To treat the cuttings in water, the solution of the required strength is put in a glass or an enamelware container to a depth of about half an inch. The cuttings are placed in an upright position in the container with their basal ends standing in the liquid. During the several hours of immersion they are kept in the light, at room or greenhouse temperatures, but not exposed to direct sunlight. The best strength of solution varies among different species. In the writer's experience with immature cuttings of woody plants, indolebutyric acid at the rate of 5 milligrams in 100 cubic centimeters of water has been effective for a number of species, whereas others responded best to 8 to 10 milligrams per 100 cubic centimeters of water. (One gram is the equivalent of 1,000 milligrams.)

The period of immersion giving best results also varies among different plants. A period of 18 to 24 hours is frequently recommended, but a shorter time may suffice for most plants. The intake of the chemical is faster at first than later and not in proportion to the length of time the cuttings are immersed.

Results from treatments of a number of plants with indolebutyric acid in solution are shown in table 1. In group 1 are listed those that responded by a gain in time of several days to more than a month. However, when the counts were taken most of the check, or untreated, cuttings were still in good condition and they might have rooted later. In group 2 are plants that formed roots more freely as a result of the treatment but that showed no important gain in either time or percentage of successful rooting. In group 3 are listed those that responded by a very decided gain from the treatment inasmuch as very few were successful without it. Although the number of plants in this group is comparatively small, it includes some of high importance among ornamentals.

When the chemical is used in the form of powder the treatment consists in first wetting the cuttings and then dipping their basal ends into the powder and then planting them at once. Care is needed while handling to avoid rubbing off the powder that adheres to the cuttings. This means of using the chemical has gained favor recently as it is easier to use, and results have in general been rather similar to those from solutions. However, the amount of chemical taken into the cutting cannot be controlled as accurately as when solutions are used.

From the results shown, from experiments at other research stations, and from practical nursery experience it is evident that a considerable shortening of the time required to form roots on many plants may be expected from the proper use of these root-stimulating substances. Although by treatment with these chemicals a number of species regarded as difficult to root may yield good percentages, these substances do not perform miracles and their value has sometimes been exaggerated in printed articles and in advertising matter. It should be pointed out also that their use does not take the place of the customary discrimination in the selection of the best wood for cuttings, of their care while in the sand, and of precaution to prevent wilting and to keep them in a healthy state until roots have developed.

U. S GOVERNMENT PRINTING OFFICE: 1948

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 20 cents

Henry Pittman

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1567

PROPAGATION OF TREES AND SHRUBS

THIS BULLETIN describes briefly some of the methods frequently employed for the propagation of deciduous fruit trees as well as a number of the trees and shrubs used for the adornment of home grounds. Practical details concerning the care and handling of tree seeds, the culture of seedlings, the successive steps in the handling of cuttings, layers, grafts, and buds in order to succeed in these operations, as well as the methods of propagation most suitable for the several different kinds of woody plants, are presented.

Washington, D. C.

Issued April 1929
Slightly revised August 1945

II

PROPAGATION OF TREES AND SHRUBS[1]

By GUY E. YERKES, *Horticulturist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

CONTENTS

INTRODUCTION

IN NATURE woody plants reproduce their kind most frequently by seeds; they also reproduce by root sprouts or suckers and by layers. By such means species or general types are perpetuated and increased. In addition to these, man has developed propagation by the use of cuttings, as well as grafts and buds, to reproduce peculiarly desirable qualities found in a single individual and to multiply the number of such individuals.

Since ancient times man has employed grafts and cuttings as well as the means of propagation more commonly met in nature. The ancient methods, modified and improved by successive generations, constitute the foundation on which is based the present-day culture of trees in the nursery. Some of these operations have become more or less standardized, although they must frequently be altered to meet the widely different conditions under which trees are grown.

Besides actual propagation, many details enter into the preparation of trees to fit them for permanent planting. Cultivating, transplanting, pruning, control of diseases and insects, and other operations must also be given attention, in order to obtain vigorous growth with well-developed roots and properly formed tops. An intimate knowledge of these details, which can be had only by special training and experience, is essential to the efficient production of high-grade trees. Hence the ordinary planter usually depends on the nurseryman equipped for quantity production to supply his trees. There is no reason, however, why anyone with a general knowledge of trees can not propagate them, provided he will learn the easily under-

[1] Manuscript submitted to the chief of the bureau Sept. 21, 1927.

stood manipulations and give the plants the necessary care and attention.

The most appropriate means of propagation depend on the kind of plants, the use for which they are intended, the facilities which are available, and other circumstances.

Seeds very often offer the readiest and least expensive means for the reproduction of species. Seedlings, however, usually vary more or less in their characteristics; hence dependence can not be placed on them to furnish plants which are exact reproductions of their parents.

Cuttings are used to reproduce like plants of many varieties of ornamentals, also some of the fruits. For practical purposes the plants so reproduced are similar in all respects to the mother plants, although bud variants or "sports" appear occasionally.

Layers are useful in propagating many woody plants, especially when only a small increase is required. In ordinary nursery practice, however, layering is too slow a process except for certain classes of plants which are not easily propagated by other means.

Suckers, or shoots originating from the roots or the stems of the plants below ground, are used to a limited extent. Comparatively few species form such shoots freely enough to make a rapid increase possible by this means.

Grafting and budding are means extensively employed for the propagation of varieties that do not root easily from cuttings.

PROPAGATION BY SEEDS

Under conditions in the wild, most woody plants are dependent in large measure upon seed for their reproduction. Falling from the trees the seed is covered by leaves or scattered by the wind to drop in moist soil or in crevices; it is floated down streams and left in the mud on the banks; it is frequently carried many miles by birds. Large seeds, such as acorns and nuts, are often buried by squirrels in places where the conditions are favorable for germination.

Much can be learned about the principles of caring for tree seed in the nursery by observing conditions under which it germinates and grows in the wild. Often these natural conditions can be imitated and improved by the various artificial aids designed to give protection to the seeds and seedlings as well as to provide suitable conditions for germination and growth. Nature is extravagant with seed, whereas the desire of the propagator is to produce the largest number of good seedlings with the minimum amount of seed and labor.

The first necessity is fresh seed of good germinating quality. If seed-bearing trees of the desired species are growing near at hand, they are usually the best source of supply. When collecting seed, it is advisable to examine a number of seeds from each tree by cutting them open to see if the kernels are plump before expending labor on gathering them. Close observation of the various species must be made to determine when the seed is ripe. If not harvested at the right time it is likely to be scattered from the seed vessels or otherwise lost.

The maturity of the seed of conifers usually can be determined by cutting open the cones from time to time. As the seed matures, the outer coat changes to brown and the seed itself loses its milky state and becomes firm. Seeds having a more or less pulpy covering, such as hawthorn, rose, plum, and the like, are usually ready to collect when the fruits are well colored. Often such seeds can be cleaned by mashing the outer coats and placing the mass in water for two or three days to soften the pulp. When separated, the good seed settles to the bottom of the container and the pulp and light seed afloat can be washed off.

When seeds are not procurable from near-by sources dependence must be placed on collectors and dealers from a distance. Large growers of seedlings give much attention to locating the best sources of seed and making contacts with collectors. Smaller users are dependent largely upon dealers in tree seed. This branch of the seed business is an important one represented by a number of firms which issue catalogues offering a wide variety of seed of trees and shrubs.

STORAGE OF SEEDS

The proper care of tree and shrub seeds during the interval between the time of collecting and that of planting is a matter of importance which frequently is overlooked. Some conifer seed, such as pine, spruce, and arbor vitae, keeps in good condition after drying if stored in tightly covered containers or in paper bags where the air is dry and cool and away from mice. Seeds of other conifers and of some of the important species of deciduous trees and shrubs grown for ornamentals are injured by drying and should be placed in cool, moist storage within a short time after gathering. When seeds are to be procured from a distance it is advisable to place the orders before the time of harvesting, so that they may be received without unnecessary delay and placed at once under favorable conditions to prepare them for germination.

Some kinds of seed will not germinate when they are collected, but require a period of several months for the complex internal development called "after ripening." Some complete this process during the winter if planted in autumn or kept moist at a temperature a few degrees above freezing and will germinate the following spring; others, as some species of dogwood, hawthorn, holly, juniper, viburnum, and yew, may require a longer period and sometimes refuse to germinate until the second spring.

To store seeds and prepare them for later sowing, the most common way of providing constant moisture is stratification. Moist sand and seeds are placed in shallow boxes in alternating layers from one-half to 1 inch deep, depending on the size of the seed. (Fig. 1.) The boxes containing the sand and seeds are kept in a cool cellar, preferably between 35° and 45° F., where the sand will remain moist, or are buried in a well-drained place, or the container is set on top of the ground and covered with some material that will retain the moisture. Mice and rats are very fond of some kinds of tree seeds, and these pests must be guarded against by covering the tops of the boxes with wire screen or in some other effective way.

Instead of placing the seed between alternating layers of sand, the same results can be obtained by simply mixing the seed with about three or four times its volume of sand to aid in maintaining

proper moisture and to prevent the seed from massing together in such a manner as to cause heating. Too much or too little moisture may injure its vitality.

Another method to provide moist storage and at the same time protect the seed from rodents is by the use of flat envelopes made of ordinary galvanized fly-screen wire in which the seed is spread out in a layer about 1 inch thick. These packages may be laid on top of the ground and covered to prevent severe freezing, or they may be put away in boxes with sand around them in a cool cellar. Seed kept moist in this manner should be examined frequently in early spring for the first signs of germination, as some, such as the apple, become active with the first warm days. Once germination begins, the seed must be planted immediately.

Imported apple, pear, cherry, and plum seed usually arrives during fall or winter. When received, it should be soaked for three or four days in fresh water, changing the water each day, and then stratified. It is also kept in large quantities, in burlap bags, in layers 2 to 3 inches thick, between cakes of ice.

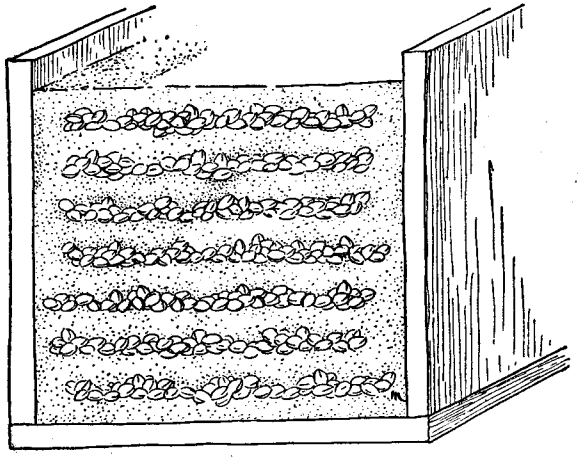

FIG. 1.—Cross section of box of stratified seed

Some seeds having hard, bony coats such as locust (Robinia and Gleditsia), yellowwood (Cladrastis), and Kentucky coffee tree (Gymnocladus), should have boiling hot water poured over them and then should be allowed to soak for a day. Those that swell will then be ready to plant; those that remain unchanged should be treated a second time. By this treatment, quicker and more uniform germination may be obtained than if the seeds are planted dry.

Peach and apricot pits usually germinate well if stored moist and subjected to freezing, which helps to loosen the sutures. Freezing is not essential, however. In the Southern States good results are obtained by keeping considerable moisture around the pits from the time they are collected and storing them in a cool place, or by planting them as soon as possible after collection.

The following seeds may be stratified as soon as procured and planted in fall or early spring:

Apple (Malus).
Apricot (*Prunus armeniaca*).
Ash (Fraxinus).
Barberry (Berberis).
Beech (Fagus).
Bittersweet (Celastrus).
Boxwood (Buxus).
Cherry (Prunus).
Cork tree (Phellodendron).
Cotoneaster (Cotoneaster).
Cranberry bush (Viburnum).
Dogwood (Cornus).
False indigo (Amorpha).
Firethorn (Pyracantha).

Flowering quince (Cydonia).
Fringe tree (Chionanthus).
Hackberry (Celtis).
Hawthorn (Crataegus).
Holly (Ilex).
Honeysuckle (Lonicera).
Hornbeam (Carpinus).
Horse-chestnut (Aesculus).
Juniper, red cedar (Juniperus).
Linden (Tilia).
Locust (Robinia and Gleditsia).
Magnolia (Magnolia).
Maidenhair tree (Ginkgo).
Maple (Acer), species that ripen in fall.
Nandina (Nandina).
Papaw (Asimina).
Peach (Amygdalus).
Pear, French (*Pyrus communis*).
Pearlbush (Exochorda).
Persimmon (Diospyros).
Plum (Prunus).
Privet (Ligustrum).
Russian olive (Elaeagnus).
Shadblow (Amelanchier).
Siberian pea tree (Caragana).
Silverbell (Halesia).
Snowbell (Styrax).
Sweet gum (Liquidambar).
Tulip tree (Liriodendron).
Yellowwood (Cladrastis).
Yew (Taxus).

Seeds which may be kept dry and planted in spring are:

Althaea (*Hibiscus syriacus*).
American arbor vitae (*Thuja occidentalis*).
Bald cypress (Taxodium).
Bluebeard (Caryopteris).
Catalpa (Catalpa).
Cedar (the true cedar) (Cedrus).
Chaste tree (Vitex).
Crape myrtle (Lagerstroemia).
Cryptomeria (Cryptomeria).
Cypress (Cupressus and Chamaecyparis.)
Hemlock (Tsuga).
Larch (Larix).
Mock orange (Philadelphus).
Mulberry (Morus).
Oriental arbor vitae (*Thuja orientalis*).
Pear, oriental species (*Pyrus calleryana* and *P. ussuriensis*).
Plane tree (Platanus).
Redbud (Cercis).
Sophora (Sophora).
Spruce (Picea).
Sweet shrub (Calycanthus).
Umbrella pine (Sciadopitys).
Wisteria (Wisteria).

These seeds should be planted as soon as ripe:

Birch (Betula).
Elm (Ulmus).
Maple (Acer), species that ripen in spring.
Oak (Quercus).

CONIFEROUS SEEDLINGS

SEED BEDS FOR CONIFERS

A fairly level site which is well drained is essential for a seed bed for conifers, and if possible it should be protected from strong wind. Good seedlings can be grown in almost any fertile soil, but rich, mellow, sandy loam is preferable because it is easy to work and holds moisture near the surface. Thin gravelly soils should be avoided for seed beds. Clay soil can be greatly improved by working sand into it. It may be desirable to begin the preparation of the soil a year or more in advance by applying manure a sufficient length of time before planting so that it becomes well rotted and thoroughly incorporated into the soil, also by plowing under cowpeas or clover to add fertility and to improve its physical condition. Some of the future expense of weeding can be saved by cultivating the land in advance, to rid it of weeds. Beds 4 feet wide with 2-foot paths between them and of any length are desirable for conifers, as such beds are convenient for working. In final preparation the beds should be spaded or plowed deeply, all roots and stones removed, the soil pulverized and then carefully leveled. Under most conditions some provision for watering the young seedlings is necessary, as they must not be allowed to become dry.

SHADING

Protection from full sunlight is usually necessary for best results in the seed bed, as conifers are easily injured by too much heat. Both low and high types of shading structures are in use, each having its advantages and disadvantages. An inexpensive and fairly satisfactory means of shading is provided by lath frames 3 by 4 feet, with open spaces between the laths. To support these frames a line of stakes 18 inches high and 6 feet apart is put along each edge of the beds. Over each line of stakes a No. 12 wire is stretched. Such a temporary shading is an advantage in that the location of the beds can be changed easily for each crop. (Figs. 2 and 3.)

A more permanent type of structure with laths or other strips supported on a high frame, although more expensive, provides excellent conditions for the seedlings and is very convenient while caring for the young plants. Such a structure is shown in Figure 4.

The amount of shade most desirable varies with different climatic conditions and species. In many situations screens made of ordinary building laths spaced 1½ inches apart are satisfactory.

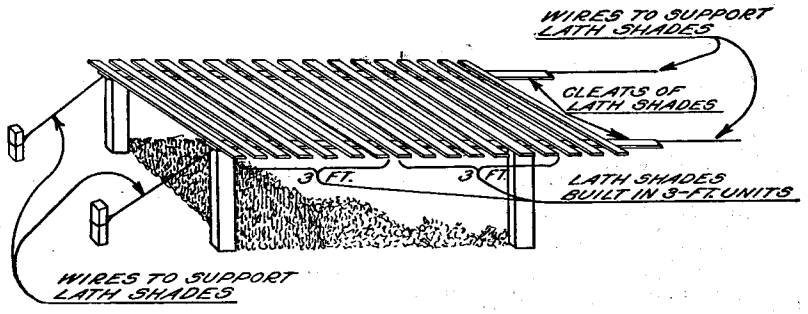

FIG. 2.—Lath shade over seed beds

TIME OF PLANTING

Both fall and spring sowing are practiced for different species of conifers. In the Southern States fall planting is often desirable for such evergreens as Italian cypress and Chinese arbor vitae. Pines, spruces, arbor vitaes, hemlocks, and many others are more commonly planted in spring, particularly in the Northern and Central States. Red cedars, junipers, yews, and others for which stratification is recommended while the seed is in storage may be planted either in fall or in early spring.

PLANTING

The seed may be sown either broadcast or in rows. Broadcast sowing is usually preferred. The young plants often do best when growing in rather dense stands of 75 to 150 per square foot, the best number depending on the species and whether they are to remain in the seed bed more than one season. To obtain this stand it is necessary to sow the seed thickly. Experiments have shown that even when fresh seed is planted under very good conditions, only one-half to two-thirds as many seedlings may be expected as there were

seeds sown. After sowing it is desirable to press the seed with a roller or packer to bring it into close contact with the moist soil and to aid in securing a uniform cover. A depth of covering equal to twice the diameter of the seeds is a fairly safe rule to follow in planting tree seeds in beds. Sand or sandy soil is preferable to heavy soil for covering.

During the period between sowing and actual sprouting, the seed is in its most critical condition and the soil must be kept uniformly moist but not wet. It is often desirable to spread burlap or other light cover on the beds to aid in holding the moisture. This cover must be removed as soon as sprouting begins.

Germination from spring sowing may be completed in from 30 to 50 days, depending upon the species, the temperature, and the moisture. If necessary to thin the seedlings, this work should be done while the plants are small.

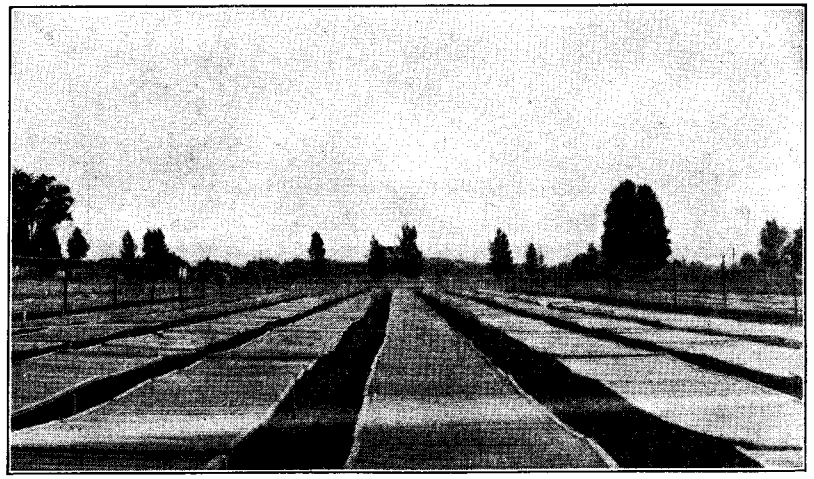

FIG. 3.—Evergreen seed beds protected by lath or other wood strips

SEED-BED CULTURE

The first few weeks after the seedlings come up is the most critical time in the life of the plants, when "damping off" or decay of the stems at the surface of the ground often causes heavy loss. Dry cool air circulating under the lath screens, and the soil suitably supplied with moisture but with the surface of the bed dry, constitute conditions for favorable growth and for keeping the plants healthy. Besides damping off, the young seedlings may suffer from the depredations of cutworms, mice, rabbits, and birds.[2]

The young seedlings are sensitive to drought. The close stand of young plants with their roots near the surface soon exhaust the available moisture, therefore close attention is needed to provide proper moisture conditions.

[2] The United States Department of Agriculture supplies information on the control of these pests.

698141°—46——2

The young seedlings can usually be wintered better by giving them protection in the beds than by lifting and storing them. In late fall the beds should be mulched lightly with pine needles, leaves, or similar material that is free from weed seeds, to guard against lifting or heaving of the roots by alternate freezing and thawing. Likewise, protection from rabbits and mice must be given during the winter.

TRANSPLANTING

When the seedlings have attained a height of 3 to 6 inches they should be transplanted into beds similar to the seed beds. Some kinds of seedlings may attain this size the first season, but the slower growing species, such as spruce and pine, may require two or more years in the seed bed. Early spring is usually the best time for transplanting.

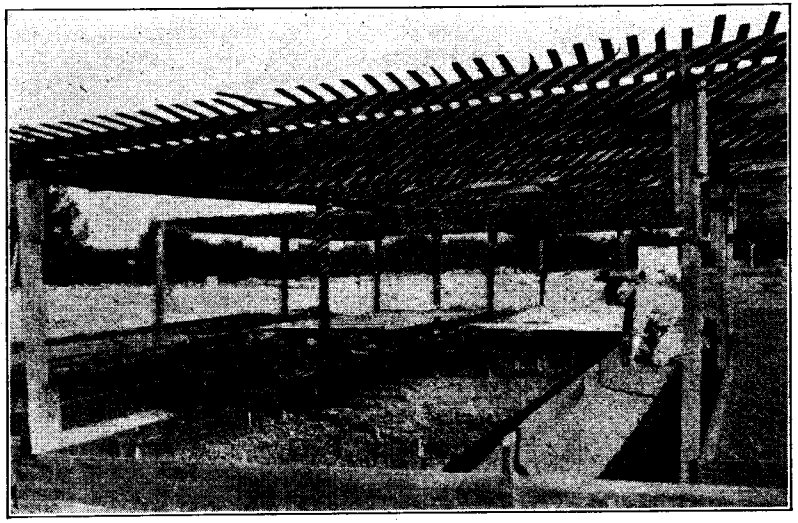

FIG. 4.—Overhead shading for seed beds. Ordinarily the sides are shaded as well as the top

The importance of keeping the roots of evergreens from exposure to dry air while out of the ground can not be overemphasized. A good way to protect the roots is to provide boxes lined with wet burlap in which to place the seedlings. When dug, they are placed in the boxes in layers, and each successive layer is covered with a piece of wet burlap. Dipping the roots in thin mud at the time of digging is a good precaution against drying. Without delay the boxes of seedlings are taken to a cellar or a damp room for sorting into different sizes. All very small and damaged plants should be thrown away. This sorting aids in obtaining uniform development in the transplant bed, because those of nearly the same size can be planted together.

Suitable planting distances in the transplanting beds are from 1 to 2 inches apart in rows 6 to 8 inches apart. Immediately following the transplanting and for two or three weeks thereafter the beds

should be watered liberally. By the end of this time root action will have commenced, when the watering should be decreased; but during the growing season the soil should be kept moist to within perhaps an inch of the surface. Frequent shallow cultivation should be given to conserve soil moisture, and all weeds should be kept out. The transplant beds need winter protection similar to that for seed beds. Fast-growing species need only one year in the transplant bed, whereas slower growing ones may remain two years before transplanting again.

DEVELOPMENT IN THE NURSERY

In transplanting to the open nursery rows the same care must be given to the roots as described for the seedlings. As the plants must have space to develop shapely tops, about 2 feet apart in rows 4 feet apart is usually advisable. After one or two seasons' growth in the open, the young trees may be sufficiently developed to be usable for permanent planting. If it is desirable to continue the plants in the nursery to develop a larger size, they should be transplanted every two years.

Seedlings of the same species often vary in the rate of growth, form, and color. As soon as those of undesirable habit can be recognized, they should be disposed of for windbreak or massed planting, rather than to continue to give them the valuable space and the costly care required to develop specimen trees.

DECIDUOUS SEEDLINGS

ORNAMENTALS

Many of the deciduous tree and shrub seeds intended to produce plants for landscape planting can be handled best in beds similar to those described for conifers. However, once germination has taken place nearly all deciduous species are less sensitive to conditions than most conifers. As they usually make faster growth in the seed bed than conifers, it is generally desirable to plant the seed in rows rather than broadcast. One season in the seed bed is sufficient for most species. The second spring they may be transplanted to the open ground, or, in the case of those which grow more slowly, to frames or beds. Some seeds, such as those of the catalpa, ash, locust, and others that are hardy and make vigorous growth from the start, may under favorable conditions be planted in the open ground without the protection of frames or shading. Fruit-tree seeds, which are here considered separately because of their importance, are usually so planted.

FRUIT-TREE SEEDLINGS

Aside from the raising of new varieties, the principal interest in fruit-tree seedlings is for their use as roots in the propagation of varieties by grafting and budding. Seedlings of apple, pear, cherry, and plum for this purpose are mostly grown as special crops in localities where soil and climate are especially favorable to their development. (Fig. 5.) Nurserymen who propagate fruit trees generally find it better, except for the peach and apricot, to buy the

seedlings graded and ready for use from specialists who have the conditions and equipment, together with the experience, to grow them in quantity. Certain areas in eastern Kansas, the Yakima Valley in Washington, and the San Joaquin and Sacramento Valleys in California produce most of the fruit stocks grown in this country, though good seedlings are being grown in certain other sections. Considerable interest has recently been awakened in seedling culture.

SOIL FOR FRUIT-TREE SEEDLINGS

Seedlings should attain sufficient size for use in one season's growth. To attain this size, apple and pear seedlings require rich, well-drained soil, preferably sandy loam, with an open subsoil.

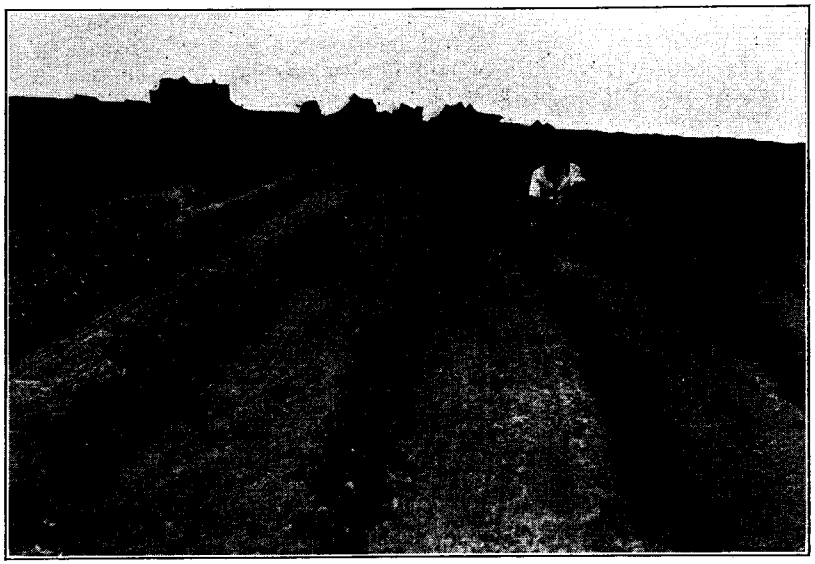

FIG. 5.—A field of fruit-tree seedlings

Cherry and plum seedlings do best on soil that is only moderately fertile; on especially rich soil they are likely to grow too large and fail to mature properly except in irrigated sections where the growth can be controlled in the fall by withholding the water. It is advisable to prepare the soil in advance by plowing under a green crop, such as cowpeas or clover, and by ridding the land of weeds as far as possible. In the fall before planting it should be plowed deeply and the surface pulverized and leveled.

PLANTING

The seed may be planted either in fall or in early spring. Fall planting is desirable if the ground can be put in good condition and the seed obtained in time. If planted in the spring the seed should be put in as early as the ground can be prepared properly. If a seed drill is to be used for planting, the moist seed is dried just enough so that it will run through the drill freely. Apple, pear, and cherry

seeds are covered usually about 1 inch deep in rows spaced wide enough for horse cultivation, or they can be grown in beds for hand culture. For nearly all fruit-tree seedlings a stand of 10 to 15 seedlings per foot is desirable. To obtain this stand, seed must be used rather freely unless it is known to be of very good germinating quality.

Apple seed is often obtained from pomace from cider mills. Power cider mills which have sharp knives for cutting the apples often injure a considerable proportion of the seed. When planting, allowance must be made for such defective seeds. Small hand cider mills usually injure but few of the seeds.

Often cherry and plum seedlings can be grown to advantage in double rows, spacing the rows about 6 inches apart with space for horse cultivation between the double rows. On especially good soil seed may be sown in a shallow furrow, scattered over a strip 4 to 6 inches wide, thus permitting a larger number of seedlings per foot of row.

As soon as planted it is advisable to draw a ridge of soil 3 or 4 inches high over the row, to aid in keeping the seed moist at all times and to check washing out, but this ridge must be removed as soon as germination is well advanced. The seed should come up within two or three weeks after warm weather begins. If thinning is necessary it should be done while the plants are small; overcrowding is sure to produce many small, worthless plants.

CULTURE

Efforts should be made to encourage all the growth possible during the early part of the season. Frequent cultivation with a wheel hoe and hand weeding while the seedlings are small are necessary. By early summer the seedlings are generally large enough for horse cultivation. The soil should be stirred frequently during the summer. Cultivation should be discontinued in early fall to avoid further stimulation of the growth, with a view to securing well-matured firm wood. If grown under irrigation, it is advisable to withhold water during the latter part of the autumn to permit proper ripening of the wood.

DIGGING

Digging should be delayed until late in the fall; the quality of the seedlings is impaired when they are dug prematurely. If necessary to dig them before the leaves have fallen, they are placed in small piles, covered with soil immediately, and allowed to remain a few days to remove the leaves. They are then ready to be sorted into different sizes. For convenience in handling, the tops are cut back and the soil shaken or washed off.

GRADING

Custom has brought about the recognition of certain standards in seedling sizes. As usually defined, the grades are as follows: No. 1 grade in all types of seedlings, caliper from three-sixteenths to about five-sixteenths of an inch. The caliper measure is taken just at the collar. Sometimes an extra large grade above the No. 1 is made of

all the seedlings from one-fourth to seven-sixteenths of an inch caliper. The No. 2 grade is from one-eighth to three-sixteenths of an inch, except in the case of the apple; No. 2 apple seedlings are graded two and one-half-sixteenths to three-sixteenths. Apple seedlings are separated into two types—straight roots, which are preferred for piece-root grafting because two or more grafts can be obtained from a single root, and branched roots, which are preferred for budding and whole-root grafting. In grading the straight type, the roots should maintain practically the full size of their grade to a length of 8 or 9 inches in the case of the No. 1 grade, and to 6 to 8 inches in the case of the No. 2 grade. (Fig. 6.) Those that taper out to a smaller size before reaching this length are called "stubs" and are used either for whole-root grafts or for planting out to bud later in the season. Smaller seedlings than No. 2 grade are little used except where conditions favor unusually large growth, as in some of the Southern States and certain irrigated sections of the Pacific States.

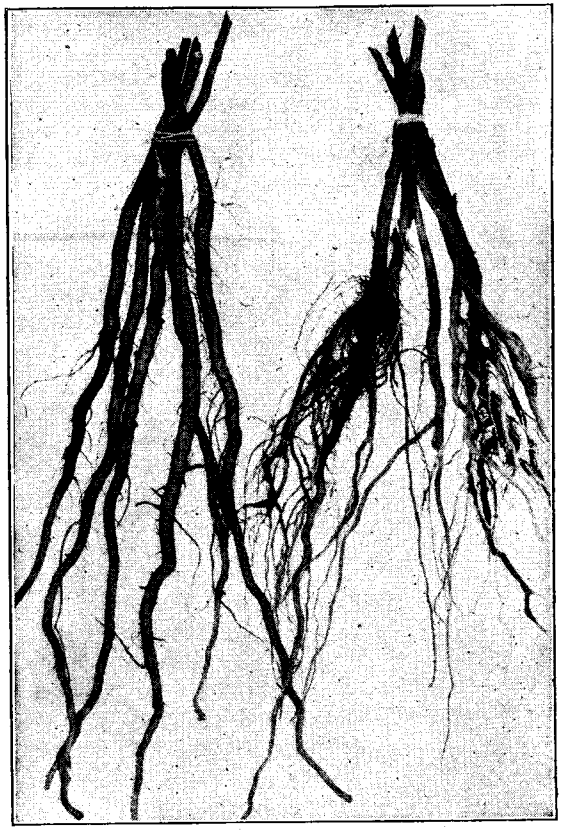

FIG. 6.—Straight-root and branched-root apple seedlings

PROPAGATION BY CUTTINGS

Cuttings are extensively employed for the propagation of woody plants as an assurance that the new plants will be similar in all respects or true to variety. Many kinds of ornamental trees and shrubs and a few kinds of fruit trees and plants will grow from cuttings. They vary greatly, however—even varieties originating from the same species—in their readiness to form roots.

CLASSES OF CUTTINGS

Cuttings are made both from growing wood and from mature wood. For the purpose of treatment stem cuttings taken from wood in active growth at various stages of immaturity may be classed as immature or half-ripe cuttings. These are usually rooted under glass in summer. Those taken from fully matured wood during the dormant season may be classed as hardwood or dormant cuttings. Deciduous hardwood cuttings are ordinarily planted in the open ground in the spring, whereas evergreen cuttings are usually rooted in greenhouses during the fall and winter months. Some kinds of trees and shrubs may also be propagated by cuttings made from roots.

The practical choice between the two classes of stem cuttings depends on circumstances. Some plants root easily from immature cuttings under glass, but with difficulty from mature wood in the open ground; others root easily from either class of cuttings, although even from these a more rapid increase may be obtained from a given number of plants by half-ripe cuttings if a greenhouse or hotbeds are available. Although such cuttings require close attention during the process of rooting, a large number may be accommodated in a small space. On the other hand, if plenty of wood is to be had, or if glass equipment is lacking, the best results for a number of deciduous kinds may be obtained by the use of hardwood cuttings planted in the open ground.

PLANTS OFTEN INCREASED BY IMMATURE CUTTINGS

Among the different varieties of deciduous trees and shrubs that are frequently started from cuttings under glass in summer are abelia, azalea, crape myrtle, deutzia, forsythia, honeysuckle, hydrangea, lilac, mock orange, privet, rose, spirea, snowberry, and weigelia. Under good conditions these and a number of others may be expected to root within a month or two. Certain evergreens also are so propagated, including varieties of arbor vitae, boxwood, holly, and retinospora. They may require a longer period to form roots, often two or three months.

FACILITIES

A high degree of humidity in the air around the cuttings is necessary to keep them fresh while roots are in process of formation. Rooting is hastened by maintaining the sand or other rooting medium 5° to 10° warmer than the surrounding air. This bottom heat is not essential, however, for most kinds of cuttings during warm weather. To provide such conditions, the most convenient type of structure is the modern greenhouse designed for the purpose. In such a house as is shown in Figure 7 the temperature, light, humidity, and sanitation can be given proper attention with a minimum of labor. However, good results can be obtained with less expensive facilities. Ordinary hotbed frames covered by glass sash are used in many places, and large quantities of cuttings of trees and shrubs are rooted in them each summer. In localities favored by warm, nearly uniform temperature, cuttings may be rooted in frames protected by muslin instead of glass and without special provision for bottom heat.

ROOTING MEDIUM

Clean sand of a texture fine enough to retain moisture around the cuttings but coarse enough to allow water to drain through it freely is the rooting medium most generally used. Sand such as builders

use for plastering often is suitable. It should be free from organic matter and all foreign materials such as lumps of clay. If necessary it should be passed through a screen to remove coarse gravel and then washed to free it from sediment.

FRAMES FOR SUMMER CUTTINGS

Where hotbeds are utilized the frames are usually made for ordinary 3 by 6 foot sash. For convenience in shading, it is advisable to have the frames run east and west with the glass sloping to the north. They are commonly made about 2 feet deep, so constructed that half or more of their depth is below the ground level. (Fig. 8.)

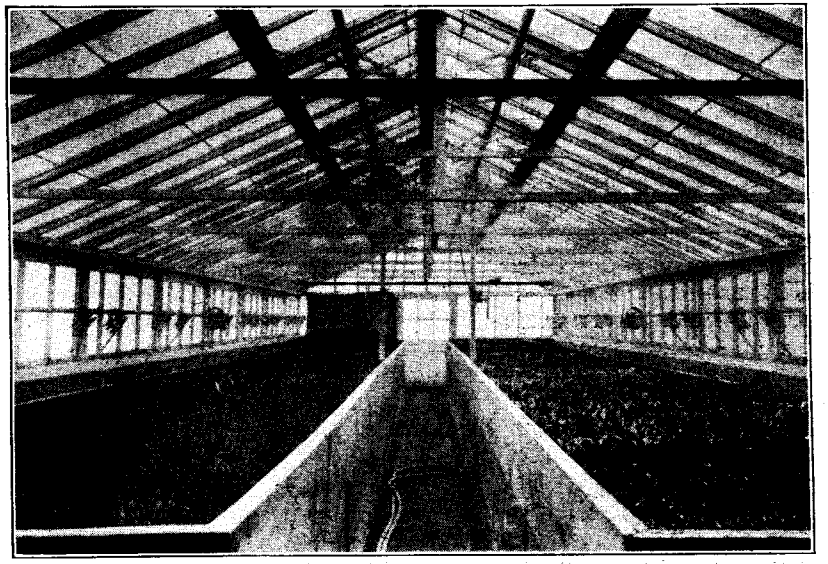

FIG. 7.—Greenhouse designed for propagation of evergreens. Concrete benches 4 ft. 6 in. wide piped for bottom heat of 55° to 65° F. night temperature in the sand, with air temperature 50° to 55°. Benches can be converted into grafting cases by covering them with glass sash. Walk in middle, 2 ft. 6 in. wide. Walks at each side 2 feet wide. Crossbars overhead are provided to support canopy when needed. For the best light, such a house should run north and south

In June or July, when the new growth of the varieties to be propagated has reached the proper stage, the frames are prepared by putting in sufficient stable manure to make a depth of about 1 foot. This material not only provides a mild heat but also insures good drainage. After leveling the manure carefully, a layer of 4 to 6 inches of clean sharp sand is placed on it. When the first strong heat from the manure has been spent, usually within two or three days, the frame is ready for the cuttings.

Instead of placing the sand directly on the manure, it is frequently desirable to put it in shallow boxes or "flats" about 16 by 20 inches, or of other convenient dimensions, and about 4 inches deep. When planted with the cuttings these flats are placed in the frames, care being taken that they are set level and fitted close against one another. One advantage to be derived from the use of flats is that if

the cuttings do not root during the period in summer when conditions are favorable in the frame they can be transferred to a greenhouse bench in the fall. This necessity for a longer period for rooting is more likely to occur with evergreens or cuttings put in late in the season than with deciduous cuttings made earlier in summer.

SHADING

An important feature of summer propagation is the proper shading of the cuttings. Direct sunlight must be kept off, but as much light should reach the cuttings through the sash as can be given without overheating them. Shading can be provided in several ways, one of which is to stretch a canopy of heavy muslin on supports 3 or 4 feet above the frame and along the south side, and so arranged that it can be readily put in place in the morning as soon as the rays of the sun begin to reach the cuttings and taken off in the late after-

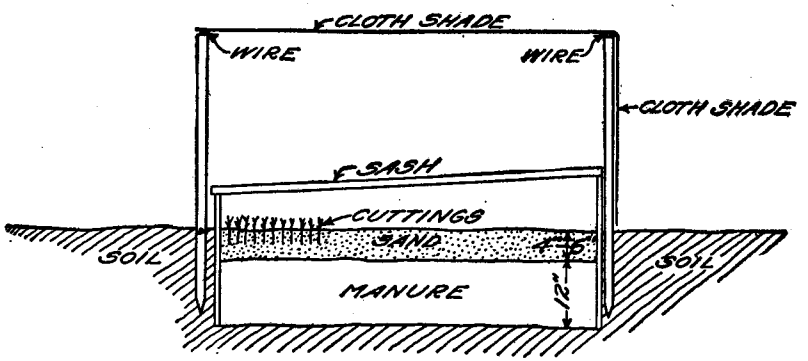

FIG. 8.—Section of frame for summer cuttings

noon and during dark, cloudy days. (Fig. 8.) This covering serves to keep the cuttings in a moisture-laden atmosphere with the temperature preferably between 70° and 90° F. A canopy over the glass is preferable to painting the glass with whitewash, as it enables a better control of the light.

WOOD FOR SUMMER CUTTINGS

The plants from which cuttings are to be taken must be healthy and vigorous if the best results are to be obtained. Cuttings from plants affected by leaf diseases or otherwise in poor condition nearly always prove disappointing. The best stage of growth to use varies with different kinds of plants. It can best be learned by experience and close observation of the cuttings in the sand; some root easily at almost any stage of growth, whereas others are more particular and succeed well only when the growth has reached a certain stage. Cuttings of a number of the spring-flowering shrubs thrive if taken from the vigorous growth that follows the period of blossoming. Generally, the wood taken just as it is beginning to harden will root more quickly than the harder wood.

698141°—46—3

SUMMER CUTTINGS

Summer cuttings are made usually 3 to 4 inches long with the lower end cut through a leaf joint. The leaves are removed except one or two at the top, which may be left entire, or, if large, part of each may be cut off. (Fig. 9.) When the largest number of cuttings from the wood available is desired, each cutting is made to include but a single joint with the leaf at the top. A sharp thin-bladed knife is necessary to insure clean, smooth cuts without loosening or disturbing the bark. As fast as the cuttings are made they are dropped into clean water or placed under moist paper to keep them from wilting. They should be planted with little delay.

FIG. 9.—Rooted cuttings of immature wood of rose, weigela, mock orange, spirea, lilac, hydrangea

INSERTING THE CUTTINGS

The sand is moistened, leveled, and tamped as firmly as possible with a brick or block of wood, and then a groove is cut (with a case knife or a thin piece of wood), into which the cuttings are planted upright about 1 inch apart at such a depth that most of the stem is in the sand. When a row is placed the sand is made as tight as possible around the cuttings, by firming it first with the fingers and then laying a straight-edged strip close to the row and striking it lightly with a hammer or mallet. If it is not well tamped, too much air may be admitted around the base of the cuttings, causing them to dry out. The rows may be spaced from 2 to 4 inches apart, or as far as necessary to prevent much overlapping of the leaves. As soon as planted they must be watered thoroughly. It is not necessary to fill the entire bench or frame at once; the work of making and inserting the cuttings may extend over several days.

CARE OF CUTTINGS IN THE SAND

At first the beds or benches are kept closely covered. After the first week it may be desirable to admit a little fresh air for a short time each day, to reduce the danger from mold or other fungi. It is necessary to syringe the tops of the cuttings and the glass and sides of the inclosure lightly two or three times daily for the first few days, to keep the air saturated and to avoid wilting. Later, when the cuttings have begun to draw up moisture through their stems, less spraying is needed except during very hot days. Cuttings usually will root sooner if the leaves left on them can be kept fresh until roots have started; hence the care of the beds should be such as to maintain these leaves in a growing condition.

TREATMENT AFTER ROOTING

When well rooted the cuttings are transplanted into either small pots or flats of soil. They are very easily injured when first taken from the sand and therefore must be carefully handled and protected from wilting. At first they should be placed where moisture and temperature can be kept similar to those of the benches or beds in which they were rooted, but as they gradually become established more air and light are admitted to harden the young plants. After two or three weeks, when active growth has begun, they may be transferred to lightly shaded coldframes or to a well-ventilated greenhouse bench.

(2) EVERGREEN CUTTINGS FROM MATURE WOOD

A number of choice varieties of evergreens which do not come true from seed may be increased without difficulty in various types of greenhouses during winter as well as in frames during summer. Among these are varieties of arbor vitae, boxwood, juniper, retinospora, yew, and a number of others. Most varieties of evergreens are slower to root than deciduous plants. Arbor vitae and retinospora cuttings may root within two months, while some forms of juniper may require six or eight months, or may even remain until the second year and then strike roots.

The wood for the cuttings is usually in good condition in fall after a few light frosts have checked the growth and it has ripened. Cuttings may be made at any time up to midwinter with good results. The wood, however, should not be cut or handled while in a frozen condition. The vigorous branches on the sides and near the tops of the trees furnish the best wood.

The cuttings are usually made from 3 to 8 inches long. Often the side shoots may be stripped from the branches to include a small portion or "heel" of older wood. This heel is desirable though not essential. The foliage is removed from the lower portion of the stem, leaving a part of that at the top. (Fig. 10.)

The cuttings are inserted in the sand so that about half their length is covered. They are spaced one-half to 1½ inches apart in rows, according to the size of the cuttings. Sufficient space should be left between the rows so that the sunlight may reach the sand,

as an aid in keeping fungi in check. Care must be taken to settle the sand very firmly around the cuttings, as previously described for summer cuttings. As soon as planted the bench must be watered thoroughly.

At first some shade over the cuttings is necessary. This may be provided by a single thickness of newspaper laid over them for a few days. In cold weather, however, little shade, except perhaps in midday, will be needed, and direct sunlight may be beneficial; but with the longer, warmer days of spring, some shade must be provided. The ventilators should be kept closed except for a short time in the middle of the day, to keep the air moist at all times. If other stock requiring ventilation is being grown in the same house, the bench of evergreen cuttings should be screened by means of muslin or burlap curtains. Watering is necessary only when the surface of the sand begins to dry.

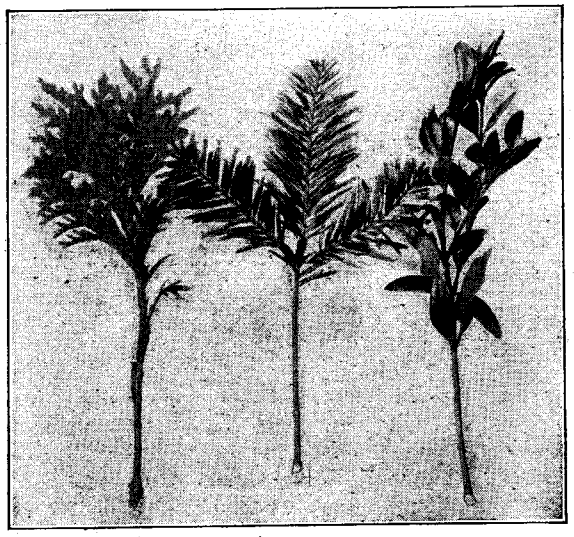

FIG. 10.—Cuttings of arbor vitae, yew, and boxwood

A temperature of 50° to 60° F. at night is often regarded as most desirable, although evergreen cuttings will stand considerable variation without injury. From 40° to 50° at night is sufficiently warm to maintain most coniferous cuttings in good condition during winter. Rooting may be expected during the spring months. In March or April the bottom heat should be increased to hasten root activity.

When rooted, the cuttings are usually potted or planted in flats and kept in the greenhouse until they are in active growth, then transferred to coldframes in late spring. Some growers, however, prefer to let them remain in the sand until more roots have formed and then transplant them into outdoor frames in May or June, giving close attention to watering and protecting them from sun and wind until they have become established in the soil.

(2) DECIDUOUS HARDWOOD CUTTINGS

Hardwood or dormant cuttings planted in the open ground afford one of the most important means of propagating a considerable number of deciduous trees and shrubs for ornamental and windbreak planting. Among the trees so propagated are the willows and poplars; among the shrubs are included such species as deutzia, honeysuckle, mock orange, privet, spirea, tamarix, and weigela, together

with some varieties of barberry, dogwood, and rose; among the fruits are the currant, grape, and fig. The different species and varieties vary in their readiness to form roots on hardwood cuttings, as is the case when immature cuttings are used. Moreover, some kinds that are easy to grow in one locality may prove difficult in another; for example, some oriental pears and their hybrids, often grown from cuttings in Florida and other parts of the South, usually fail in sections farther north.

THE CUTTINGS

The form of hardwood cuttings usually employed consists of a straight portion of a twig of one season's growth, containing two or more leaf buds. At the lower end it is usually cut through or just below a leaf bud. Cuttings taken to include a small portion of the older wood at the base of the twig, called "heel cuttings," are preferred in some cases, but have the disadvantage that only one such cutting can be made from each twig.

Wood of one season's growth of medium size and well matured should be chosen. The best time to cut the wood from the plant is in the late fall or early winter. It can be kept in good condition until it is made into cuttings by packing it in slightly moistened sawdust or moss and storing in a cool cellar, or it can be buried in the open ground. If it is necessary to cut the wood from the plants in the winter when frozen, it must be handled carefully and placed in a cool room or in cold water to thaw.

Cuttings may be made any time during the winter, but the best results are obtained by making them in January or February, or at such time that they may be kept nearly inactive for several weeks. When a long, cool period without freezing the soil may be expected to follow, they may be planted when they are made, with good results.

Most hardwood cuttings are made 5 to 10 inches in length. Usually 6 inches is long enough, but whatever length is chosen it is desirable to make them uniform in order to facilitate handling. Wood with long joints, such as that of the grape, should be cut to include at least two buds. As a rule, roots form most readily at a leaf joint, therefore it is customary to cut the lower end through or just below a bud. The upper end is cut a short distance above the top bud. When made, the cuttings are tied in bundles of 50 or 100 each, taking care that they are all laid one way to facilitate planting them right end up.

STORAGE OF HARDWOOD CUTTINGS

The bundles of cuttings are packed in slightly moistened material, such as sphagnum moss or sand, and stored in a cool place where they will remain fresh. Frequently they can be kept in good condition by burying them in a well-drained place in the open ground and providing protection from excess water and from freezing. When buried, it is customary to place the cuttings with the butt ends up.

The first change seen in the condition of the cuttings is the formation of a mass of tissue on the lower end, known as callus. Although roots do not ordinarily arise from the callus itself but from the tissues underneath or along the stem above it, this formation is a

common preliminary to rooting. Some kinds of plants, however, may root without any apparent callus tissue.

SOIL AND ITS PREPARATION

Well-drained fertile sandy loam is to be preferred, though cuttings can be grown in any good soil suitable for ordinary garden crops. Thorough preparation in the fall is usually necessary, so that the cuttings can be planted without delay in the spring. The soil should be plowed deeply and the surface harrowed and smoothed, as for small seed crops.

PLANTING

Planting should be done before growth starts from the buds. Early spring is the usual time, although the cuttings can be planted in the fall in sections where the winter is mild. Farther north autumn planting may be practiced if sufficient mulch is put over the cuttings to protect them from lifting out of place caused by freezing and thawing.

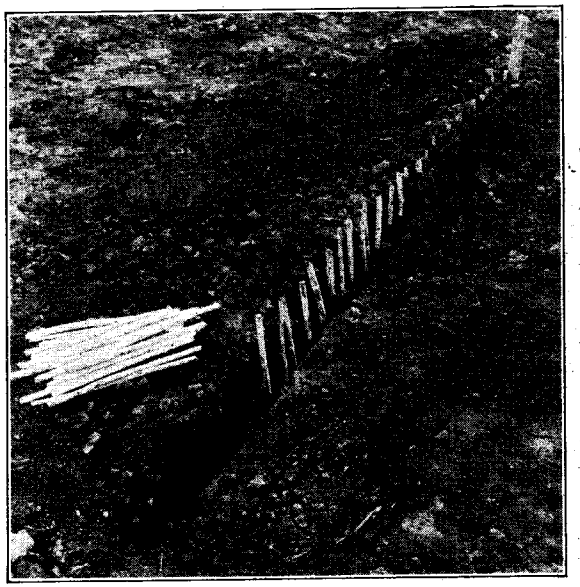

FIG. 11.—Hardwood cuttings in place in a trench

The cuttings are usually planted in rows far enough apart for horse cultivation, but they can be grown in beds to be cultivated by hand tools. When spaced for horse culture, a small plow can be used to open the furrow. The cuttings are set in a vertical or slightly inclined position with the top bud near the ground level. (Fig. 11.) Very long cuttings must be planted in more reclined positions to avoid a too deep planting of the lower ends. Ordinarily they are spaced from 2 to 6 inches apart in the rows. When they are grown in beds for wheel-hoe cultivation a spade is used to open the trench for planting. It is important that the soil be well firmed about the lower ends of the cuttings and that nearly their entire length be covered with soil.

CULTURE

If the cuttings are to be profitable it is just as essential to obtain a robust growth as it is to root them, therefore the culture should

be such as to encourage maximum growth, especially during the early part of the season. Frequent cultivation is necessary, and all weeds should be kept down.

ROOT CUTTINGS

Some kinds of woody plants may be propagated from cuttings made from roots. The advantageous use of root cuttings is confined mainly to plants difficult to root from stem cuttings. The apple, cherry, hawthorn, flowering quince, plum, and pear may be mentioned among trees that are frequently more easily grown from root cuttings than from stem cuttings.

To provide root cuttings the trees are dug in late fall, or, in mild climates, during the winter, care being taken to obtain all the roots uninjured. The trees are heeled in or stored to keep the roots in good condition. In the late winter or early spring the roots are trimmed off, leaving only enough on the mother trees to enable them to continue growth. Then these trees can be replanted after pruning the tops, preferably in fertile sandy loam, to produce another crop of roots.

Roots from one-fourth to one-half inch in diameter are the most desirable size for cuttings, although smaller ones will grow if given favorable conditions. They may be planted in the open ground in the spring as early as the soil can be put in good condition, or started in a greenhouse at a temperature of 50° to 60° F., or in a frame to be transplanted to the open after growth has started.

Best results are obtained by making root cuttings two or three weeks in advance of planting time. This permits them to callus and begin the formation of leaf buds while stored at a temperature of 40° to 50° F. under conditions similar to those used for hardwood cuttings. The most desirable length to make the cuttings depends on the conditions under which they are to be started. For planting directly in the open ground, 3 inches is a desirable length; for starting indoors 1 to 1½ inches is sufficient length, thus procuring a much larger number of cuttings from the same amount of material. For convenience in handling, the cuttings are made into bundles of a size to hold in the hand. Rubber bands are easier to use than twine for making the bundles.

Leaf buds usually arise near the top end of a root cutting; that is, the end that grew nearest the parent tree, whereas new roots form at the lower or distal end. Hence the best condition for growth and the best formed plants are obtained by planting the cutting in a vertical position. The formation of leaf buds and roots on a root cutting is illustrated in Figure 12.

When planted in the open ground, the cuttings should be placed with the top end near the ground level, taking care to firm the soil well around them. A ridge of soil 2 or 3 inches high is then drawn over the row to maintain moisture around the cuttings and to prevent a crust from forming in close contact with the tops. This ridge should be raked off when the shoots have grown about 1 inch. Under ordinary conditions this stage of growth is reached about a month after planting.

PROPAGATION BY LAYERS

Layering consists in bringing branches or shoots into contact with the soil to develop roots while still attached to the mother plant. It is one of the simplest and surest methods for propagating many kinds of woody plants. When only a few new plants are required, layering may be advantageously employed even for many kinds which are ordinarily increased by cuttings, because layers require less attention than cuttings. On the other hand, layering is not commonly practiced on a large scale, except in the case of certain kinds not readily increased by other means, because a comparatively large number of mother plants must be provided, and in other respects the operation is somewhat cumbersome.

FIG. 12.—Root cuttings of apple species about one month after planting

Layering may be done in several different ways. The most useful for trees and shrubs includes simple layers whereby roots are developed on a buried portion of a branch, and stool layers and trench layers, whereby roots are developed on new shoots arising from the buried portion.

SIMPLE LAYERS

Simple layers are made by bending branches to the ground and covering a part of their length 3 to 6 inches deep, so that the buried portion will remain in moist soil during the process of rooting. Generally this is done in the spring before growth begins. The tip ends of the layered branches are left exposed to form the tops of the new plant. Frequently rooting is stimulated by making a slanting cut into the branch on the lower side at the point where roots are desired. Many trees and shrubs so treated will strike roots the first season, whereas others may require two seasons. When well rooted, the layers are severed from the mother plant during the dormant season and treated as independent plants.

The propagation of rhododendrons exemplifies one of the applications of this method. The varieties desired are planted several feet apart to allow space to bend all of the branches to the ground.

Previous to layering, the plants are allowed to become well established and are headed low to induce vigorous shoots to start near the ground.

During March or early April is the usual time for putting down rhododendron layers. The growth made the preceding season is the best, but older wood will form roots. The branch is prepared by stripping off a few leaves from the portion of the stem to be buried and by removing any flower buds. At the point where the roots are desired on the branch, a cut is made about 1½ inches long, running upward and slanting toward the center of the branch, thus forming a "tongue." The shoot is then gently bent over to avoid breaking and is so buried in the soil that the tongue points nearly straight downward and is several inches below the ground level, with 6 inches or more of the tip of the shoot nearly erect above the ground. The branch is held in this position by wooden pegs or stiff wires, and the soil is pressed firmly around it. All of the vigorous branches of the mother plant that can be brought to the ground may be treated in the same manner. (Fig. 13.)

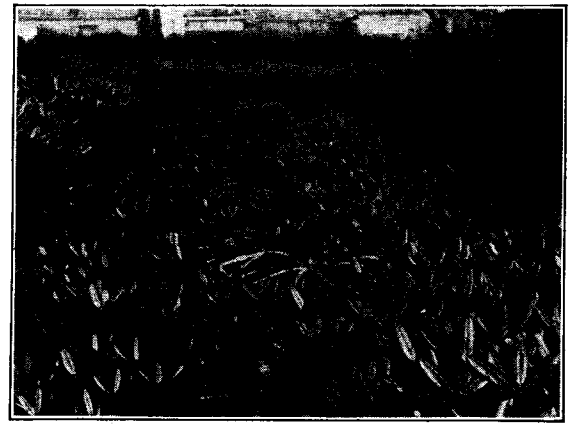

FIG. 13.—Layered rhododendrons

The soil around the buried portion should be moist all through the season. A heavy mulch of oak leaves for rhododendrons and other plants requiring acid soils helps to retain the necessary moisture and also improves the soil as the leaves decay.

Rhododendron layers make the best plants if they are allowed to remain two years, although some roots may form the first season. The second spring they are severed from the mother plants and carefully transplanted into beds of especially prepared soil. The first year these beds should have lath shade and facilities for watering. The second season they are ready to be transplanted to the open ground.

STOOL LAYERS

Stool or mound layering is well adapted to plants that form shoots freely near the ground level. It is the method often employed for the propagation of the quince and gooseberry, also the Doucin and Paradise types of apple used for dwarfing stocks.

Fertile sandy loam which is easily worked and in a situation that is nearly level to avoid washing should be selected for mound layers. After the beds are established, yearly crops of rooted shoots can be

698141°—46——4

obtained from them without renewing the mother plants; hence especial consideration in the choice of a favorable site is important.

The plants to be propagated are spaced 4 to 5 feet apart each way, a sufficient distance to allow ample room for root development and to permit a mound to be made several inches high around each plant. They are grown a year before layering to become well established, during which time they are given care to encourage as much growth as possible.

Before growth starts the following spring the plants are cut off at the ground level. When the shoots growing from the stubs are 4 or 5 inches high, soil is drawn up leaving only the tips exposed. It is advisable to spread the shoots a little apart when hilling the first time, to give each shoot more space and to induce uniform growth. Root formation is aided if the hilling is begun while the shoots are still small. As growth progresses, from 4 to 6 inches of soil are drawn up around the shoots at intervals during May and June. Figure 14 shows such a stool with the rooted layers ready for removal. The rooted shoots can be cut off in the late fall or early the next spring. The stubs or "stools" are left undisturbed, to produce another crop of shoots the following year.

FIG. 14.—Mound or stool layers of Paradise apple

TRENCH LAYERS

Instead of cutting back the mother plants to form stools, the stems may be brought down into a furrow made 4 to 6 inches deep beside the row (trench layering). This is done early in spring before growth starts. Care should be taken to peg down the branches horizontally in the bottom of the furrow at the same distance below the ground level. Two or more stems may parallel and overlap each other, thus providing for a close stand of new shoots in the row. When the new growth is 2 to 4 inches long, soil is brought in to cover the lower part of the new growth, leaving only the tips exposed, and, as growth develops, more soil is brought around the stems. Roots ordinarily form most readily near the base of the shoot, hence this portion should be sufficiently covered by soil that is constantly moist. As rooting may frequently take place most freely in the fall, it is advisable to defer the removal of the rooted layers until very late in the autumn or early the following spring. (Fig. 15.)

PROPAGATION BY GRAFTING AND BUDDING

Grafting and budding are the means employed to propagate most of the fruit-tree varieties and some ornamental plants whose seeds do not reproduce the characteristics of the variety and whose cuttings do not root easily. In addition to multiplying plants of the varieties desired, other objects that may be sought are to secure better trees by the use of hardier or more vigorous or disease-resistant roots; to change the rate of growth of the tree, for example, the use of quince roots to produce dwarf pear trees; or to change orchard trees from one variety to another.

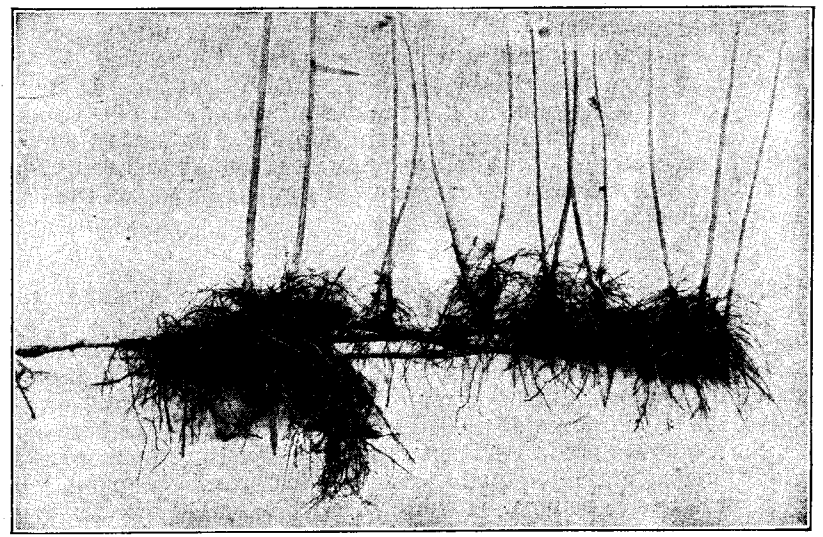

FIG. 15.—Trench-layered Doucin apple roots on new shoots formed in one season

A grafted tree is made by the union of two parts—the scion, which is cut from a twig of the variety desired from which the top is to be developed, and the stock, which is usually of the same species or a closely related one, from which the root system is to be developed. Given these two parts of close botanical relationship, the essential for a successful union is that the cambium layer of the scion be brought into close contact with that of the stock and held there under suitable conditions until the two parts have grown together. The cambium layer is the thin zone of cells between the wood and the bark from which new tissues are developed.

Budding differs from grafting in the use of a single bud instead of a scion and also in the season of the year when the operation is performed. Budding is done in summer while growth is active, whereas grafting is usually done in winter or spring with dormant

scions. The resulting trees are essentially the same whether propagated by budding or by grafting.

Local conditions, the kind of plants to be propagated, and the expense and convenience determine the choice between budding and grafting. In general, stone fruits are budded oftener than grafted. Apple and pear are grafted more frequently in the Central States and budded in other sections, although both methods are widely used and may be regarded as of equal utility in nursery work. Budding, however, appears available for a larger number of species.

THE STOCK

The characteristics most desired in a stock are that it be adaptable to the climatic conditions in which it will have to live; it must be capable of making a good and lasting union with the variety; it should be at least as hardy and vigorous as the variety worked on it; it should be resistant to insect and fungous pests; it must be capable of being easily and rapidly propagated at a reasonable cost, so that it can be made available in the desired quantities. In actual practice few of the stocks in use possess all these attributes in the desired degree, and numerous experiments are now under way in search of better stocks. The following brief summary indicates some of the characteristics of the most generally used stocks for the common deciduous fruits.

APPLE STOCKS

Seed from the French crab imported from Europe is used to produce most of the apple stocks in the United States. It is a type of apple little known in this country. The fruit, used extensively in France and Austria for cider making, is characterized by high sugar and tannin content, quite different from our familiar varieties. It has been the chief source of seeds for apple stocks for many years.

Of the domestic seed, Vermont crab from seedling trees of New England is used in limited quantities. Seed from widely grown commercial varieties is being used to an increasing extent during recent years. Seedlings of Tolman Sweet, Oldenburg (*Duchess*), McIntosh, Hibernal, Wealthy, Siberian crab, and Whitney have given evidence of more resistance to cold than the French crab. Other varieties which furnish seed that germinates well and makes vigorous seedlings are Delicious, Fameuse, Winesap, Jonathan, Ben Davis, and Rome Beauty. So far as they have been tested, they appear to make suitable stocks for general use.

Paradise and Doucin stocks increased by layers are used in propagating dwarf apple trees. These are dwarf European forms which impart their habit of growth to varieties worked on them. Paradise has the most dwarfing effect, while the Doucin is intermediate between that of Paradise and the ordinary apple-seedling stocks.

PEAR STOCKS

French pear (*Pyrus communis*) has been for many years the most generally used and best-known stock for all varieties of pears. Although other stocks more resistant to diseases have come into use, the French pear continues to be more widely used than any other.

It makes strong, lasting unions with all varieties. The roots grow well in the different types of soil. It will tolerate wetter soil and endure more cold than any other pear stock that has been thoroughly tested. The most serious defect of the French pear is its susceptibility to pear blight, the most destructive of pear diseases. The young seedlings are also subject to leaf spot in the nursery. While much of the French-pear seed comes from Europe, large quantities of seed from the Bartlett variety are now being obtained in the Pacific States.

Japan pear (*Pyrus serotina*) also has been extensively used for the past 30 years. Nearly all varieties make good unions with it, and the trees usually make as vigorous growth as those on the French pear. The roots grow well in deep open soils, but are not satisfactory in heavy soils such as adobe or those that are shallow or wet. It is more satisfactory in the Southern States than in the northern pear sections. It will not endure as much cold as the French pear. The young seedlings make vigorous growth and have some resistance to leaf diseases in the nursery, hence are relatively easy to grow. Although it is generally more resistant to pear blight than the French pear, it is by no means immune. Most of the Japan pear seedlings are grown from imported seed in Kansas and the Pacific States.

Pyrus calleryana, a native of central China, has become recognized as a pear stock in recent years. Nearly all the pear varieties on it have made even more vigorous growth than those on French pear, and the unions appear to be strong. It grows well in many different types of soil. Its high degree of resistance to pear blight is one of its most valuable characteristics. It is little affected by leaf diseases in the nursery and usually continues in vigorous growth all season even through periods of dry weather. For this reason it is easy to bud any time during summer. It can not be recommended for cold climates, however, as it has given evidence of winter injury where subjected to temperatures below zero.

Several other oriental species of pears, especially *Pyrus ussuriensis*, have given evidence of desirable qualities and are being made subjects of extensive experiments. Much attention also is being given to the testing and propagating of individual seedlings that have proved highly resistant to pear blight.[3]

The Oregon Agricultural Experiment Station has discovered certain strains and varieties that are not only resistant to pear blight but are desirable as stocks from other standpoints. The use of these selections is increasing in the pear sections of the Pacific States as they become better known.

As dwarfing stocks for pears, the quince is used. The Anjers quince propagated by layers or, under favorable conditions, by cuttings is considered superior to seedlings, though the latter are often used and are obtainable at less expense than layers or cuttings.

CHERRY STOCKS

Most of the cherry trees in the United States are budded on either mahaleb or mazzard stocks. Except in the Pacific States mahaleb is the more generally used.

[3] REIMER, F. C. BLIGHT RESISTANCE IN PEARS AND CHARACTERISTICS OF PEAR SPECIES AND STOCKS. Oreg. Agr. Expt. Sta. Bul. 214, 99 p., illus. 1925.

Mahaleb (*Prunus mahaleb*) is a native of central Europe. The tree is readily distinguished from mazzard or any other cherry by its small curved shiny leaves and slender twigs. The fruit is bitter, small, and glossy black when ripe. The roots adapt themselves to a wide variety of soil conditions and will endure more cold than mazzard. In the nursery the young seedlings make vigorous and continuous growth. For this reason they can be budded during a long period. Although it is more highly regarded as a stock for sour cherries than for either the sweet or Duke varieties, all three types unite with it and usually make strong growth for the first few years. However, the present evidence indicates that the trees are shorter lived, at least in some sections, than those on mazzard.[4]

Mazzard (*Prunus avium*) is a seedling form of the sweet-cherry varieties. As a tree its appearance is similar to these varieties. In its soil requirements it is perhaps more exacting than mahaleb, but it is adaptable to those of the principal cherry sections, except where severe cold is a factor. The trees make rapid growth and are long lived. In the nursery the young seedlings are vigorous, but their growth is often checked in summer by leaf diseases or drought, making the period for budding uncertain. For this reason the trees on it usually cost more to produce than those on mahaleb. An abundant though little utilized seed supply, superior in quality to that imported from Europe, is to be had from the old wild trees found scattered throughout the Eastern States.

While mahaleb and mazzard seedlings are the only cherry stocks used extensively, several others have been tried, some of which are of local importance. Morello seedlings are sometimes used for sour varieties where extreme hardiness is required. A serious defect of morello is its tendency to sprout from the roots. One form of morello propagated by suckers has been in use for many years in northern Illinois on which sour cherries have proved especially productive and long lived. This or a similar form of it is being used for sweet cherries near Stockton, Calif., as it does well in rather heavy wet soil. In both of these sections the suckers from the roots are dug each year for propagation, hence this habit of suckering is not regarded as a defect.

PLUM STOCKS

Myrobalan (*Prunus cerasifera*) is the most generally used stock for the principal varieties of plums. It makes strong lasting unions, and nearly all varieties on it develop into large smooth trees in the nursery. Its roots adapt themselves to many different soil types. Though the seedlings are usually vigorous, the individuals vary greatly in size and color of fruit, size of pits, time required for germination, rate of growth, and the form of the seedling trees. In California, where most of the domestic seed supply is grown, improvement is being brought about by the selection of the best strains for stocks and growing these strains for their seed. It will not endure as much cold as some of the other species, but is sufficiently hardy for most sections where plums and prunes are important crops.

[4] HOWE, G. H. MAZZARD AND MAHALEB ROOTSTOCKS FOR CHERRIES. N. Y. State Agr. Expt. Sta. Bul. 544, 14 p., illus. 1927.

St. Julien (*Prunus insititia*), a European plum, is a stock preferred by some plum growers for the European varieties. They find that long-lived vigorous trees free from suckers may be obtained when these varieties are budded on it. Its use is limited, possibly because the seedlings are not always available in the market, and they are usually a little higher in price than other plum stocks.

Prunus americana, a widely distributed native plum, is frequently preferred where resistance to cold is a factor. It is regarded as an especially good stock for the native plum varieties. It will unite with European and Japanese plums also, but with these types it is less certain than myrobalan.

Marianna, a variety readily propagated from hardwood cuttings, is often used, particularly in the Southern States.

Peach seedlings are used to some extent for Japanese plum varieties in the Pacific Coast States. In some places they are preferable to the plum, as the peach roots succeed better on the drier soils.

PEACH STOCKS

For the eastern and central parts of the country, the principal supply of peach pits is obtained from the wild or half-wild trees growing in the mountainous parts of Kentucky, Tennessee, and North Carolina. These pits are small in size, averaging from 6,000 to 7,000 per bushel. The supply of these "natural" or seedling pits is diminishing, on account of the passing out of many of the old trees. For the Pacific Coast States the main supply comes from the peach varieties used for drying, such as Salwey, Lovell, and Muir. A wild peach from China, *Prunus davidiana*, makes good unions with peach varieties and has proved more tolerant to alkali soils than any of the other forms of peach used for stocks.

APRICOT STOCKS

Pits from apricot varieties are the principal source of stocks for this fruit. Myrobalan plum is used also, especially where the trees are to be grown on heavy soil. Peach seedlings commonly fail to make good unions with apricot. The Japanese apricot, *Prunus mume*, is being tried as a stock in California because of its resistance to the armillaria disease or oak-root fungus.

GRAFTING

SELECTION AND TREATMENT OF SCION WOOD

Wood of one season's growth is preferable to older wood because unions with it are more easily made and the buds are more likely to grow. Twigs that have made a vigorous growth of 12 inches or more in the last season are usually the best, though shorter ones if well matured may be used with good results. Although scion wood is ordinarily taken from bearing trees, nurseries that make grafts in large quantities frequently maintain apple and pear trees of the desired varieties for the special purpose of supplying such wood, giving these trees special attention to encourage the growth and to keep them free from pests. Such trees supply an annual crop of smooth straight twigs.

Scion wood is usually cut in late fall, after the leaves have fallen, or during winter. If no danger of winter injury exists the wood may be left on the trees until later and cut when it is to be used. It should not be cut or handled, however, while in a frozen condition. When taken in advance of the time of grafting, it is made into bundles, labeled, and stored in a cool cellar packed in slightly moistened sphagnum moss or sand. If a suitable cellar is not available it may be kept in good condition by simply burying it in a pit located in a well-drained place. When the wood is made into scions the tip ends are usually discarded.

FIG. 16.—Long apple root cut for piece-root grafts

THE UNION

Grafts may be classified according to the position on the stock where the union is made. They are termed root grafts when made on root tissue, crown grafts when on the stem near the ground level, stem grafts when made high on the stem, and top grafts when made on the branches.

Unions may be made in a multitude of ways, but in actual practice comparatively few are simple and rapid enough to meet the demands of general use. Of these the whip graft, cleft graft, splice graft, bark graft, and veneer graft, with various modifications, have application in propagating fruit and ornamental trees.

METHODS OF GRAFTING

WHIP GRAFT OR TONGUE GRAFT

The whip or tongue graft, also called bench graft because the work is done indoors at a bench or table, is the method in common use for root grafts of apple and pear, as well as for some ornamentals. It is a particularly desirable method for species which unite easily and where stock and scion are nearly the same size. The grafting is done during the winter, when the scions and stocks are dormant.

The entire root may be used for a single graft, to make a whole-root graft, or it may be cut into portions to make piece-root grafts. For whole-root grafts, seedlings with branched or stubby roots are preferable; for piece-root grafts, long straight roots with diameters as large or a little larger than the scions are selected, each root furnishing two or more pieces about 3 inches in length. (Fig. 16.)

Whole-root grafts usually make somewhat larger trees the first year than piece-root grafts, owing to the larger root, but in their subsequent development no material difference in the two styles of grafts is observed.

For making grafts efficiently, a knife with a thin stiff straight blade that will hold a keen edge is necessary. Figure 17 illustrates one form of grafting knife suitable for the purpose.

The scion, 3 to 6 or 8 inches in length, is prepared by cutting off the lower end diagonally with a single stroke of the knife, making

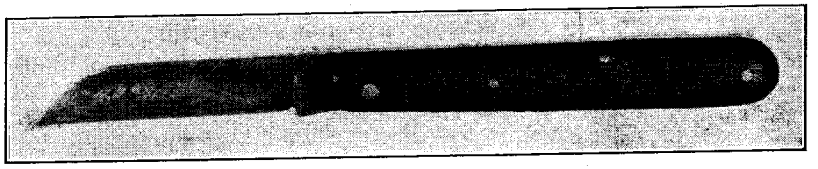

FIG. 17.—Grafting knife

a flat surface about 1¼ to 1¾ inches long. If the knife is held at an acute angle with the scion while making the cut, as shown in Figure 18, it is easier to make the cut surface smooth with straight edges than if held at a right angle with the scion. A cleft is then made, starting a little back from the tip of the cut surface and running back about half its length to form a thin "tongue." (Fig. 19, A.)

The upper end of the stock is prepared correspondingly. If the stock has branching roots they are trimmed to stubs. The stock and scions are then joined together as shown in Figure 19, B, care being taken that the inner bark (cambium layer) corresponds at least on one side.

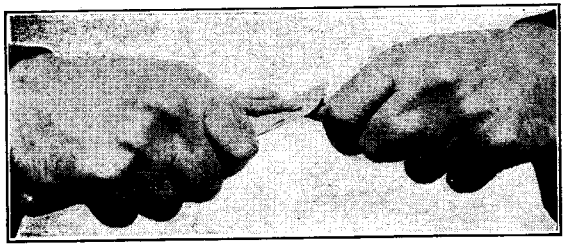

FIG. 18.—Cutting the scion

The two parts are held in place with several wraps of No. 20 or No. 30 crochet cotton or similar light twine (fig. 19, C), previously prepared by dipping the balls into melted grafting wax for a few minutes. When they have become impregnated with the wax they are allowed to drain and cool. When in use the ball of waxed cotton is placed in water kept warm by a small kerosene stove or lamp, so that the twine is soft and pliable. Each turn of the twine around the graft should be drawn as tight as possible without cutting into the bark. When the graft has been wrapped the twine is simply broken off, no knot being needed to hold it in place. (Fig. 20.) Raffia or some form of light tape to cover the entire wound is sometimes preferred, although a little slower to put on than waxed thread or twine. Such a bandage helps to protect the cut edges from infection. Heavy twine or other durable material is objectionable because it may not decay in time to avoid constricting the graft after growth has started.

If the work is done in a fairly cool room where the air is slightly moist the scions and stocks can be exposed an hour or two without injury. Care must be taken, however, to prevent the material from drying.

To obtain well-made grafts, the stocks should be at least as large or a little larger than the scions. The two parts should be fitted with care, especially the lower tip of the scion, and wrapped to hold the parts firmly.

Storage of whip grafts.—Immediately after the grafts are made they are tied in bundles and packed in boxes with slightly moistened sphagnum moss or sawdust to keep them fresh. Clean moist sand also is a good packing material, but it makes the boxes heavy to handle.

FIG. 19.—Whip graft. A, Scion and stock prepared; B, fitted together; C, wrapped with waxed twine

Grafts are commonly stored in a cool cellar, preferably where a temperature of 40° or 45° F. can be maintained. The first activity to be noticed is the formation of a spongy outgrowth of callus along the edges of the union. The stored grafts should be examined from time to time, and if any mold appears they should be unpacked and exposed to the air of the cellar for a few hours to dry and then repacked in slightly drier, clean material. If growth is found to be starting from the buds the scions should be stored in a cooler place or else planted.

Nursery care of whip grafts.—Fertile, well-drained soil and good culture are requisites for the production of trees from grafts. The value of the trees depends in large measure on the size they attain during the first year or two, hence the need for favorable conditions to secure maximum growth.

The grafts are planted as early in spring as the ground can be worked properly, while the scions are still dormant. They are usually spaced about 6 or 8 inches apart. Care is taken that the union and most of the length of the scion is underground, only the top bud remaining above the surface. The soil should be pressed firmly around the roots without disturbing the union.

During the early part of the season is the time to encourage as rapid growth as possible. If the grafts get a vigorous start in spring they are much more likely to produce good trees the first season than if checked for any reason. Frequent cultivation and weeding are necessary at first.

As growth develops the lateral shoots are kept pinched out without disturbing the leaves of the main stems, to force all the growth into the terminal bud until the main stem has reached a height of

FIG. 20.—Wrapping whip grafts with waxed twine

perhaps 30 inches. In localities where a long-growing season permits unusually large size, the tip may be cut off when the desired height for the trunk has been reached and the trees allowed to branch. In the Northern and Central States the trees are more commonly kept to a single stem the first season. If they make a growth of 3 or 4 feet the first season they are of desirable size for orchard planting. When kept in the nursery the second season to develop branched tops they are cut back to a uniform height, usually 24 to 30 inches, before growth starts. This cutting back induces branching at the desired height. Apple or pear grafts that make less than 2 feet of growth the first season are of much less value than those of more vigorous growth.

CLEFT GRAFT

The cleft graft is often used for grafting in the open, especially when the stock is larger than the scion. (Fig. 21.) The work is done in the late winter or early spring while the scions are still dormant, and usually the stock is dormant also. However, in top grafting, as in the case of an apple tree, it is not a disadvantage

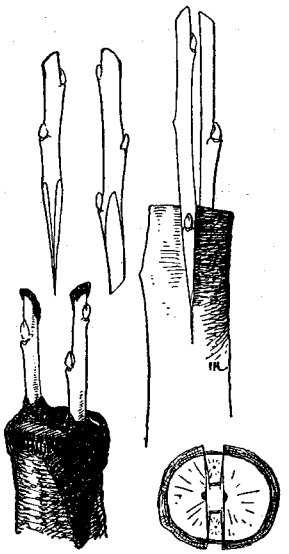

FIG. 21.—Cleft graft. Scions prepared, set in place, and waxed

if the tree has started growth. The stock is cut off at the place where the union is desired. A cleft is then made in the end of the stub with a grafting tool having a curved edge and a wedge-shaped face, as illustrated in Figure 22. The object of the curved edge of this blade is to avoid tearing the bark at the end of the stub. The cleft is held open by the wedge-shaped prong on the grafting tool while the scion is being inserted. Though this tool is a labor-saving convenience, the cleft can be made satisfactorily with a broad chisel or similar blade if carefully used. The cleft can be held open to receive the scion by the use of a wooden or metal wedge.

The scion is made from a portion of the previous season's growth, usually of such length as to include three buds. It is advisable to cut it so that the lower bud will be on the outside near the end of the stock. The lower end of the scion is wedge-shaped, the surfaces being about 1 to 1¼ inches long with the outer edge a little thicker than the inner so that when the wedge is removed and the cleft closes

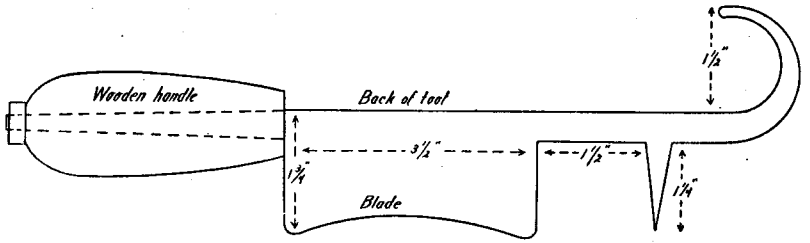

FIG. 22.—Tool for cleft grafting

against the scion more pressure is applied where the cambium layers are joined. To make the contact of the inner bark still more certain, the scion is often set at a slight angle with the stock, so that the cambium layers cross. If the stock is large enough, a scion should be set on each edge of the cleft, to increase the chance of obtaining at least one good union. Both scions should be of the same size. Ordinarily it is not necessary to tie the union, the pressure of the stubs being sufficient to hold the scions in close contact. When set, all the cut surfaces including the tip end must be covered with grafting wax. If both scions grow, one should be removed within the succeeding year or two.

BARK GRAFT

Bark grafts (fig. 23), with several modifications, are also frequently used for outdoor work when the stock is larger than the scion. The work is done in the spring after the sap rises, so that the bark can be separated from the wood easily, but while the scions are still dormant. The stock is cut off as for the cleft graft. A lengthwise cut about 1½ inches long is made through the bark downward from the end of the stub. (Fig. 23, B.) The scion is shaped with a shoulder (fig. 23, A) and inserted under the bark, care being taken that the bark is loosened only enough to admit the scion, which is held firmly in place by bandaging with twine or by the use of slender brads about

half an inch in length. If the union is above ground all the cut surface must be waxed to exclude the air. Another way of making a bark graft is illustrated in Figure 24.

GRAFTING WAX

Grafting wax to be applied with the hands may be made by melting together 4 parts of resin, 2 parts of tallow or linseed oil, and 1 part of beeswax. While hot the liquid mixture is poured into a vessel of cold water and when hardened sufficiently to handle is pulled and worked until it is light yellow. When handling the wax, the hands should be kept coated with linseed oil, tallow, or other grease. The wax may be kept in convenient form for use by

FIG. 23.—Bark graft. The scion (A) is cut with a shoulder. The bark of the stock (B) is cut and the edges raised to admit the scion, which is held in place by two brads about one-half inch long. All cut surface should be waxed

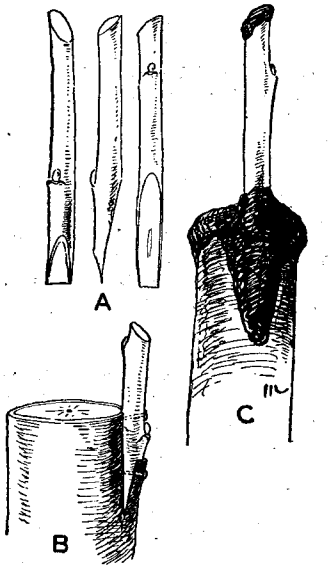

FIG. 24.—Bark graft. A, Scions made by slanting cuts without a shoulder; B, stock prepared by taking out a piece of bark to admit the scion; C, the complete graft with all the cuts waxed

wrapping it in oiled paper. It may be applied with a brush if kept in a semiliquid state by heating. Care must be taken, however, that it is not applied hot enough to injure the tissues. It is frequently used for waxing the twine used for wrapping grafts.

Another grafting wax regarded as more durable than that described above is made with 5 pounds of resin and 1 pound of beeswax. When these ingredients are melted, one-fourth pint of linseed oil is stirred into it, and the mixture is then removed from the fire, after which one-half pound of lampblack or powdered charcoal is

worked into it a little at a time. Adding the ingredients separately lessens the danger of fire, which would be likely to occur if the mixture boiled over. This wax is intended to be applied with a brush while kept soft by heating.

GRAFTING UNDER GLASS

Because grafts of evergreens and certain deciduous trees valued for landscape planting do not unite quickly enough to succeed well under outdoor conditions, some form of glass-covered inclosure or "grafting case" inside a greenhouse is necessary to give the grafts proper conditions for uniting. This method of propagation, being relatively expensive, is utilized in a practical way for only the comparatively few varieties that are slow and uncertain to root from cuttings. Some of these, however, are especially desirable and valuable, including the named varieties of spruce, pine, rhododendron, Japanese maples, and others. At the present time most of the grafting of evergreens in this country is done where specially equipped greenhouses are provided and such grafting is not often attempted by unskilled growers. The frequent queries received by the Department of Agriculture, however, indicate considerable interest in the methods employed.

GRAFTING CASE

Inclosures inside a greenhouse suitable for the grafts may be made in several ways. An ordinary greenhouse bench piped to supply bottom heat may be utilized. A bench in the middle of the greenhouse is usually preferable to a side bench, because the light is more uniform. The sides of the bench are made of boards 12 to 15 inches in height over which are put glass sash, or light glass bars may be fitted across to support panes of glass, thus providing a level glass top which admits the light freely but confines the air.

STOCKS

Seedlings of the same or closely related species as the varieties to be propagated are used for stocks. They are grown in beds, as previously described under "Coniferous seedlings," until their stems are of suitable diameter for grafting, about two-sixteenths to three-sixteenths of an inch, preferably a little larger than the scions to be worked on them. The stocks are potted in early fall and kept in a cool greenhouse or in a frame protected from freezing. By midwinter, new roots having formed, the stocks are in condition to start growth quickly. They are brought into a heated greenhouse two or three weeks in advance and are ready to graft as soon as a little growth has started.

GRAFTING

Grafting is done during January and February. The union made on the stem by what is termed a side graft is used. Scions are taken from the dormant trees outside when they are to be grafted, the vigorous twigs from the terminals of branches being selected.

The veneer graft illustrated in Figure 25 is a form of side graft frequently used for evergreens. The union is made in the stem of the stock just above the pot. The stock is prepared by cutting out a thin wedge-shaped section about 1 inch long, as shown in that figure. The lower end of the cut extends into the stem a distance equal to about one-third of its diameter. The lower end of the scion is cut off diagonally and the end trimmed to correspond with the opening in the stock, so that when put in place the cambium layer or inner bark matches on the lower end and at least on one side. If the cuts are so made that the inner bark can be matched on both sides the chances for a perfect union are increased. The union is tied firmly with waxed twine or with raffia. No wax is used over the union. The stock above the union is left intact.

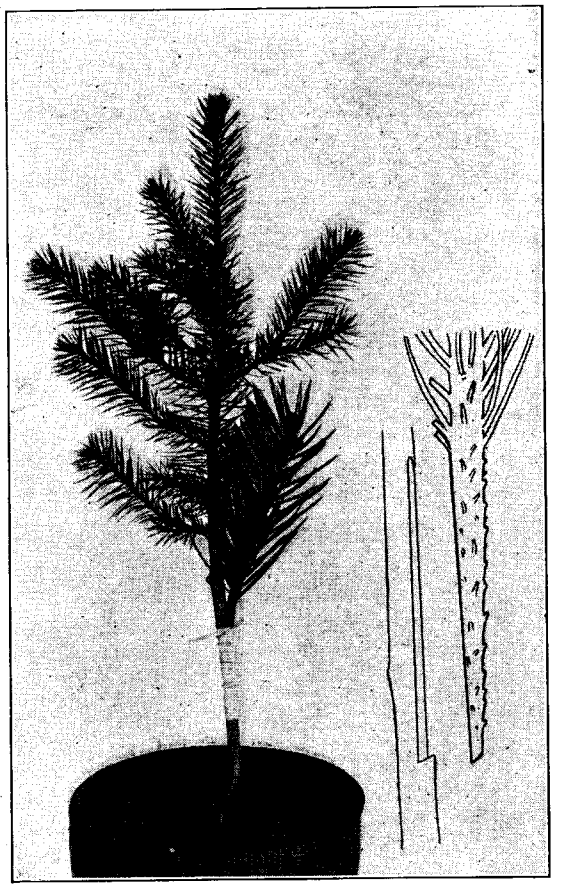

FIG. 25.—Veneer graft for evergreens

Another form of side graft, preferred by some for slender stems and scions, such as junipers, is illustrated in Figure 26. A downward cut is made in the stock, about 1½ inches long, running just inside the wood but not slanting inward as for the veneer graft. The scion is prepared by paring off about one-fourth its diameter from each side to fit the opening in the stock, leaving the sides nearly parallel. The lower end is cut off at a slant, making the end chisel shaped. The scion is fitted with the longer side next to the stock, and the flap of bark on the stock is brought over the end and along the side of the scion. It is firmly tied, as described for the veneer graft.

CARE OF EVERGREEN GRAFTS

The sides and bottom of the grafting case should first be whitewashed to aid in keeping it free from mold. The pots are laid in an inclined position with the graft uppermost in the case, and moss is packed around the pots to keep the soil moist. The leaves of both

stocks and scions should be kept from contact with the moss to lessen the danger of decay. The case is kept closed except for a short period for ventilation each day. For evergreens a night temperature of about 60° F. in the grafting case is desirable. A lower temperature may be used satisfactorily, but wide fluctuations should be guarded against. After about three or four weeks part of the top of the stock is cut off to divert the growth gradually to the scion. After another four weeks the remainder of the stock is cut away just above the union and the plants are brought out of the case and put on a greenhouse bench.

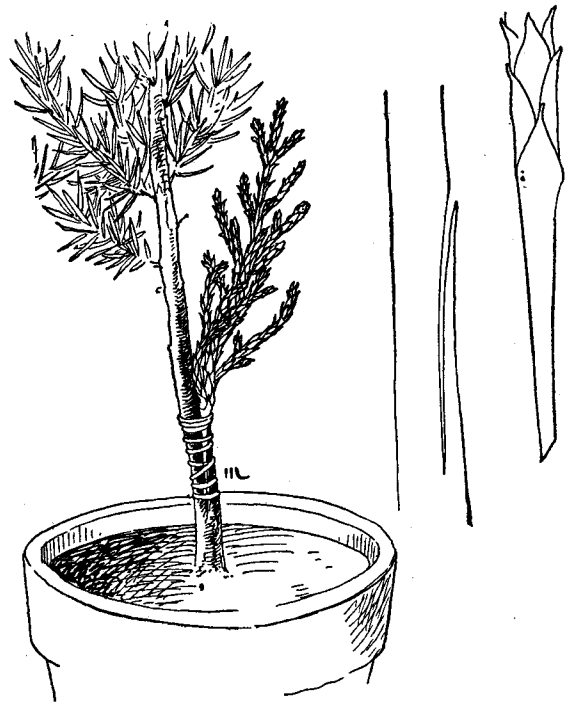

FIG. 26.—Side graft for evergreens

During the summer the plants can be shifted out of the pots into frames. At first they are easily injured by drought or hot weather, and they should therefore have protection from full sunlight and from wind. Overhead irrigation is valuable in keeping the plants cool as well as supplying the necessary moisture.

BUDDING

Budding is one of the most economical modes of propagation for certain kinds of deciduous woody plants, reproduction being by means of a single bud of the variety instead of three or more buds usually included on a scion in grafting. The operation can be done speedily by a skilled workman.

PLANTING AND PREPARATION OF STOCKS FOR BUDDING

For ordinary field budding of cherry, plum, quince, apple, pear, and such ornamental plants as roses and lilacs, 1-year-old stocks are planted in early spring. The roots are trimmed back to 6 or 8 inches so that they can be readily planted without bending them out of their natural position, as an aid in developing well-branched shapely root systems. (Fig. 27.) The tops are cut off about 12 inches above the ground. The plants are spaced 5 to 10 inches apart in rows about 4 feet apart to allow space for horse cultivation.

Fruit-tree stocks, which are usually budded on the stem just above the ground, are planted with the crown 1 or 2 inches below the ground level. Seedling rose stocks, which should be budded on root tissue just below the crown, are easier to bud if planted with the crown a little above the ground level, then protected by a ridge of soil 3 or 4 inches high, which is drawn away at the time of budding.

For peach and apricot stocks, the pits are planted in the fall or early spring in the rows where the young trees are to be budded, because they attain sufficient size to be budded during the first year's growth.

During the early part of the season the stocks should receive good culture to promote vigorous growth. Care to avoid injury to the bark on the stems is necessary in hoeing and cultivating the young trees. At budding time the stems should be about the thickness of a lead pencil, though smaller ones can be budded. Stems more than five-eighths of an inch in diameter are usually harder to bud because of the thick bark and difficulty in tying the buds firmly. At the time of budding, the leaves and twigs within 6 or 8 inches of the ground are removed so that the buds can be placed on smooth, clean stems.

FIG. 27.—Branched root apple stock trimmed for planting

SELECTION AND PREPARATION OF BUDS

The buds used for propagation are taken from wood of the current season, after growth has progressed so that those on the middle portion of the twigs or "bud sticks" have fully developed. Peach trees often bear a cluster of three buds at each leaf on the lower part of the twig, which should be discarded unless buds are scarce; if used, the two outside ones or flower buds should be rubbed off, leaving the middle or branch bud. Those near the tip of the twigs of most kinds

of trees are likely to be too immature. Generally the four or five along the middle portion of the twig are the best to use.

At the time the bud sticks are cut, the leaves are trimmed off, leaving about a quarter of an inch of leaf stem to protect the bud and to aid in handling it. It is advisable to cut the buds at the time they are used, but if necessary they can be kept fresh for two or three days wrapped in wet burlap or paper or buried in a shady place. They can be kept for a longer period if properly packed and stored on ice.

SEASON FOR BUDDING

The time for budding is during July, August, and September, when the buds have sufficiently matured and the stocks are making active growth so that the bark peels easily. Some stocks, such as the mazzard cherry and French pear, may stop growth by midsummer, making their budding season short; others, such as the peach, can be budded over a longer season. Generally it is useless to bud if the

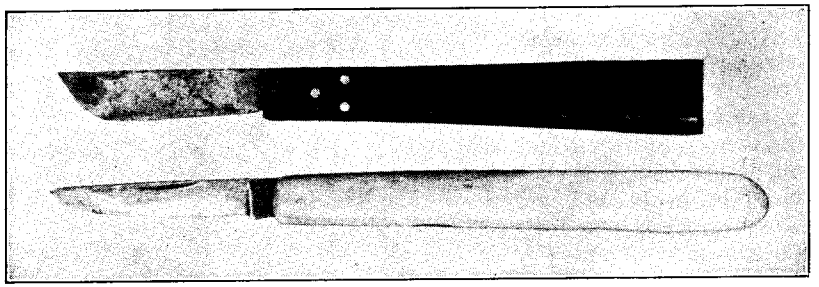

FIG. 28.—Two styles of budding knives

bark is so tight that it must be lifted forcibly, exposing a dry, fibrous condition in the cambium layer.

BUDDING KNIVES

A good budding knife has a thin blade which ends in a curve on the cutting edge. Handles are made in several different shapes, two of which are shown in Figure 28. A plain straight handle is good for trees that have tough bark which peels easily; a bone handle with a flat end to lift the bark without injury is best for roses and trees with thin tender bark. While in use the knife must be kept very sharp.

SHIELD BUDDING

Shield budding with several modifications is the most widely used method of budding. The bud is pared from the twig in the form of a shield to include a portion of the bark above and below it and a thin shaving of wood underneath it. This bit of wood is sometimes removed, but ordinarily it is disregarded. The bud is inserted into a matrix under the bark of the stock made by two cuts—one along the stem, the other across it.

The manner of operating varies among different budders. One efficient method for fruit trees whose bark peels easily is illustrated in Figures 29 to 34. The bud is put preferably on the north side of

the stock in order to shade it. The first cut on the stock is made lengthwise of the stem; next the crescent-shaped crosscut (fig. 30) is made with a rolling movement of the knife which lifts the corners of the bark where the two cuts cross each other. If the bark does not separate easily enough to admit the bud without injury by the method just described, it is raised along the cut edges with the point of the knife or the flat end of the handle, as shown in Figure 31. Then the bud is cut from the stick (fig. 32), holding the knife at an angle to assist in making the edge straight and smooth, and is held on the blade of the knife with the thumb until pushed down into place in the matrix, as shown in Figures 33 and 34. If the bark at the top of

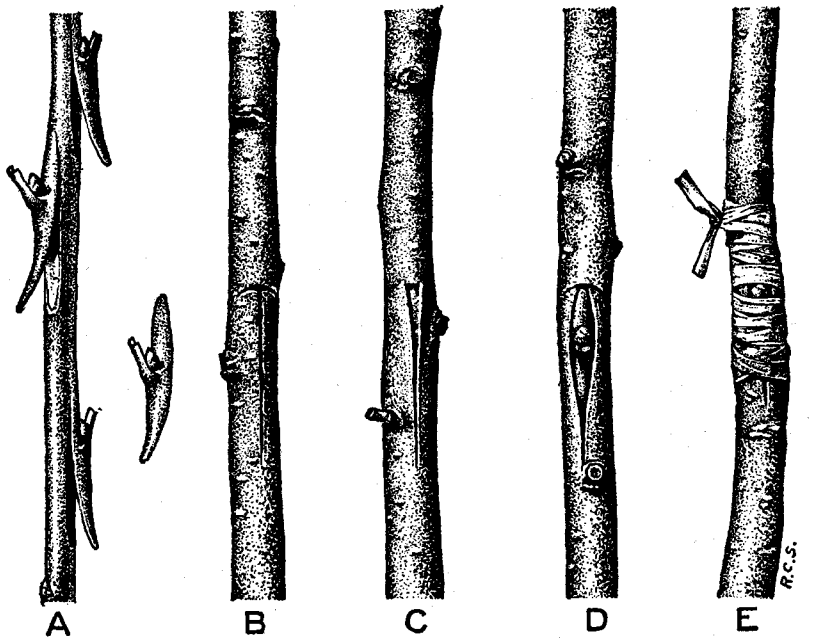

FIG. 29.—Shield bud. A, Bud stick; B, T-shaped cut through the bark of the stock; C, bark raised to admit the bud; D, bud in place; E, bud wrapped with raffia

the shield projects above the matrix it should be cut off evenly, so that all the cut surface under the bud fits snugly against the wood of the stock.

The operation is completed by tying the bud in place. Several different materials are in use for the bandages. Light cotton twine cut into lengths sufficient to allow six or eight turns around the stock is often used for fruit trees. Many budders prefer raffia, which is kept moist while in use so that it is soft and pliable. Light bands made from a special grade of rubber have come into use in recent years for fruit trees because they maintain constant pressure and expand with the growth of the stock. In some cases muslin that has been dipped into melted paraffin or beeswax is preferred.

The manner of wrapping the buds also varies among different operators. One way much used is to begin the wrap just below the bud, making the end lap under the first course to hold it. (Fig. 35.)

For most kinds of fruit trees three or four wraps of twine both below and above the bud are sufficient; for roses and other plants easily injured it is better to use raffia or other material that will cover the entire wound, leaving only the bud exposed. The tie may be made above the wound by lapping the end under the last course and drawing it tight, as shown in Figure 36, or by tying a knot. Irrespective of the method used, the wrapping must be such that the bud is held securely at all points against the stock.

THE JONES METHOD OF BUDDING

A mode of budding which was called to the attention of workers in the United States Department of Agriculture by the late J. F. Jones,[5] of Pennsylvania, is very simple and can be used rapidly. In comparison with ordinary shield budding during the last three seasons this method has given very good results.

FIG. 30.—Making the crosscut in the stock

A section of bark about 1½ inches long is pared from the side of the stock by a single downward stroke of the knife, exposing but not cutting into the wood beneath. The upper part of the piece of bark is cut off, leaving the lower portion attached to the stock. (Fig. 37, A.)

The bud is cut as for the ordinary shield bud, or perhaps a trifle thicker, and placed against the cut surface of the stock in the position shown in Figure 37, C, the flap of bark on the stock serving to hold the bud until it is tied. Muslin dipped into melted beeswax and then

[5] Mr. Jones, under date of Feb. 2, 1927, wrote as follows:

"Answering your letter relative to the method of budding that I showed you, this was original with me. As I told you, it might not have been new—some one might have used it previously—but if so I had no knowledge of it; neither have I up to this date.

"I first used this in 1895. I do not recollect using it on anything but chestnut that year. In these initial experiments the bark was cut down, the cut being made about one-half inch longer than required for the bud, the bud pushed down and the bark lapped over it and tied with wrapping twine. My idea was that with difficult subjects, like the chestnut, which callus slowly, the bark would unite with the stock at the top and, being connected with the stock top and bottom, would remain green long enough to hold the bud plump till a union could take place. We made the first rather extensive use of this method in budding at Mountain Grove, Mo., in 1900, when 22,000 peaches were budded late in October after the sap was practically gone and the bark set on most of the stocks. As in previous tests on fruit trees, we secured a good stand on buds in this block. With the exception of the chestnut, where the bark was thick and heavy, the bark lapped over the buds did not remain green for any great length of time, directly over the bud, although it united with the stock at the top, yet in most cases it had to be cut away to release the bud and to ascertain if the buds had taken.

"Subsequent trials in budding, cutting away the bark, and wrapping with waxed muslin proved just as effective, and we have practiced this since. I have used this method entirely with fruit trees for a good many years, as it is easier and quicker and we think we get better stands of buds, at least with cherry. The mazzard cherry, considered one of the most difficult fruit-tree stocks to bud, we have budded here as late as October and secured good stands of buds. The work of budding is much easier on sappy stocks and of course results are more sure, but with careful work and the use of waxed muslin in wrapping the buds any of our more common fruit trees can be budded successfully after the sap is gone and the bark set, provided, of course, the buds have time to make a good union with the stock before freezing weather sets in, as is generally the case where premature hardening of the stocks is caused by drought; but the budwood must also be well matured and ripened. Sappy budwood will not give results on dry stocks."

torn into narrow strips about 8 inches long is preferred for the bandage, though raffia may be used.

CARE OF BUDDED TREES

The bandages are allowed to remain until the tissues have united, but should be cut before they seriously constrict the stocks. In the case of fast-growing stocks, such as peach, they should be cut 10 days or two weeks after budding, while they may remain a month or more or even until the following spring on slow-growing stocks without injury. When the bandages are cut, the buds that have "taken" may be distinguished easily by their fresh, plump appearance. If some have failed they may be rebudded at this time. Ordinarily the buds are intended to remain dormant the season they are inserted and grow the following spring.

FIG. 31.—Lifting the bark with the flattened end of the knife handle

About the time that growth starts the following spring, the tops of the stocks are cut off just above the buds. Figure 38 illustrates the sloping cut so made that new growth will soon cover the wound.

The result of one season's growth of a stock that has been properly cut off just above the bud with the wound nearly healed is shown in Figure 39, A, while one that has been cut off too far above the bud with the disfiguring stub remaining is shown in Figure 39, B.

At intervals during the first few weeks of active growth all the sprouts arising from the stock around and below the bud must be removed, as such growth would soon smother the buds. If the young trees are to be grown as "whips," all the side or lateral shoots from the growing bud are pinched out wherever they appear, without disturbing the leaves on the main stem. Apple and pear trees are often so treated. If branched trees are desired, as is usually the case for peach and plum, the laterals are pinched out during the early part of the season or until the stems have reached the required height. Laterals subsequently formed are allowed to develop in a natural

manner to form a branched top. If shrubby low-branched plants are wanted, lateral branches low on the stem are encouraged by pinching or cutting back the terminal of the main shoot early in the season while the wood is still soft. This treatment is especially desirable for hybrid tea roses, not only to increase the number of low branches but to lessen the danger from wind, which often causes loss by breaking off the long tender shoots before the wood has hardened.

The culture of budded trees should be such as to encourage rapid growth. Much of the future value of the trees depends on thrifty growth the first season. Trees that have attained a good size as a result of culture in the nursery may be expected to succeed far better than those that have been checked or stunted. Nearly all trees should make sufficient growth from the bud in one season to fit them for transplanting to their permanent location.

FIG. 32.—Cutting the bud

FIG. 33.—Starting the bud into the matrix while holding it on the knife blade

JUNE BUDDING

In the Southern and Pacific States where the long season permits, peach and other stone fruits often are budded as early as the stocks are large enough. The buds are then forced into quick growth with the object of obtaining trees large enough for orchard planting the same season they are budded, thereby gaining a year.

In some cases the wood from which the buds are to be taken is cut during the previous dormant season and kept in cold storage until the time for budding; in others the new growth from the varieties desired is depended upon to mature sufficiently to supply the buds.

This budding is done in May or June. Part of the stock top is either cut off or broken over at the time of budding, which treatment tends to induce the bud to start into growth rather than remain dormant all summer. Later, as growth from the bud starts, the stock is headed back still more, and when the shoot is several inches long the stock is cut off at the bud. Sometimes the stock is cut away entirely as soon as the bud has started instead of shortening it gradually, but such severe treatment has a weakening effect on the growth.

FIG. 34.—Pushing the bud down into place with the thumb

DOUBLE-WORKED TREES

Trees with trunks or intermediate portions differing from the roots or the tops by reason of having been twice grafted or budded are known as double-worked trees. The variety which is to form the trunk is grafted or budded and grown for one or two seasons in the ordinary manner, when it is again grafted or budded at the desired height with the variety which is to form the fruit-bearing top. Sometimes the intermediate is allowed to develop scaffold branches which are worked to the desired variety 1 foot or more from the main stem.

The object of double-working is to produce trees having trunks hardier, more resistant to diseases, or more vigorous than the varieties themselves. Examples where double-working is an advantageous practice are numerous. In the Pacific States the loss from pear blight on susceptible varieties such as Bartlett and Anjou is being greatly reduced by the use of a variety such as Old Home, known to be resistant, to form the trunk and framework branches. In the event the blight strikes the tops, it can spread only as far as the union with the resistant scaffold branches, and these can be worked later to form new bearing tops. Grimes Golden and other varieties of the apple subject to collar rot are made resistant by the use of some other variety such as Northern Spy or Delicious to form the lower part of the trunk. Weak-growing sorts such as Red Canada (*Steele's Red*) and Tompkins King are improved by top-working them on a variety that makes straight, vigorous trunks.

PROPAGATION OF SPECIFIC KINDS OF ORNAMENTAL TREES AND SHRUBS

In the following notes, brief reference is made to the methods most generally used for propagating certain kinds of plants about which questions are frequently asked. However, as conditions vary so widely, no one method of propagating a given plant may be said to be the best in all cases. The facilities available, the season of the year when the work may be fitted in with other operations, the condition of the mother plants, the number of new plants desired, and other factors all have a bearing on the choice of the most appropriate method.

Abelia (Abelia).—Cuttings of half-ripe wood in summer, or, in the South, by hardwood cuttings in the open.

Apple (Malus).—Ornamental species and varieties usually by whip grafting or by budding on ordinary apple seedlings.

FIG. 35.—Starting the bandage by lapping the raffia over the lower end of the cut

FIG. 36.—Completing the bandage by lapping the end under the last course, then drawing it tight

Arbor vitae (Thuja).—Seed kept dry and planted in spring. Varieties by cuttings under glass in summer or fall.

Ash (Fraxinus).—Seed, which should be stratified as soon as procured.

Azalea (Azalea).—The deciduous outdoor species by seed as described for rhododendrons. The Indian azaleas by cuttings of immature wood under glass and by grafting. All forms of azaleas can be layered.

Bald cypress (Taxodium).—Seed, planted in spring, which usually germinates poorly, hence should be sown thickly.

Barberry (Berberis).—Seed freed from pulp and planted in fall, or stratified over winter, is the readiest means for the species. Cuttings of nearly ripe wood in fall under glass and immature wood in summer are used successfully, but most varieties are rather slow to strike roots. Also by root grafting and by layering.

Beech (Fagus).—Seed stratified and kept in a cool place for spring planting or else planted as soon as procured. Purple beech usually is grafted on seedlings of European beech. Seedlings of purple beech have more or less purple color.

Birch (Betula).—Seed, which should be planted in fall or as soon as it ripens. Varieties are budded in the open ground or grafted on seedlings established in pots. White birch, *Betula alba*, is often used as a stock for cut-leaf weeping birch. Varieties are propagated also by layers.

Bittersweet (Celastrus).—Usually by seed freed from the outer coats and planted in fall or stratified over winter. Also by layers, root cuttings, and suckers.

Bluebeard (Caryopteris).—Cuttings of immature wood root easily. Also by seed planted as soon as ripe in fall under glass.

Boxwood (Buxus).—Cuttings of half-ripe wood in summer, or ripe wood in fall or winter under glass. Layers easily. Also by seed, but it is slow to germinate, and the seedlings develop very slowly.

Butterfly bush (Buddleia).—Immature cuttings in summer.

Catalpa (Catalpa).—Seed kept dry and planted after the ground warms in spring. *Catalpa bungei* as used for ornamental planting is budded or grafted several feet high on stems of *C. speciosa*, the hardy western catalpa. For the straight tall stems to form the trunk, 1-year seedlings are grown in rich soil one season, then cut back to the ground. The following spring the strongest shoot arising from the stump is saved and all other growth kept off. By late summer this shoot should be tall enough to permit top-working at the height desired. The union may be made by budding in September. It is advisable to use two or three buds on different sides of the stem to assist in the formation of a symmetrical head. The union also may be made in early spring by whip or cleft grafting. Grafted unions should be waxed.

Cedar (the true cedar; Cedrus).—Seed kept dry and planted in spring after the soil becomes warm. Varieties by cuttings in summer or fall under glass or veneer grafted in winter on seedlings.

Chaste tree (Vitex).—Usually by seed planted in spring.

Cherry, Japanese flowering (Prunus).—Budded or grafted on seedling stocks. Mazzard is the stock most frequently used at present, though evidence indicates that the trees on this stock are short-lived in many situations. Grafts planted with the union several inches below ground level will often strike roots within a year or two from the scion above the union. Own-rooted trees obtained by this means are safer for general planting than those budded on mazzard. *Prunus serrulata, P. sachalinensis, P. pendula,* and probably other oriental cherries are regarded as better stocks than mazzard. Seed of these species is imported from Japan.

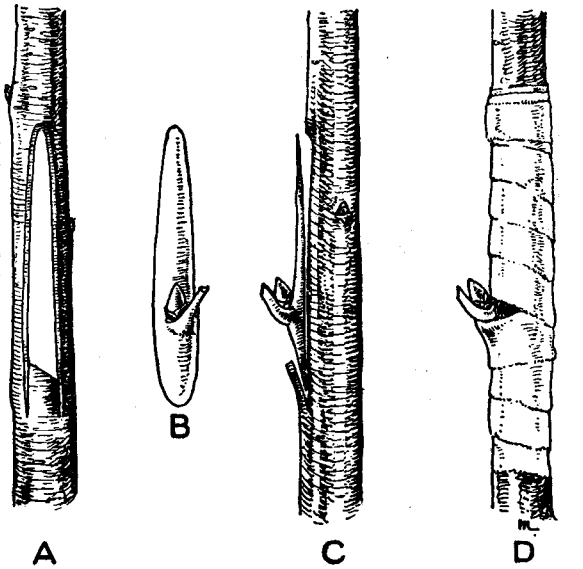

FIG. 37.—A simple and useful form of plate bud. A. Stock prepared by paring off a piece of bark, exposing the wood; B, bud cut similar to that for ordinary shield budding; C, bud in place; D, completed operation. Bud wrapped with waxed muslin

Cork tree (Phellodendron).—Seed planted in fall or stratified over winter.

Cotoneaster (Cotoneaster).—Seed stratified as soon as harvested. Often the seed lies dormant the first season. Also by mound layers. Some evergreen forms by cutting under glass.

Cranberry bush (Viburnum).—Seed stratified as soon as ripe and planted in fall or spring. Usually seed does not germinate until the second spring. Layers commonly root in one season. Also by immature cuttings under glass.

Crape myrtle (Lagerstroemia).—Seed kept dry and planted after the soil warms in spring. Cuttings of immature wood and hardwood cuttings root easily.

Cryptomeria (Cryptomeria).—Seed kept dry and planted after the soil becomes warm in spring. Cuttings in summer or fall under glass will root though slowly.

Cypress (Cupressus and Chamaecyparis).—Seed planted in spring. Varieties by cuttings in summer or fall under glass.

Deutzia (Deutzia).—Immature cuttings under glass or hardwood cuttings root easily.

Dogwood (Cornus).—*Cornus alba* and its varieties by hardwood cuttings. Flowering dogwood, *C. florida*, white form from seed stratified or planted as soon as ripe. Pink and red flower varieties by budding or grafting on seedlings of *C. florida*.

Elm (Ulmus).—Seed sown as soon as ripe in spring germinates quickly. The seed loses its viability if kept dry for any length of time. The oriental elms such as *Ulmus pumila* also may be root grafted on American elm, *U. americana*, or increased by immature cuttings under glass or by root cuttings.

False indigo (Amorpha).—Seed planted at once or stratified. Immature cuttings under glass.

Fir (Abies).—Seed kept dry and planted in spring.

Firethorn (Pyracantha).—Seed freed from pulp and planted or stratified at once. Cuttings of nearly ripe wood in fall under glass or by hardwood cuttings in the open where

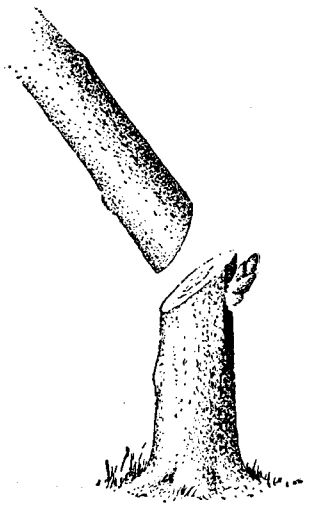

FIG. 38.—Stock top removed with a sloping cut just above the bud. Ordinarily this is done the following spring about the time growth starts

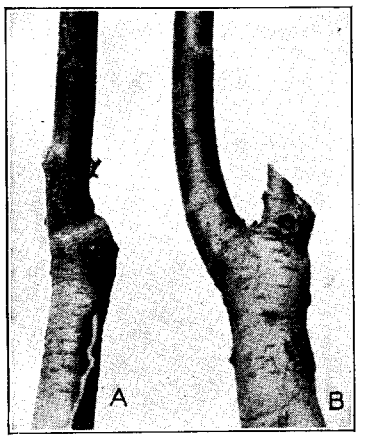

FIG. 39.—Bud unions of two cherry trees after one season's growth. Result of properly (A) and improperly (B) cut stock

conditions are especially favorable. Also by grafting on mountain ash or on hawthorn seedlings.

Flowering quince (Cydonia).—Cuttings of nearly ripe wood in fall under glass or by seed, stratified or planted as soon as procured. Colors do not come true from seed. Also by layers, by division of the clumps, and by root cuttings.

Forsythia (Forsythia).—Either immature cuttings under glass or hardwood cuttings root easily.

Fringe tree (Chionanthus).—Seed kept stratified. Frequently the seed does not germinate until the second spring.

Gold-dust aucuba (Aucuba).—Cuttings of half-ripe wood in summer or nearly ripe wood in fall under glass.

Hackberry (Celtis).—Seed freed from pulp and kept stratified or planted in fall.

Hawthorn (Crataegus).—Seed freed from pulp and kept stratified. Usually does not germinate until the second spring. Varieties are budded or grafted on seedlings or layered.

Hemlock (Tsuga).—Seed kept dry and planted in spring.

Holly (Ilex).—Seed, which requires a long period for after-ripening, usually does not germinate until the second spring. Cuttings of immature wood root well if made in July and given mild bottom heat under glass. Also from mature cuttings in fall. The slender twigs stripped from the sides of branches with a heel make the best cuttings.

Honey locust (Gleditsia).—Seed either kept dry or stratified over winter. In spring place the seed in water heated nearly to the boiling point, set aside, and allow to soak for about 24 hours, then plant at once.

Honeysuckle (Lonicera).—Seed sown in fall or stratified over winter. Cuttings of immature wood under glass and hardwood cuttings grow readily.

Hornbeam (Carpinus).—Seed planted in fall or stratified over winter.

Horse-chestnut (Aesculus).—Seed planted in fall.

Hydrangea (Hydrangea).—Cuttings in summer under glass and hardwood cuttings. Also by layers.

Juniper (Juniperus).—Seed should be stratified as soon as collected, after freeing it from pulp. Some species often delay germination until the second spring. Horticultural forms of *Juniperus chinensis* and *J. communis* are often propagated by cuttings under glass in summer or fall. Some forms of Juniperus root so slowly that veneer grafting on potted stocks is the readiest means. Red cedar is the stock most commonly used. The low-growing forms such as *J. sabina* can be increased by layers.

Kentucky coffee tree (Gymnocladus).—Seed treated as described for honey locust.

Larch (Larix).—Seed kept dry and planted in spring.

Lilac (Syringa).—Varieties are easily grafted or budded on Amur River or California privet. If the graft union is planted low so that the scion above the union stands in moist soil, the plants may become established within two or three years on scion roots. Although lilac seedlings make good unions with the varieties, they have the objectionable tendency to send up growth from below the union which may be overlooked, owing to the similarity of the foliage. Cuttings made in early summer at the time the wood begins to harden root well under glass with mild bottom heat.

Linden (Tilia).—Seed stratified as soon as procured and planted in fall or early spring.

Magnolia (Magnolia).—The different species usually by seed freed from pulp, then stratified, and planted in spring after the soil becomes warm. The seed is easily injured by drying. Heel cuttings in summer will root, though slowly. Grafted on *Magnolia kobus*, which is one of the best stocks, also on *M. acuminata* and *M. tripetala*, seedlings using the veneer graft on potted stocks. Also by layers put down in early spring and separated the following spring. The rooted layers should be planted in beds with protection, or potted and started in frames.

Maidenhair tree (Ginkgo).—Seed planted in fall or stratified over winter.

Maple (Acer).—Seed of species that ripen in spring should be planted as soon as ripe for immediate germination, as it soon loses its viability in storage. Seed of species that ripen in fall should be stratified or planted in autumn. Varieties by grafts on seedlings of species from which they sprung. The veneer or cleft graft is used under glass on stocks established in pots. Norway maple, *Acer platanoides*, is the stock for Schwedler maple. *A. palmatum* seedlings are used for Japanese maple varieties.

Mock orange (Philadelphus).—Usually by hardwood cuttings or by half-ripe cuttings in June or early July. Species may be reproduced by seed.

Mountain laurel (Kalmia).—Seed kept dry and planted under glass in early spring in peaty soil or leaf mold as for rhododendrons. Also by layers.

Mulberry (Morus).—Seed kept dry and planted in spring.

Nandina (Nandina).—Seed stratified as soon as procured. Often irregular in germination.

Oak (Quercus).—Seed planted in fall. Varieties are grafted on seedlings of closely related species.

Osmanthus (Osmanthus).—Cuttings of nearly ripe wood in fall under glass.

Papaw (Asimina).—Seed freed from pulp and stratified as soon as procured, then planted in fall or spring.

Pearlbush (Exochorda).—Seed planted in fall, preferably under glass. Cuttings from half-ripened wood in June or July under glass. Also by layers.

Persimmon (Diospyros).—The American species, *Diospyros virginiana*, and one of the oriental species, *D. lotus*, are readily grown from seed. Both are used as stocks for the Japanese fruiting varieties and the select forms of the native persimmon, but the American species is hardier and is more frequently used. To improve the scanty root systems of the seedlings it is advisable to grow them in beds one season, then transplant them to the open nursery for one season before grafting or budding them. The whip-graft union is successfully employed for both bench grafting and field grafting when the stocks are small.

For top-working larger trees the cleft or bark graft is used. When done in the open the union should be waxed.

Plane tree (Platanus).—Seed kept dry and planted in spring. Also by hardwood cuttings.

Plum (Prunus).—Species from seed, which should be freed from pulp and stratified as soon as ripe. Varieties usually field-budded. Myrobalan is one of the best stocks for the purple leaf plum, *Prunus pissardi.*

Privet (Ligustrum).—Seed stratified as soon as procured. The forms of privet commonly used for hedges are easily increased by hardwood cuttings in the open ground or by immature cuttings under glass. *Ligustrum lucidum* grows readily from seed, though cuttings root slowly. The variegated forms of *L. lucidum* and *L. japonicum* are grafted or budded on Amur or California privet.

Redbud (Cercis).—Seed stratified as soon as procured and planted in fall or spring.

Retinospora (Chamaecyparis and Thuja).—Cuttings in summer or fall under glass.

Rhododendron (Rhododendron).—Seed, layers, and grafts. The seed is kept dry until planted, usually in early spring in flats or pans of specially prepared soil under glass. The necessary acid soil can be provided by a mixture of one-half peat or partially decomposed oak leaves with one-fourth sand and one-fourth potting soil. The mixture should be dried and then rubbed through a screen. The prepared soil should be pressed down in the flats, leveled and watered, then allowed to stand overnight before sowing. The seed is very fine and usually mixed with chaff, hence should be sown thickly. It should be covered with a very light and uniform layer of sphagnum moss rubbed while dry through an ordinary fly-screen mesh. As an aid to preserve uniform moisture, it is desirable to cover the flats with panes of glass and stand them in shallow pans of water so that syringing or spraying will be unnecessary. Germination should take place within 30 or 40 days. The panes of glass may be kept in place until the seedlings begin to show their third leaves, when they are ready to be transplanted, spaced about 1 to 2 inches apart, into soil prepared as for the seed beds.

Layers are often employed for propagating the named varieties.

For grafting the named varieties, the principal stock is *Rhododendron ponticum* from seed. This stock, however, lacks the extreme hardiness required for the North. The plants are grown for two seasons to attain the proper size, then established in pots. Grafting is done usually in early spring under glass, with the use of scions from outdoors. The veneer graft is used to make the union.

Rose (Rosa).—Seed is the usual means of increasing the species. As soon as ripe the seed is separated from the hips and kept moist by stratifying it. Planting may be in either fall or spring. The seed may germinate quickly during the first warm days of spring, hence it must be planted early. The seed beds should be situated so that they can be watered if necessary, but the young seedlings ordinarily need no protection from direct sunlight.

The varieties of climbers and Polyantha types as well as some botanical species are often grown from hardwood cuttings in the open ground, especially in the South.

Hybrid teas are extensively propagated by immature cuttings in spring or summer under glass. Cuttings from plants grown in greenhouses usually root more easily than those from plants grown in the open. The stem is in condition for the cuttings about the time the flower opens. It is important that the plants from which cuttings are taken be healthy and free from leaf diseases. The cuttings may be made to include only one bud, called single-eye cuttings, but it is preferable to include two or three buds, removing the leaves except the one at the top bud.

Roses of nearly all types, but especially hybrid teas intended for outdoor planting, are also propagated in large quantities by budding in the open ground. Several stocks are in use. Manetti propagated by hardwood cuttings is one of the most widely used and best-known stocks. *Rosa multiflora japonica* from seed is one of the principal stocks in the Eastern States, and its use is increasing. *R. rugosa* from hardwood cuttings was formerly employed to a greater extent than at present. It is objectionable because of its persistence in sending out suckers from the roots. Gloire des Rosomanes (Ragged Robin) from hardwood cuttings is used for hybrid teas to a considerable extent in California. *R. odorata* from hardwood cuttings is coming into more extensive use, particularly in the Southern States, and also for greenhouse roses.

Russian olive (Elaeagnus).—Seed planted in fall or stratified. Often delays germination until the second spring. *Elaeagnus angustifolia,* also by hardwood cuttings.

Shadblow (Amelanchier).—Seed kept stratified or planted in fall or spring. Also by whip grafts and by layers.

Siberian pea tree (Caragana).—Seed planted in fall or kept stratified over winter.

Silverbell (Halesia).—Seed planted at once or stratified. Usually does not germinate until the second season.

Shrub althaea (Hibiscus syriacus).—Easily raised from seed planted in spring, but the seedlings do not come true to color. Varieties of both single-flowered and double-flowered forms by hardwood cuttings, also by grafting on seedlings. Variegated leaf varieties by half-ripe cuttings.

Snowbell (Styrax).—Seed planted as soon as procured or else stratified. Often fails to germinate the first season.

Spirea (Spirea).—Usually by hardwood cuttings or by immature cuttings in summer. Some species may be grown readily from seed planted as soon as ripe in summer.

Spruce (Picea).—Seed kept dry and planted in spring. Varieties are grafted under glass on seedlings established in pots. Norway spruce, *Picea excelsa,* or white spruce, *P. alba,* are used as stocks for the horticultural forms of Colorado blue spruce, *P. pungens.*

Sweet gum (Liquidambar).—Seed planted in fall or stratified for spring planting.

Sweet shrub (Calycanthus).—Seed planted in fall or stratified over winter. Mound layers.

Tamarix (Tamarix).—Usually by hardwood cuttings which root easily.

Tulip tree (Liriodendron).—Seed planted in fall or kept stratified over winter. Many of the seeds are likely to be imperfect, therefore thick sowing is advisable.

Weigela (Weigela).—Most varieties root easily from immature cuttings under glass or from hardwood cuttings.

Wisteria (Wisteria).—Seed grows readily. Also layers and by root cuttings in greenhouse with bottom heat. Cuttings of nearly-ripe wood in fall under glass will root, though slowly.

Yellowwood (Cladrastis).—Seed treated as described for honey locust.

Yew (Taxus).—Seed stratified as soon as procured and planted in fall. May delay germination until the second spring if allowed to dry. Cuttings in summer or fall under glass.

USE OF ROOT-STIMULATING CHEMICALS ON CUTTINGS

Several organic chemicals have been found to hasten and stimulate the formation of roots on cuttings. Indolebutyric acid, naphthaleneacetic acid, naphthalene acetamide, and indoleacetic acid have been tested rather extensively and are best known, but several others may prove at least equally effective. Very minute quantities of the chemical induce root formation, and excess amounts injure the cuttings. It is important, for this reason, to measure accurately. The chemical is used either in water solution or as a powder diluted with talc or some other powdered material.

The chemicals prepared ready for use are sold by seed stores and garden-supply firms, under several trade names (Hormodin, Rootone, Stim-Root, etc.), with directions for the treatment of cuttings. The directions should be followed closely at first and the results observed. To obtain the best effect when solutions are used, it may be necessary to vary the strength or the period of immersion somewhat, because the conditions under which the wood for the cuttings grew, the stage of maturity, the temperature, and other factors may affect the response of cuttings after they are planted.

TABLE 1.—*Response of cuttings of various plants to treatment with indolebutyric acid*

GROUP 1 (PLANTS THAT ROOTED 1 TO 5 WEEKS SOONER BUT THAT DID NOT DEFINITELY GAIN IN EVENTUAL PERCENTAGES THAT ROOTED)

Scientific name [1]	Common name	Cuttings rooted		Best treatment		Rooting period	Notes on condition of cuttings
		Untreated	Treated	Amount in 100 cc.	Period		
		Percent	*Percent*	*Milligrams*	*Hours*	*Days*	
Abelia grandiflora	Glossy abelia	33	93	5	21	34	Growing wood best; little response to treatment on harder wood.
Azalea kaempferi	Hiryu azalea	0	85	5-8	4	47	Twigs still in active growth.
Azalea	Azalea var. Carmen [2]	30	100	3-10	4	40	Do.
Do	Azalea var. Cattleya [2]	0	79	5-10	4	36	Short laterals better than main branches of all Kurume azaleas.
Do	Azalea var. Damask Rose [3]	65	95	3-8	4	34	
Do	Azalea var. Snow	33	80	3	21	54	
Do	Azalea var. Yayegiri [2]	67	100	5	4	48	
Buxus sempervirens var. *arborescens*	Common box	33	70	3-5	20	70	Cuttings taken earlier yielded similar results.
Buxus sempervirens var. *handsworthii*	Handsworth tree box	70	100	3	20	69	Earlier cuttings suffered from heat.
Celastrus scandens	American bittersweet	0	90	5	20	34	Vines in active growth.
Chamaecyparis pisifera var. *plumosa*	Sawara falsecypress	15	65	3-8	20	68	
Cotoneaster microphylla	Rockspray cotoneaster	45	100	8	4	25	Nearly mature; July and August cuttings failed.
Euonymus patens	Spreading euonymus	40	91	5	4	14	Easily rooted; similar results from cuttings made earlier.
Gordonia alatamaha	Franklinia	34	83	3	4	29	Taken from young trees after terminal buds had formed.
Ilex cornuta	Chinese holly	0	30	3-8	4	62	Softwood best; no results from August cuttings.
Ilex crenata	Japanese holly	57	100	8	4	43	Cuttings from growing wood rooted soonest.
Ilex crenata var. *microphylla*	do	20	87	5	4	62	Do.
Ilex glabra	Inkberry	0	90	5	4	41	Half-ripe wood.
Ilex opaca	American holly	0	96	10	18	23	Wood nearly mature; 93 percent of untreated cuttings taken July 10 rooted in 30 to 90 days.
Juniperus chinensis var. *pfitzeriana*	Pfitzer juniper	0	40	5-8	20	88	Similar results from earlier cuts.
Osmanthus ilicifolius	Holly osmanthus	20	93	15	4	32	Uninjured by 20 mg. per 100 cc.
Pyracantha coccinea	Scarlet firethorn	45	81	3	4	70	Nearly mature; July and August cuttings failed.
Styrax japonica	Japanese snowbell	10	100	5	4	23	Terminal buds were forming.
Taxus cuspidata	Japanese yew	30	95	5-8	22	56	Short laterals; winter cuttings rooted sooner than those taken in July, August, October, and November.
Thuja occidentalis var. *globosa*	Globe arbor vitae	25	85	6-8	20	69	August cuttings suffered from heat.
Thuja plicata	Giant arbor vitae	8	79	8-10	22	62	Do.
Viburnum dentatum	Arrowwood viburnum	80	100	3-5	4	44	
Viburnum dilatatum	Linden viburnum	70	100	3-10	2	31	All viburnums rooted best from wood taken while growth was still active.
Viburnum sieboldii	Siebold viburnum	0	92	3-5	4	26	
Viburnum tomentosum var. *plicatum*	Japanese snowball	0	33	3-5	20		
Viburnum wrightii	Wright viburnum	59	100	3-10	4	26	

GROUP 2 (PLANTS THAT RESPONDED BY MORE ROOTS BUT THAT DID NOT GAIN MUCH IN TIME OR IN PERCENTAGES THAT ROOTED)

Azalea arborescens	Sweet azalea	70	60	8-10	4	63	Wood in active growth; deciduous azaleas withstood somewhat stronger concentrations without injury than Kurume varieties.
Azalea nudiflora	Pinxterbloom azalea	56	73	8-10	4	62	
Azalea poukhanensis	Yodogawa azalea	57	67	8-10	4	63	
Azalea viscosa	Swamp azalea	63	58	8	4	62	
Azalea	Azalea var. Christmas Cheer [2]	100	60	5	4	40	
Do	Azalea var. Debutante [2]	61	89	5	4	32	
Do	Azalea var. Firefly [2]	94	95	3-10	18	54	
Do	Azalea var. Hinodegiri [2]	75	85	3-10	20	52	
Do	Azalea var. Hinomayo [2]	66	81	5-8	20	42	
Do	Azalea var. Maxwellii	82	100	3-8	20	47	
Callicarpa purpurea	Beautyberry	87	100	3-10	20	18	Easily rooted at different stages of growth.
Cornus amomum	Silky dogwood	53	73	3	20	22	Taken when terminals were forming.
Deutzia gracilis	Slender deutzia	79	90	8-10	4	17	Easily rooted at any time.
Elaeagnus pungens	Thorny elaeagnus	72	100	3	4	70	Earlier and later cuttings failed.
Ginkgo biloba	Maidenhair tree; ginkgo	80	90	5	20	36	Taken after terminals had formed; results similar from August and September cuttings.
Juniperus horizontalis var. *plumosa*	Creeping juniper	60	60	5	20	48	
Ligustrum japonicum	Japanese privet	94	95	3-5	20	28	Growing tips rooted much sooner than older wood.
Philadelphus grandiflorus	Mock orange	70	75	3-5	4	33	Best soon after flowering.
Rosa odorata	Tea rose	89	95	3-10	18	12	Easily rooted at any time.
Syringa	Lilac var. Louvois	41	49	5	3	61	Softwood, soon after flowering; no results from wood that had begun to harden.
Viburnum cassinoides	Withe-rod viburnum	30	30	3-5	4	26	Taken while in active growth.
Viburnum lantana	Wayfaring-tree	58	66	5	4	26	Do.
Viburnum tomentosum	Doublefile viburnum	92	91	3-5	4	26	Do.

GROUP 3 (PLANTS THAT ROOTED WHEN UNTREATED CUTTINGS FAILED TO ROOT OR YIELDED SMALL PERCENTAGES THAT ROOTED)

Azalea calendulacea	Flame azalea	0	40	5-10	22	73	Taken while in active growth; no results from older wood of deciduous azaleas.
Azalea japonica	Japanese azalea	0	35	5-10	4	62	
Azalea mollis	Chinese azalea	10	70	3-10	4	73	
Cornus florida var. *rubra*	Pink dogwood	0	60	5	4	27	Best results from wood taken shortly before terminal buds formed.
Cornus paniculata	Gray dogwood	0	66	8-10	4	41	
Kolkwitzia amabilis	Beautybush	0	100	6-10	4	34	Taken before terminals had formed.
Magnolia kobus var. *borealis*	Kobus magnolia	0	58	8-10	22	24	In active growth when taken.
Magnolia liliflora	Lily magnolia	21	100	5	22	49	From young trees taken when terminal buds were forming.
Malus	Crabapple var. Eleyi	0	70	5	4	34	Wood from young trees in active growth.
Philadelphus	Mock orange var. Norma	0	87	3	4	33	Softwood soon after flowering.
Do	Mock orange var. Voie Lactée	10	42	8	4	33	Do.
Prunus triloba var. *plena*	Flowering plum	0	33	5-10	4	21	Terminal buds had formed; indications of better results from younger wood.
Tsuga canadensis	Canada, or eastern, hemlock	0	79	5-10	22	62	No results from cuttings made in summer and fall.
Vitis rotundifolia	Muscadine grape	0	44	2	20	22	Best rooting from third to sixth nodes back from growing tips.

[1] The plants called azaleas by the nursery trade are referred to the genus *Rhododendron* by most botanists. [2] Kurume type. [3] *Rhododendron mucronatum* var. *sekidera*.