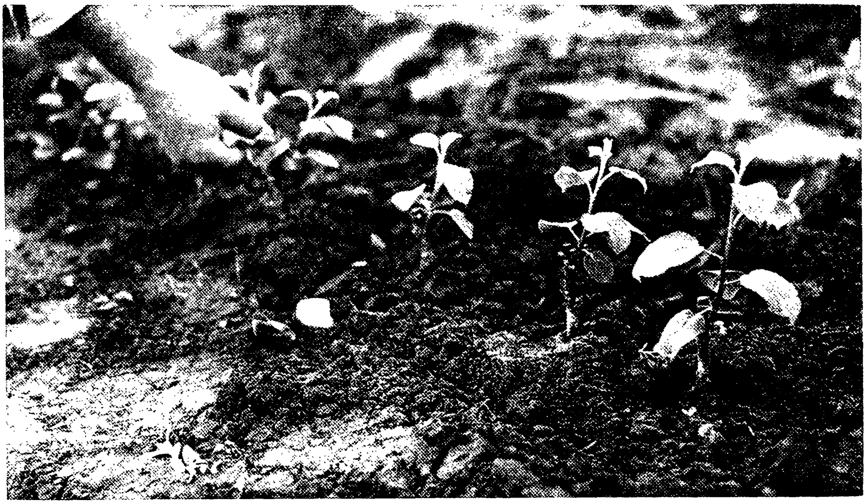


Fig. 24.—Sprouting budded apple rootstocks in mid-May. All new shoot growth, except that from the inserted bud, is rubbed or pulled off. Note sprouts on ground.

Apple and pear trees, on the other hand, are often left to grow for a second season and in such

Fig. 25.—Properly sprouted sweet cherry budlings on Mazzard rootstock in early June.

instances the young budlings are headed back to a uniform height in early spring of the second growing season (Fig. 26). The height at which they are headed depends on the rootstock on which they grow. Standard trees that are growing on seedling or vigor-inducing clonal rootstocks are headed back at 34 to 36 inches measured from the bud union. Semi-dwarf apple trees on rootstocks EM VII and II are best headed back to 24 to 30 inches. Dwarf apple trees on EM IX and dwarf pear trees should be headed back to from 20 but not more than 24 inches.

Four to six buds near the top of the budling that has been headed back are allowed to grow to form the tree head. All other buds are eliminated by rubbing them off as soon as leaf growth has started.

Essentials of Grafting

The chief purpose of grafting, as of budding, is to multiply varieties that cannot be propagated by cuttings or layers. Grafting differs from budding in two ways. First, it can be done when the two components to be grafted, the stock and the scion, are still dormant. Second, instead of a single bud, as in budding, a short section (scion) of a 1-year shoot that may contain only a single bud or several buds is used.

Grafting involves, as does budding, the bringing together of the cambium layers of two different individuals that will unite as one. Growth of both stock and scion in the cambium region results in an interlacing of tissues and "union". A clean straight cut, careful matching of cambium regions, snug fitting and fastening, and careful protection from drying of the tissues both before and after the grafting operations all contribute to successful grafts.

Classification of grafts

Grafts are classified according to the position they take upon the stock, as root graft and top graft. They are also classified according to the type of cut and purpose of the graft, as tongue or whip graft, nurse-root graft, interstock graft, cleft graft, bark graft, notch graft, side graft, and bridge graft. Accordingly, a plant may be root-grafted by whip grafting or it may be top grafted by the cleft graft method.

Fig. 26.—Heading back one-year-old apple budlings in early April.

Selecting and storing scion wood

Scion wood for grafting of deciduous plants must be dormant when it is collected and when it is used. One-year-old shoots collected in early winter are best, but 2-year-old wood may also result in successful grafts. All other precautions already described under selection of budsticks must also be observed in the collection of scion wood. Frost-injured wood should not be used nor should scions be collected during freezing temperatures.

Particular care should be taken in collecting scion wood of sweet and sour cherry varieties. Both have relatively short dormant periods and therefore should be stored at a temperature not over 40° F. If stored at 45° F or higher, the buds, particularly on sweet cherry scion wood, will start to swell and grow in early March at the time when grafting outdoors is not yet possible in the northeast.

Scion wood is stored in such a way that no drying out occurs. The collected shoots are tied in bundles, properly labeled, packed in moist sawdust or moist peat moss, and stored in a cool place. Or the shoots may be wrapped in polyethylene sheets and stored.

Whip or tongue grafting

This method is used in grafting a scion on a stock that is of similar diameter. The stock may be a 1-year-old seedling, a short piece of a root, a rooted or nonrooted cutting, a seedling on which a previously inserted bud failed to grow, or a 1- to 3-year-old tree that is to be top worked to some other variety. The technic is used in grafting young stock plants that are either in the nursery row or that have been dug to be retransplanted after being grafted. In the latter case, the term bench grafting is used, i.e., the grafting operation is carried out indoors and the operator has his grafting materials on the work bench. Bench grafts are stored in the same manner as scion wood until planting can take place in the spring. The whip graft is easily made and is one of the most commonly used because the several uniting edges of this graft form a strong union. It is suitable for apple, apricot, cherry, pear, plum, prune, and grape. Quince and peach, however, do not unite readily by whip grafting and budding during summer is the preferred method for these two fruits.

Whip grafting technic

With a sharp grafting knife, sloping cuts from 1 to 1½ inches long are made at the base of the scion and at the selected place on the stock. The length of these cuts varies according to the diameter of the material. Stocks and scions of larger diameter require slightly longer and more oblique cuts (Fig. 27A, B). On each of these cut surfaces, starting about one-third from the tip, a ½-inch long reverse cut is made nearly parallel to the first (Fig. 27C). Both pieces then are fitted together so that the cut surfaces match perfectly on at least one side (Fig. 27D). The final operation consists of tying the graft with a rubber budding strip (Fig. 27E) by overlapping each turn and by

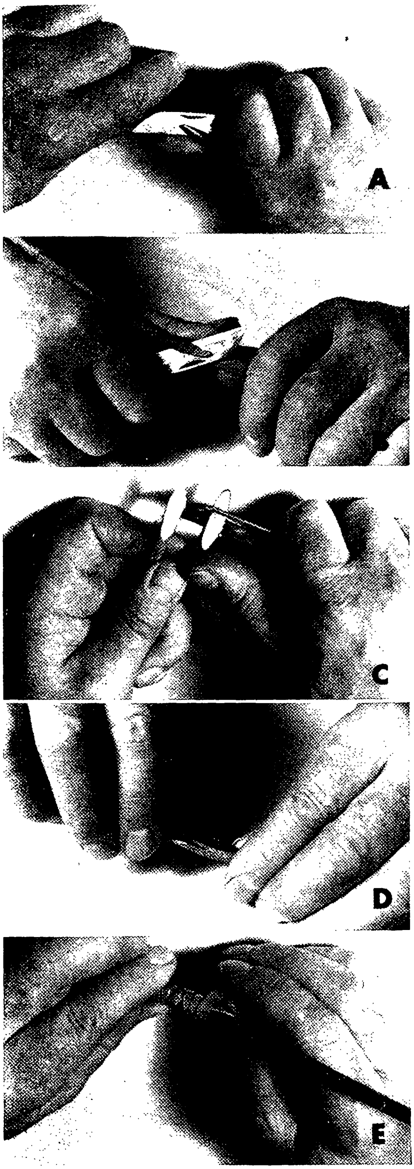


Fig. 27.—Steps in whip grafting. A, making sloping cut on the scion; B, making sloping cut on the stock; C, making reverse cut on scion and stock; D, fitting stock and scion together; E, tying the finished graft with a rubber budding strip.

placing the free end back under the last turn. By careful and proper tying the graft is well protected without the use of grafting wax. However, the properly placed and tied scion, after being cut to the desired length, must be covered with wax at the tip. This is done by dipping the tip of the finished graft into soft grafting wax.

Rubber budding strips for tying whip grafts have several advantages over other materials. First, the rubber is elastic and expands with growth. Second, it is easier and more rapidly wrapped than sticky waxed string or tape. Third, it does not have to be cut after a firm union has taken place because it becomes brittle on exposure to the sun and will break after a month or two.

In tests carried out at this Station on bench grafting 1-year-old apple seedlings by the whip graft method, it was found that a very short scion containing a single bud above the actual graft union gave strong and very straight shoot growth (Fig. 28) and excellent tree stands. Of 707 McIntosh and 305 Monroe whip grafts planted out, 705 and 303, respectively, grew into salable trees (Fig. 29).

Nurse-root grafting

A useful method for establishing scions on their own roots in instances when they cannot readily be propagated from cuttings is by means of nurse-root grafting. This type of graft is very similar to the so-called root grafting employed by the nursery industry, primarily in the midwestern states. However, it differs from root-grafting in that

Fig. 28.—One-year-old apple tree produced by bench grafting a short scion to a seedling rootstock. Note graft union (A), scion (B), and strong straight growth from the single bud on the scion (C).

the root serving as the stock is gradually eliminated. The purpose of the nurse-root is to supply temporary roots which will keep the scion alive until it has developed its own roots. At this Station many scions of potential apple rootstock materials have been established on their own roots by the use of the nurse-root graft.

In the search for rootstock material that can withstand low temperatures, or that will resist attack by soil fungi, or that may be immune to the ravages of certain insects, the plant experimenter may, at the start, have only a few scions at his disposal. To make use of these scions as rootstocks, it is necessary to establish each on its own roots. Once a scion is growing on its own roots it can readily be multiplied by taking roots from the young plant and making them into root cuttings.

In nurse-root grafting a 5- to 6-inch scion is joined with a 3-inch

Fig. 29.—Bench-grafted apple trees (Monroe) in early June of second growing season in the nursery.

root piece by a whip graft, tying the graft union securely with a rubber budding strip of 0.016 gauge which will gradually choke off the nurse root. This is a slightly heavier strip than that normally used for budding and grafting in the northeast. This gauge strip will remain intact for more than two years below ground, although it would deteriorate within a month or two if exposed to sun and air. The finished grafts are stored in sawdust until planting time, when they are set sufficiently deep so that only the uppermost bud of the scion is above ground.

The success of nurse-root grafting depends on several factors, including the rooting ability of the scion, compatibility between the scion and nurse-root, and the tying materials used to secure the graft union. Rooting ability varies widely between varieties. For instance, McIntosh is much more prone to root than Rome Beauty. A shy-rooting apple scion may be induced to root more readily by using a pear nurse root. By far, the greatest influence on scion rooting is brought about by the tying material used to secure the graft. Thin copper wire has been suggested as a tying material, but when tried the wire girdled and cut off the nurse-root during the first growing season, before the scion had developed any roots of its own.

Nursery grafting tape, in contrast, expanded with growth of the graft and under the action of soil moisture, disintegrated too soon. Thus, girdling at the point of union did not occur. The nurse-root, because it was not restricted by the tie, produced a smooth union and developed strong roots of its own (Fig. 30), interfering with root initiation and root development on the scion itself.

Making use of this property and using a slightly heavier gauge rubber, it is possible to choke off the nurse-root gradually and stimulate root development and root growth on the scion rather than on the nurse-root.

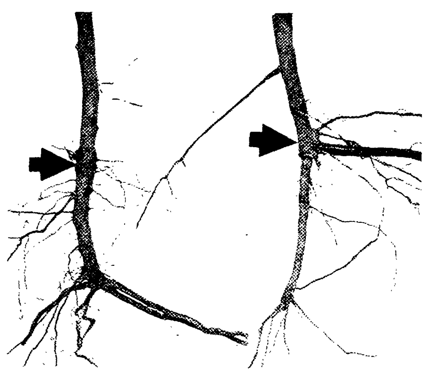


Fig. 30.—Scions of Hibernal apple grown on a nurse root for two seasons. Left, graft union (arrow) tied with grafting tape, no girdling at union, few small roots on scion; Right, graft union tied with rubber strip (arrow), nurse root has gradually been choked off, scion has developed strong root system.

Interstock graft

Experiments carried out at this Station have proved that when a short stem piece of a dwarfing stock is interposed between the rootstock and the scion variety, shoot growth of the scion variety is dominated by the stem piece that was interposed. Use is made of this discovery in propagating dwarf fruit trees that do not need support (Table 2). A dwarfing interstock introduced as

Clark's Dwarf is identical to EM VIII, according to studies made at this station.[6]

In order to produce trees that are checked in growth by a dwarfing interstock, two different propagation methods can be employed. By the first method a 7- to 8-inch long scion of either of two dwarfing apple stocks, namely, EM VIII or IX, is bench grafted by a whip graft in late winter to well-graded branch-rooted 1-year-old apple seedling rootstocks and the grafts lined out in the nursery row in the spring (Fig. 31). In midsummer the desired apple variety is budded into the scion, now becoming the interstock, so that at least a 4- to 5-inch long stem piece of the dwarfing interstock remains between the rootstock and the varietal bud. It takes two growing seasons to produce a plantable tree by this method.

By the second method the dwarfing interstock is budded in midsummer onto the seedling rootstock growing in the nursery. (See section on budding.) The following year, again in midsummer, the desired variety is budded into the resulting whip at a point 4 to 5 inches above the previous bud union.

This second method, a double budding technic, requires three growing seasons to produce plantable trees. The disadvantage of an additional growing season is outweighed, however, when material

[6]Similarity of the Clark Dwarf and East Malling Rootstock VIII. Karl D. Brase. *Proc. Amer. Soc. Hort. Sci.*, **61**, *95–98. 1953.*

Fig. 31.—Seedling apple rootstocks bench grafted (arrows) over winter to the interstock EM IX, lined out in April; condition of grafts in early July a month before budding.

is in short supply in that a maximum number of trees can be grown from a limited supply of dwarfing interstock by this method. Only a single bud of the dwarfing stock is required for each tree instead of a 6- to 7-inch long scion.

The double budding technic should also be employed in the propagation of dwarf pear trees. Varieties that do not make a strong bud union on the quince dwarfing rootstock can be grown on this stock by double budding (Fig. 32). A compatible variety is budded onto the quince rootstock and the following year the incompatible variety is then budded into the budling of the compatible one (Table 3).

Fig. 32.—Dwarf apple tree with a 5-inch interstock (arrow) obtained by the double-budding technic.

Top grafting or top working

Whenever it becomes desirable to change the variety of an older tree, it is possible to graft scions of the desired variety onto the skeleton or framework branches. This is called top working or top grafting. In top working, branches from 3 to 4 inches in diameter can be cut off at a distance from the main trunk and scions of the desired variety are set on the cut ends. In preparing trees for top working it must be remembered that the larger the pruning wound the longer it will take to heal. It is better to graft higher up onto two or three smaller lateral branches than on a large one at a lower level. There are many types of grafting procedures. The usefulness of each depends upon the particular material to be grafted and the time when it is done.

Cleft grafting

Cleft grafting is the most commonly used method on large trees and is best carried out in early spring just before new growth starts. However, it can also be done in late winter or even after growth has started. The branches to be grafted are sawed off squarely and are split with a grafting chisel and mallet (Fig. 33A).

In making the split care must be taken that it does not run into a knot but extends straight down on either side. The cleft is opened by inserting the wedge-shaped end of the grafting chisel.

Scions to be inserted should bear two or three buds, although scions with only one bud may be used. Beginning on either side of a bud, the lower end of the scion is cut in the form of a wedge with two strokes of a sharp grafting knife. One side of the wedge should be slightly narrower than the other (Fig. 33B). The sides of the scion must be cut straight to an even taper. Otherwise the point of contact with the stock will be only at the thickest portion of the scion rather than throughout its length. The wedge-shaped scion is inserted into the cleft, with its narrow side toward the center of the stock, thus allowing the outer and thicker edge to be firmly gripped when the wedge of the grafting chisel is removed (Fig. 33C). Two scions are inserted on opposite sides in each cleft. Care must be taken to match the growing layers, or inner bark, of the scion with that of the stock. The cambium layers of both must come in contact. If the scion is set too far towards the center of the cleft, the cambial zones will not match and a failure or improper union will result.

The final step consists of waxing over all cut surfaces, including the tip of the scion.

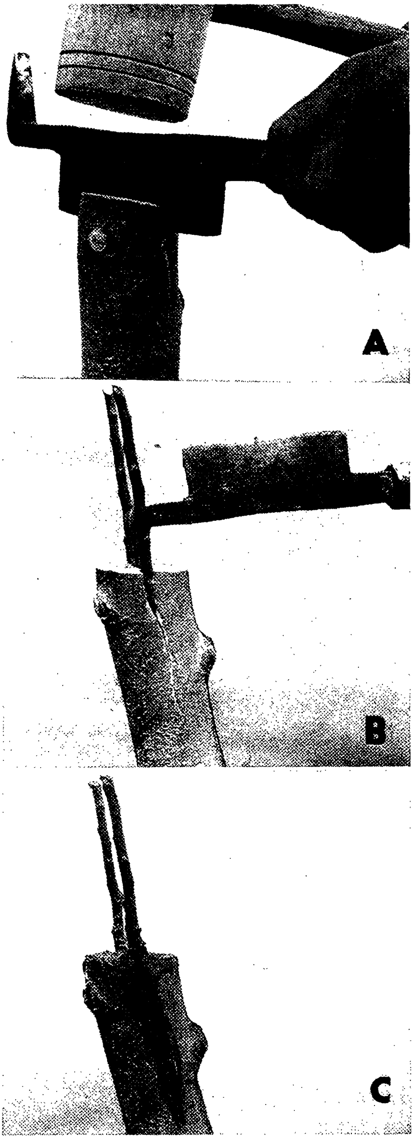


Fig. 33.—Steps in making a cleft graft. A, splitting the stock; B, properly cut scion is inserted into the cleft; C, grafting chisel is removed, the inserted scions are held firmly in place, and all cut surfaces carefully waxed.

Bark grafting

Bark grafting is done in the spring when the bark begins to separate easily from the wood. Since the stock is not split as in cleft grafting there is less danger that decay organism can enter the wood than when the cleft graft method is used. Bark grafting is the preferred method for top working larger limbs on cherry trees.

Various modifications of bark grafting have been devised but only the simplest ones are described here.

The limb is cut off as for the cleft graft and a slit made downward in the bark. This slit should be just long enough so that the scion can be pushed in place without splitting the bark. The scion is cut flat and wedge shaped with a longer cut on one side than the other. A shoulder is cut on the side having the longest cut (Fig. 34). Thus prepared, the scion is pushed down between the slit bark so that the scion rests on the cut surface of the stock. The scion can be held in place with slender nails, driving one through the scion and one through the bark. The scion can also be held securely in place by wrapping with grafting tape or string. Depending on the size of the stock from one to three scions may be inserted (Fig. 34). The entire graft must be covered with wax.

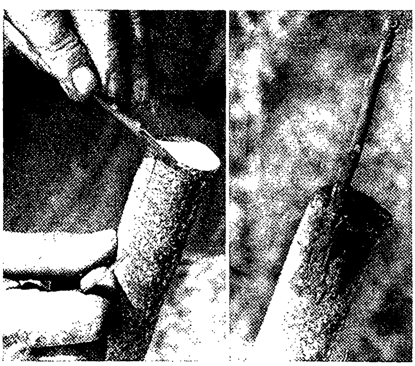


Fig. 34.—Steps in bark grafting. If the bark is thin, a single slit is made through the bark (left) and the properly cut scion pushed under the bark where slit was made. All cut surfaces are carefully waxed (right) to prevent drying out.

If the bark on the stock is very thick, a portion of it may be cut out just the size of the scion and the scion fitted in tightly (Fig. 35).

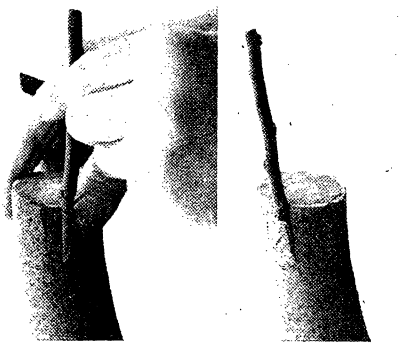


Fig. 35.—A bark graft on a stock with thick bark. Instead of a single slit, two slits are made (left) and scion pushed into place (right) where strip of bark has been separated.

Notch grafting

This grafting method is most useful when scion wood of small diameter must be used or when the stock is too large for whip grafting but too small to use a cleft graft. A curved pruning knife is used to cut the triangular notch on the stock. Extensive damage by splitting of the stock is avoided. The wound is limited to the place of insertion and no hollow space remains that may

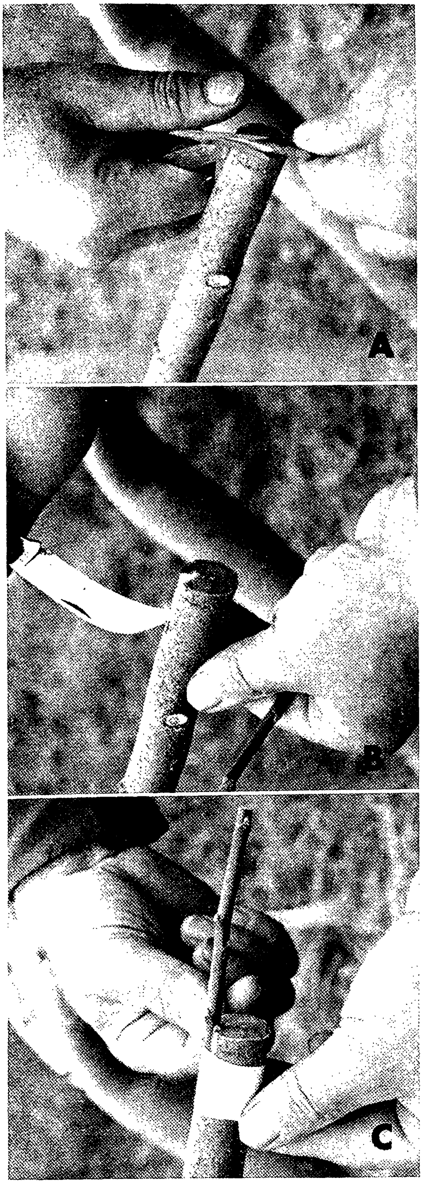


Fig. 36.—Steps in notch grafting. A, cutting a triangular sideways wedge on the scion; B, cutting notch in stock; C, tying the fitted scion in place.

interfere with the proper healing of the scion. The method is well adapted to top working young fruit trees, particularly cherry and plum.

The basal end of the scion is cut to a triangular sideways wedge by two equal cuts (Fig. 36A). The stock is cut off squarely and grooved by two cuts the same size and angle as those on the scion (Fig. 36B). The groove in the stock must be deep enough so that the cambium of the scion comes in contact with that of the stock. The scion firmly placed in the groove is tied (Fig. 36C) with grafting tape or rubber budding strips and all exposed cut surfaces are sealed with grafting wax.

Side grafting

Side grafting is employed on large bare branches to establish new bearing wood. It is one of the less commonly used methods that has certain advantages because grafts can be made rapidly and because a great number of scions can be placed on a single branch. A downward slanting cut is made crosswise on the branch. The scion is cut wedge shape, as for the cleft graft, only more bluntly. By bending the branch to open the cut the scion is pushed down into the slanting cut and the cambial zones are matched. Although tying the graft is not necessary since the spring of the wood will hold the scion in place, it is advisable to secure the scion more firmly by wrapping grafting tape around the grafting wound (Fig. 37).

Aftercare of Grafted Trees

Grafting is followed by profuse

sucker growth from the stock. When the graft is placed on young seedling stocks, as in bench grafting, all suckers should be removed as they arise. Bench-grafted stocks are handled the same way as described under after-care of budded stocks.

Larger trees that are top worked should be carefully inspected several times and suckers removed if necessary during the first growing season. Any sucker growth from the stock should be thinned out but not all suckers removed. If the scions made vigorous growth during their first growing season, most of the suckers growing below the graft can be removed the following spring. It will take from two to three growing seasons before all sucker growth is eliminated. But even during later years attention should be given to any sucker growth that may again arise below the graft.

Where more than one scion is growing from each grafted stump the better placed one should be encouraged by reducing the others until it is entirely removed. Such removal can take place as soon as the grafting wound is completely healed over. Where scions have failed to grow new shootgrowth from the stock should be allowed to develop to prevent the dying back from the cut end. A new cut can be made the following year and scions placed on it. Top worked trees should not be allowed to bear crops until a sufficiently strong framework has developed from each graft.

Fig. 37.—Side grafts one year after the grafting operation.

Bridge Grafting

This grafting procedure is used to repair and improve trees completely or partially girdled near the ground level by rodents or suffering from low temperature or disease injuries. Such injured trees may die unless the injured areas of the trunk are bridged over by living tissue to reconnect the fruit-bearing top with the root system.

Ragged edges and loose bark must be cut away cleanly in early spring. When the injury extends to the roots, the earth must be removed from the base of the tree and from the larger roots until sound bark is uncovered.

There are various ways of inserting the scion. When dealing with younger trees having relatively thin bark (Fig. 38C), a short slit is made through the healthy bark above and below the area to be bridged over. A dormant scion is cut wedge shape on both ends, but the cut on one side is only about half as long as on the opposite side (Fig. 38A). The wedge-shaped ends are then inserted under the bark at the point it was slit so that the longer cut surface is in contact with the wood of the tree. Scions are placed about 3 inches apart and should be from 3 to 4 inches longer than the space to be bridged. The scions should be long enough to bow outward from the trunk when in place (Fig. 39). Each scion is secured by driving a small nail through each end of the scion and the loosened bark. That part of the scion inserted under the bark is thoroughly waxed over.

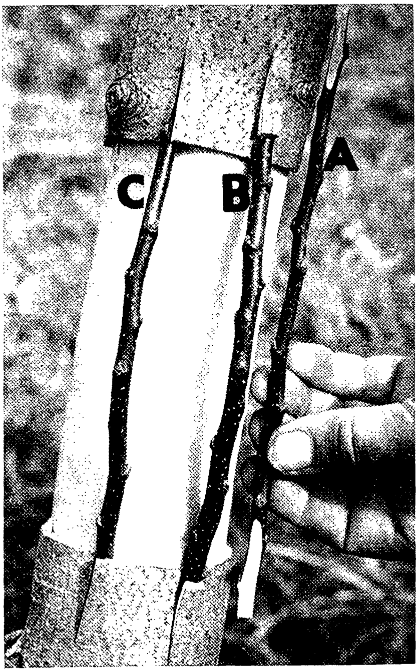


Fig. 38.—Steps in bridge grafting. A, properly cut scion ready to be placed under slit made through the bark of the trunk; B, if bark is too thick, a strip is separated from the trunk and scion fitted into the groove; C, where the bark is thin, a single slit can be made and the scion inserted as shown.

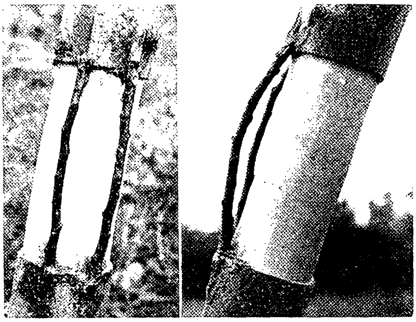


Fig. 39.—Bridge grafts in place and cut surfaces waxed (left). On right, properly placed scions, showing desirable outward bowing of scion.

With old trees having very thick bark the inlay graft instead of the bark graft is preferred. Instead of making a slit through the bark a 3- to 4-inch long strip of bark as wide as the scion to be used is separated from the trunk (Fig. 38B). The scion is cut flat on one side on both ends and fitted into the place where the bark strip has been separated. Where the inlay-graft is used, care must again be taken to cut the scion long enough to form a slight bow when in place. The properly placed scions are held firmly to the trunk by driving two small nails through each place of attachment. The ends of the scion must be covered with wax, but it is not necesary to cover all of the bridge portion of the trunk (Fig. 39).

Inarching

In instances of extensive injury to trunk and rootsystem it becomes necessary to inarch seedling or young trees into the tree to be kept alive (Fig. 40).

One-year-old seedlings or budlings are planted beside the tree and are then grafted into the tree trunk. Depending on the age and thickness of the bark, the seedling can be attached to the tree trunk by either the bark or inlay graft. Again each seedling is nailed in place and all cut surfaces are waxed. Shoots that appear on the inarched seedlings during the following growing season are best left but must be somewhat suppressed by pinching back their tips. After the inarched plants have securely united all shoot growth can be removed.

Inarching as well as bridge grafting is most successfully done in early spring as soon as the bark of the injured trees separates readily from the wood.

Grafting Waxes

Two different grafting waxes can be used, (1) a soft wax that can be applied by hand and (2) a hard wax that must be melted when applied. Grafting waxes also often contain some pigment, such as lampblack, to give them a color different from the tree. The black color absorbs sun rays which merge minute cracks formed in the wax cover during cold weather. Using colored wax also helps to determine quickly if all grafting wounds are covered.

A soft wax may be made from the following ingredients:

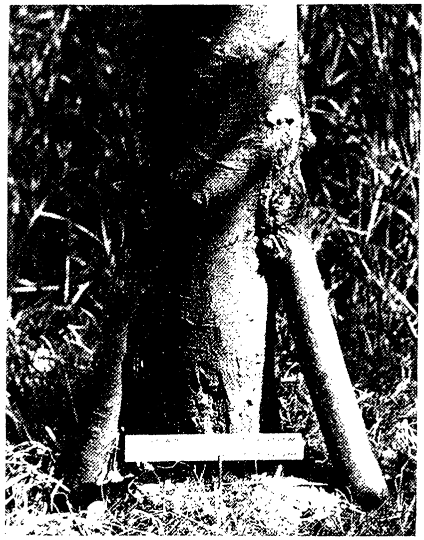


Fig. 40.—Injury to the trunk of this tree was corrected by inarching seedlings planted next to the trunk.

Resin	4 pounds
Beeswax	2 pounds
Tallow	1 pound
Lampblack	1 ounce

Melt the first three ingredients together and add the lampblack. In order to obtain a softer wax, the same amount of linseed oil may be substituted for the tallow.

A hard wax that must be applied when melted can be made from the following ingredients:

Resin	5 pounds
Beeswax	1 pound
Raw linseed oil	3/4 pint
Lampblack	1/2 pound

Melt the resin, add the beeswax and melt, add linseed oil and remove from heat, and stir in lampblack little by little. Since the materials used are inflammable proper precautions must be taken in the preparation of grafting waxes.

A publication of the
New York State Agricultural Experiment Station
Geneva, N. Y.
New York State College of Agriculture
A Unit of the State University of New York
At Cornell University