UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BULLETIN 233

Grafting, Budding and Early Care of Fruit Trees

Fig. 1.—About two-thirds of the main branches of an apple tree cleft grafted. The remaining branches, called "nurse branches", were left to nourish the tree while the scions are becoming established. These branches are to be cleft grafted the following year. The paper bags placed over the scions for 7 to 10 days to prevent rapid drying have been opened but are shown still attached to the stocks or stubs.

COLUMBIA, MISSOURI
MAY, 1925

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ESSENTIALS OF GRAFTING AND BUDDING

Success in grafting or budding may depend upon the observance of the following:

1. The scion and stock must be congenial or capable of producing growth when properly united under suitable surroundings.

2. The operation must be done at the proper season of the year and under the right conditions.

3. The growing tissues (cambium) of the scion should be in close and smooth contact with the growing tissues (cambium) of the stock.

4. To prevent drying out, all wounded surfaces must be properly protected.

5. Timely attention is generally required to make the work a success.

Grafting, Budding and Early Care of Fruit Trees

T. J. Talbert

Abstract.—All the essential principles and practices of graftage are described and illustrated. The results of an investigation of whole-root and piece-root Jonathan apple trees covering a period of 20 years are carefully considered. The successive steps in root grafting, cleft grafting, bridge grafting, double-working and various forms of budding are described and explained. Directions are also given for procuring, growing, handling and storing seeds, scions, seedling roots, grafts and young trees. Pedigreed and common nursery stocks are considered in the light of experimental work. Practical directions are given regarding the handling, planting and care of young trees.

The art of propagating fruit trees by grafting and budding has been practiced for more than 2,000 years. In olden times many who practiced the art endeavored to shroud it in mystery. The general fruit grower was lead to believe that one had to be endowed with special faculties to be able to propagate fruits successfully by budding and grafting. In fact, a touch of magic appeared necessary to grow buds of the pear upon the apple, or buds of the peach upon the plum. Now, however, the propagation of fruit trees by graftage is widely understood and the methods are so simple that anyone of average intelligence can perform the work successfully if he so desires.

PROPAGATION VERSUS BUYING FRUIT TREES

The grower with proper training and experience may be able to propagate in a satisfactory way all the tree fruits required for planting on his farm. Few, however, will take the time to follow directions and practice diligently enough to acquire the skill necessary for successful and economical propagation. The reliable nurseryman, therefore, who makes a specialty of the business of grafting and budding fruit plants is generally able to produce better fruit trees at a lower cost than the average fruit grower or farmer. After deciding to plant an orchard, the grower will also save from one to two years' time in bringing the orchard into bearing if he buys his fruit trees from the nurseryman instead of endeavoring to propagate them himself. The instructions which follow are not intended to assist the experienced nurseryman so much as to help the beginner who desires to propagate, bridge-graft or top-work his own trees.

PLANT THE BEST FRUIT TREES

It is false economy to plant inferior or low grade fruit trees. The best trees which can be secured, will in the end, be the most economical

and profitable. Growers generally do not give the matter of planting stocky, healthy, vigorous trees instead of small, weakly, unthrifty trees enough consideration. Success or failure may depend upon the vigor of the nursery stock used. Whether propagated at home or purchased from a commercial nurseryman, the importance of obtaining the best nursery stock cannot be overemphasized. Investigations at this station and elsewhere have shown that growthy, vigorous, well matured trees withstand transplanting better, are more resistant to dangerous insect pests and fungous diseases, come into bearing earlier and develop into a more profitable orchard than small, stunted and less vigorous trees.

GRAFTAGE AND REASONS FOR IT

The term graftage includes the practices of grafting, budding and inarching. It has been defined as the process of causing one part of a plant to unite with or grow upon the roots of another.

The various practices and methods which have been developed in the art of graftage have, in general, been employed for the following reasons: (1) to multiply fruit trees on an extensive scale, to supply a demand or trade; (2) to change undesirable and unprofitable varieties to suitable sorts; (3) to prevent diseases on susceptible varieties; (4) to repair damage done by rodents, cultural implements or storms; (5) to adapt varieties to different soil conditions; (6) to perpetuate certain kinds or varieties, because fruit trees do not generally come true from seed.

PRINCIPLES OF GRAFTAGE

The principle of graftage is to unite the scion with the stock or root in such a manner that growth takes place and a perfect union is secured. When this is accomplished, the graft grows as though it were on its own roots and produces fruit according to its own kind. Unions of this nature can only take place between closely related species.

In all methods of grafting it is important to remember that the inner bark of both stock and scion should be brought together in such a way that the growing layers (cambium) of both are in close contact. In so doing, the greatest use is made of available food materials and a layer of new wood is formed which binds the stock and scion together as one.

Classification of Grafting as to Position

As to position, grafting may be classified as follows:

1. Root grafting, in which a root is used as a stock.
2. Crown grafting, in which scions are inserted in stocks at the crown or collar of the plant.
3. Trunk or stem grafting, in which scions are set in the tree below the branches.

4. Top grafting, in which the main or scaffold branches are sawed off and the stubs grafted by the insertion of scions.

In all these classes, the methods of inserting the scions may differ.

GRAFTING AND BUDDING TOOLS AND EQUIPMENT

Very few special tools are required. Among the most important and efficient tools are grafting and budding knives—and these must be sharp. For top-working large trees a grafting chisel or other implement of a similar nature is needed. The top-worker may also have use for a ladder, saw, rope and hand shears. A mallet or some such implement is

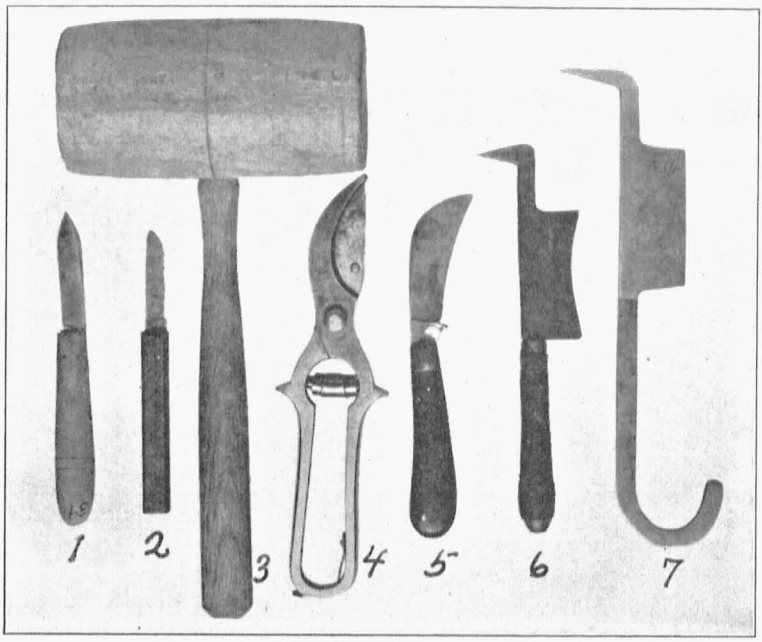

Fig. 2.—Grafting and Budding Tools. (1) Grafting knife, (2) budding knife, (3) mallet used in cleft grafting, (4) hand shears, (5) pruning knife, (6) and (7) knives for cleft grafting.

often required in cleft grafting large limbs. A short apron equipped with several pockets may be found very useful for holding scions, knives, strings, patch material, etc.

TIME FOR GRAFTAGE

Grafting is usually performed most successfully before growth starts in the spring; yet there are some types of grafting which are best done just before or just after growth starts. It is usually necessary, for best results, to keep the scions dormant. Fruit trees are generally budded during July, August and early September, although budding may be

successfully accomplished from early spring until fall. For the work of budding to be most satisfactory it is usually necessary for the bark to peel easily.

SCION WOOD AND ITS CARE

Scion wood is usually cut some time during the fall or winter from unfrozen, well matured wood of the last season's growth. One-year-old wood is preferred because experience has shown that its buds are more likely to grow successfully upon the stock than the buds from wood two or more years of age. The length of the scions will depend upon the amount of growth during the past season. This may range from 10 or 12 inches to 20 inches or more. Scions should not be cut too long for convenience in handling and storing. When taken from frozen wood or from wood which has been injured by low temperature they may prove worthless.

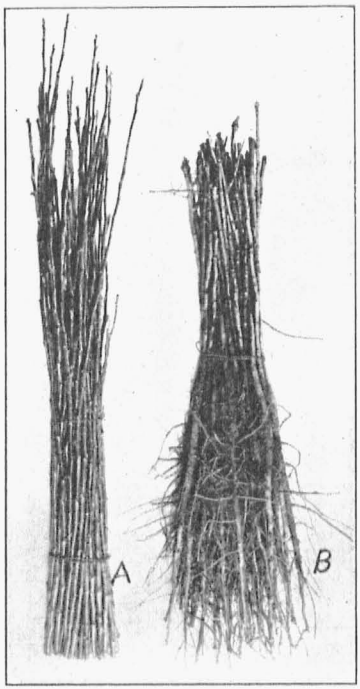

Fig. 3.—(A) Apple twigs to be used as scions, and (B) seedling apple roots as received from the nursery to be used in the propagation of the apple by root and scion grafting.

Water sprouts may be used if the wood shows no winter injury, is firm, well matured, and provided they do not originate below the graft. If the water sprouts used as scions come from the root below the graft, they usually produce seedlings which are generally worthless or very inferior as fruit trees.

The scions should be tied in bunches of from 25 to 50, stored in damp sand or green sawdust and placed in a cool cellar or cold storage. When scions are kept in a room which is too warm they may start growth and be unfit for use; while if kept too wet they may rot or be severely injured.

Where suitable cellar or cold storage is not available, scion wood may be kept in a satisfactory condition through the winter by burying it horizontally in a callus pit. For such a pit, a well drained place in the garden or field fully exposed to the sun is selected. The quantity of the scions to be stored will determine the depth of the pit. From 4 to 6

inches of sand or friable soil is generally a sufficient covering, but during severe winter weather a mulch of strawy manure or additional soil may be added to prevent severe freezing.

THE PROPAGATION OF THE APPLE

The Seed and its Treatment.—The natural method of propagating the apple is by means of apple seeds. The apple, however, like most of our cultivated fruits, does not come true from seeds; as many different varieties as there are seeds planted will generally be produced. For apples the type has not been fixed as it has in the case of many vegetable and grain crops. Moreover, experience has shown that most seedling apple varieties are inferior to standard sorts and not often is there introduced a new seedling variety of merit. As a rule, seedlings are grown only as stocks upon which to bud or graft superior or cultivated kinds.

About half of the seedling roots used in this country are imported from France. In the United States the Kaw River Valley just west of Kansas City is noted for its production of fine seedling apple roots used as stocks for named apple varieties. Seeds from our cultivated varieties like Jonathan, Ben Davis and Winesap may be used; but as a rule they lack virility and vigor and do not give as high a percentage of germination or produce as vigorous seedlings as the seeds from the French Crab or wild apple. The so-called French Crab apple seeds are, therefore, generally used in growing apple seedling roots to be used for grafting and budding purposes.

Apple seeds are generally procured by washing the pomace obtained at old-fashioned cider mills. The method may consist of placing the pomace in a barrel or other

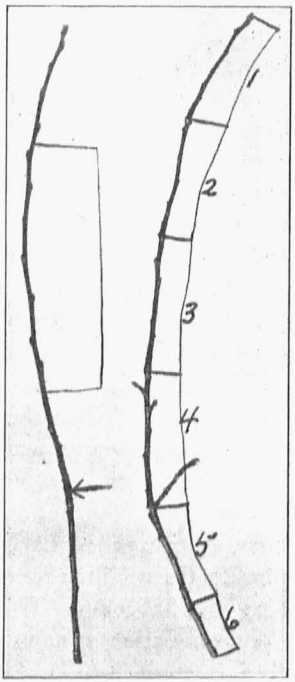

Fig. 4.—The apple twig at the left shows one and two-year-old wood. The apple branch at the right shows wood from one to six years old inclusive. See note below.

Note.—In reference to Fig. 4 it should be said that the portion of the twig from the tip downward to the first ring of scars consists of one-year-old wood. Below this ring is two-year-old wood, the buds of which are usually less likely to grow satisfactorily when used for grafting or budding purposes. The region indicated by the bracket shows the best scion wood. Immature tips should be discarded and the basal buds are generally unsuited for use. The brackets on the branch at the right indicate the age of the wood between the rings of scars which mark the termination of each year's growth. The one-year old wood of this branch (1) from the tip to the first ring of scars is undesirable for grafting purposes because it lacks vigor and is immature, while the wood below this and more than one year old would be less likely to grow.

container and adding water. In 4 or 5 days some fermentation may have taken place and by stirring the pomace vigorously the seeds may be separated from it. The pomace will rise to the top of the container, while the viable seeds will settle to the bottom. The pomace and water are then poured off and the seeds are collected.

The seeds are dried for a few days in the open air, after which they may be stratified in damp sand as follows: In a flat wooden box of convenient size is placed about 2 inches of damp sand, then a layer of seeds, and upon this, alternate layers of sand and seeds are placed until the box is filled or the work is complete. The stratified seeds should be kept moist and cool until time for planting in the early spring.

The box of seeds is sometimes buried in a well drained soil to a depth of 6 or 8 inches or placed in a cool cellar until spring. It may also be placed flat on the ground and covered with strawy manure to a depth of about a foot in order to prevent severe alternate freezing and thawing. Since the seeds begin growth early in the spring, the soil in which they are to be planted should be prepared in the fall or early winter by deep plowing. It is important that the soil be deep and rich; otherwise it will be impossible to produce straight, long roots of the kind convenient and suitable for grafting purposes.

The apple seeds are planted from 2 to 4 inches apart in rows about 4 feet apart and when the young seedlings spring up they should be given very thorough cultivations during the growing season by plowing and hoeing. In the fall after the leaves drop the little trees are dug, if large enough. When they are considered too small for use they may be allowed to grow another year before digging. For convenience in handling, the tops are shortened after digging and the trees are tied in bundles of from 25 to 50 or more. They are then packed in boxes of green sawdust, damp sand or other damp packing material and stored in a cool place. The seedling roots are used extensively for whip grafting in January and February. They are known as apple "stock" and are used in the propagation of named varieties of apples.

MAKING THE WHIP GRAFT

This method of grafting is frequently referred to as "whip and tongue grafting" or "root grafting", as the method employed usually has to do with grafting a scion upon a root. The whip and tongue graft is used in grafting the roots of seedling apple trees from one to two years old and ½ to ⅝ inches in diameter upon the scions (current season's growth, about the size of a lead pencil) of varieties of apples or pears to be propagated. The seedling roots and scions are usually removed from storage and grafted during January or February. A cellar or basement room

is generally used for this purpose, but a drier and warmer room may be used if the scions and roots are kept in their original packages and covered except when in use. Scions, roots or grafts should never be allowed to dry out. The roots may be from 14 to 18 inches long, and for grafting purposes they are frequently cut into pieces from 3 to 6 inches long, the average being about 4 inches. Each seedling root, therefore, may make from two to four grafts.

In making the graft, a sloping cut about 1½ inches long is made on one side of the upper end of the seedling root. The same kind of sloping cut is made on the lower end of the scion. The knife is then placed on the sloping cut at a distance of about ¼ or ⅓ inch from the end and a tongue is cut here on both scion and root. They are then pushed together, the tongues of each slipping into the slits made for them. To complete the graft, the scion and root are wrapped fairly tight with No. 18 or 20 knitting thread. Before tying the union or graft, however, it is important to see that the inner bark of both comes together at least on one side; otherwise, the graft is not likely to grow. Commercial nurserymen use machines for wrapping grafts. If the scion and stock are of different diameters, care must be taken to insure the proper interlapping of the edges, at least on one side. Poor unions invite crown gall or root knot and other troubles. The weak cotton string with which the stock and scion are wrapped will decay rapidly and cause no injury when the grafts are set in the soil. The finished graft, including the scion and root, should be about 8½ to 9 inches long.

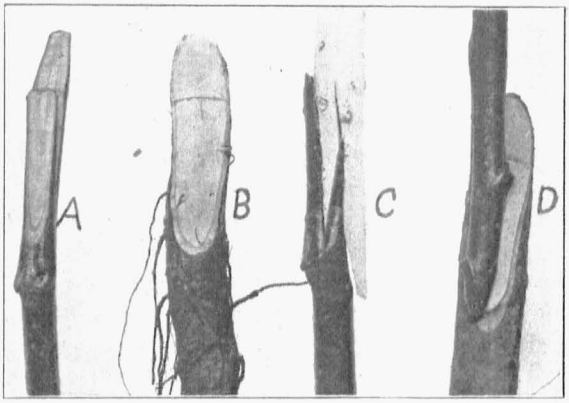

Fig. 5.—Making the Whip Graft. (A) Long, sloping cut and slit made in scion. (B) Stock prepared in a similar manner and ready to be united with scion. (C) Scion and stock pushed together with tongues interlocking—note the scion has been painted white merely for the purpose of the picture, to show the proper cambial contact. (D) Scion placed to one side to secure the proper cambial contact with the stock.

STORING, PLANTING AND CULTURE OF GRAFTS

The grafts should be packed in bundles of 50 to 100 each and stored in damp sand or green sawdust and placed in cold storage, a cool cellar or a callus pit until they are set in the nursery row in the spring. The soil

for planting should be plowed in the fall in order that the grafts may be planted as early as possible. Prepare the ground as for a garden. The grafts may be planted either in holes made by a "dibble" or along the smooth straight edge of a furrow made by a plow. In either case, it is important to leave only the top bud of the scion above ground and to pack the soil tightly and firmly around the base of the root or graft.

If the young trees receive frequent shallow cultivations throughout the spring and summer, they should grow to a height of 2½ to 3 feet or more when they are considered large enough for transplanting as "one-year-olds" any time during the late fall, early winter or the following spring. They may also be dug and stored in moist sand or green sawdust like scions or seedling apple roots. If the trees are not large enough in the fall for transplanting or if there is no ready sale, they may be left undisturbed in the nursery. The trees may be grown in the nursery row for another year and sold or transplanted as two-year-old trees, or they may be cut back in the spring to the original bud near the ground or just above the union of stock and scion. This usually causes a quick, vigorous growth of the tree and at the end of the growing season it is called a "cut-back" with a two-year-old root and a one-year-old top.

WHOLE ROOT AND PIECE ROOT JONATHAN APPLE TREES

In 1889 an investigation of whole-root and piece-root Jonathan apple trees was begun at the Missouri Agricultural Experiment Station and continued until 1920 under the direction of the late J. C. Whitten, formerly professor of Horticulture. The object was to obtain information regarding the growth, vigor, productiveness and relative value of apple trees propagated by the whip and tongue method of graftage from seedling apple whole roots and piece roots.

The character and quality of the fruit was also considered in the investigation. The so-called "French stock" or seedling apple roots were used for the grafting work. The scions used were secured from uniformly bearing Jonathan apple trees. The seedling apple roots, scions and grafts were handled and stored in the usual manner. Grafts were made by using whole roots, crown piece cuts, middle piece cuts and the lower or tail piece cuts. Thirteen grafts made by each method were set in the nursery early in the spring of 1899 and were given the same care and attention.

In the spring of 1900, after the grafts had made one season's growth, the trees were transplanted in the University Orchard at Columbia. The cultural treatments for all were the same.

Yield records were started in 1912 when the trees were 12 years old and continued until 1920 with the following trees: 11 whole root, 11

crown cut, 10 middle cut and 7 lower cut. The total yield was so small in 1913 that notes were not taken on the production of each tree.

TABLE 1.—AVERAGE ANNUAL YIELD OF JONATHAN APPLE TREES, PROPAGATED FROM WHOLE ROOT, CROWN CUT, MIDDLE CUT AND LOWER CUT SEEDLING APPLE ROOTS. (Age of Trees 12 to 20 Years.)

Year	Whole Root 11 trees	Crown Cut 11 trees	Middle Cut 10 trees	Lower Cut 7 trees
1912	5.00 bu.	5.68 bu.	5.21 bu.	5.80 bu.
1914	6.18	7.50	6.48	5.57
1915	8.64	9.47	10.62	10.85
1916	1.66	1.90	2.00	1.40
1917	7.57	6.31	7.57	9.57
1918	5.93	6.79	6.82	5.14
1919	3.79	4.22	5.35	7.46
Av'ge	5.53	5.98	6.29	6.54

Fig. 6.—Whole-root and piece-root apple grafts made by a commercial nurseryman. The three grafts at the left represent the so-called whole-root graft, while the three grafts at the right are typical for the piece-root graft.

These data show that there was no material difference between the average growth and yield of Jonathan apple trees propagated from whole roots and piece roots. It rather emphasizes the fact that the grower should give more attention to the matter of securing healthy, vigorous, growthy trees with good root development than to the question of whether the trees were propagated from whole roots or piece roots. No appreciable difference was observed in the character or quality of the fruit from the whole-root and piece-root trees.

In the propagation of the so-called whole-root trees, an entire or whole seedling apple root is rarely used. After grafting the whole root to the apple scion it is usually too long for transplanting in the average nursery soil, so a portion of the lower part is removed. Because the whole root grafts are usually too long, the smaller and more branched roots are generally selected for whole-root grafting, while the larger, longer and straighter roots are used for piece-root grafting. With good

TABLE 2.—AVERAGE GROWTH MEASUREMENTS OF JONATHAN APPLE TREES 13 YEARS OLD PROPAGATED FROM WHOLE ROOT, CROWN CUT, MIDDLE CUT AND LOWER CUT SEEDLING APPLE ROOTS.
(Measurements Taken in Inches, August, 1913)

Whole Root	Total Circumference of limbs more than 3 inches in diameter	Total Length, 3 longest limbs of each tree	Total Circumference of trunk of each tree 6 inches from ground
Whole Root	301.4 in.	617.90 in. Avg. 205.97 in.	32.93 in.
Crown Cut	303.5 in.	616.50 in. Avg. 205.50 in.	32.61 in.
Middle Cut	292.5 in.	634.2 in. Avg. 211.4 in.	32.95 in.
Lower Cut	291.8 in.	617.7 in. Avg. 205.9 in.	31.67 in.

seedling apple roots the propagator may be able to make as many as 3 or 4 piece-root grafts from one whole root.

It is common knowledge, however, among nurserymen and fruit growers that whole-root grafts or trees may make a slightly better growth in the nursery row and during the first year or two after transplanting in the orchard. This is due no doubt to the fact that the whole-root tree or graft may have a larger root system and be able to suceed better as regards the obtaining of plant foods when transplanted. After the first few years no material difference in growth has been observed. Large, growthy trees propagated from either whole roots or piece roots should be satisfactory.

CLEFT OR TOP GRAFTAGE

Principle and Method.—The principal factors deserving consideration in cleft grafting trees are: (1) vigor, (2) type of framework, (3) age, (4) blight and disease resistance and (5) variety. Cleft or top graftage is a method often used in general practice on apples, pears and quinces. The method may also be used successfully on stone fruits, especially the cherry and plum. The entire top of trees up to about ten years of age may be sawed off and the scaffold or main branches cleft-grafted at one operation. With trees older than this, however, it is usually advisable to cleft graft no more than one-third or one-half of the top in one season. For old trees the grafts are usually unable to produce sufficient foliage in one year to carry on the plant processes. The branches which are left but which are to be grafted at another season are known as nurse branches. It is a well-known fact that old apple trees will survive the grafting operation better if the limbs used are not larger than 2 to 4 inches in diameter. In from 5 to 7 years after the top grafting operation, fruit trees should develop about as much fruiting wood as ungrafted trees and may bear an average crop.

Cleft grafting work is generally most successfully accomplished just

before or just after growth starts in the spring. If there is a great deal of work to do, the grower may start 4 or 5 weeks before the buds swell. The scions should be cut from well matured, dormant wood of the current season's growth during the fall or winter and stored in a cool place in damp sand or sawdust. In cleft grafting the cherry and plum, it is particularly important that the scions be kept absolutely dormant.

Preparing the Stock.—In cleft grafting, the operation consists in sawing off the limb, leaving a stump to be grafted. The stump is split with a heavy knife and maul. The cleft or split should be made about 2 or 3 inches deep. The knife is then removed and placed in the center of the cleft in order to spread it for receiving the scions. If the stock is large, two wedge-shaped scions may be used, one in each side of the split. It is always well to use two or more scions, depending on the size

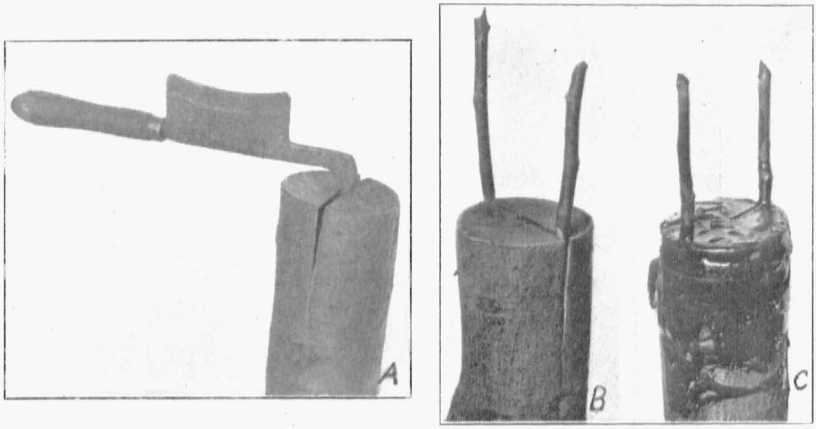

Fig. 7.—(A) An apple branch sawed off, and cleft prepared for scions. (B) Scions inserted in cleft, and stock ready for tying, when all cut surfaces should be waxed. (C) The cleft grafting operation completed. Note the stock is wrapped with cord near the edge to keep the scions in place and all cut surfaces are thoroughly covered with grafting wax.

of the stock, as scions are frequently broken out by the wind and other factors. If the stump is large and there is danger of the pressure crushing the scions, a wedge may be driven down into the middle of the split to hold the parts of the trunk open and lessen the pressure upon the scions. The top of the wedge is then cut off level with the stump. Where the stock or trunk is very large, it may be split both ways and four scions placed in it. In other cases the split is made to one side of the center so as to avoid splitting the heart wood.

Preparing and Inserting the Scions.—The scions should be so placed that the inner bark of one side makes an exact union with the cambium or inner bark of the stock. This is very important, as it is at this point only that any growth occurs. The scions, containing from 3 to 5 buds

each, about 4 or 5 inches long and about the size of a lead pencil, are prepared by making long, sloping cuts from 1½ to 2 inches in length on both sides of the lower ends. The wedge-shaped scions are then ready for insertion in the split or cavity made in the stock. Where the scion and stock are approximately the same size, the whip and tongue graft may be used more successfully than the cleft graft, in which case tying and

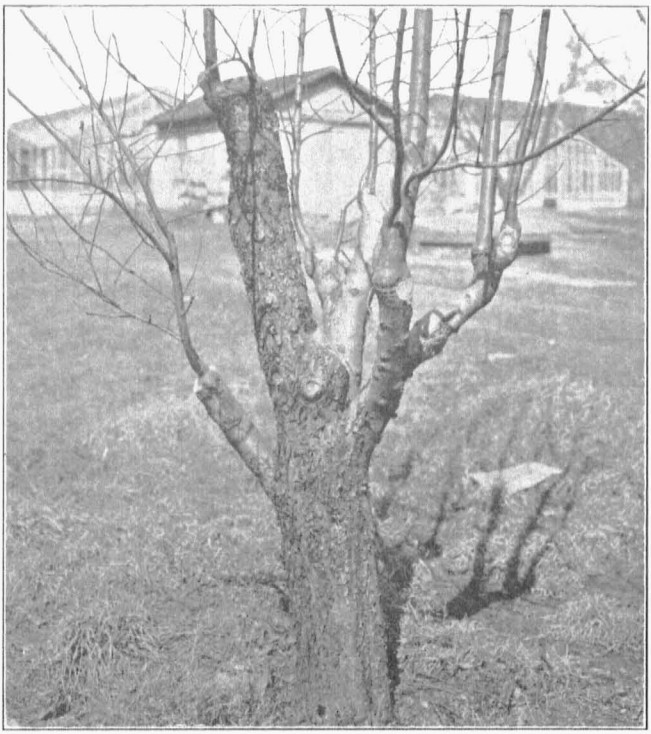

Fig. 8.—Growth of 3 and 4-year old scions on a cleft grafted apple tree. The main stem or trunk was about 8 inches in diameter, too large as a rule for satisfactory cleft grafting. Before the scions grow large enough to cover such a wound, disease is likely to enter, causing the death of the tree. Had the operation been performed on smaller limbs higher up in the tree, the work would probably have been more successful.

waxing will usually give best results. If No. 18 or 20 knitting thread is used, it will not be necessary to cut the string from the whip graft as the thread is easily broken.

Waxing and Subsequent Treatment.—After the scions are in place, all wounded surfaces should be thoroughly and completely covered with grafting wax. If the wax is hot, 2 or 3 coats will be required. The cleft must be closely sealed to keep out air and disease and to prevent the wounds from "bleeding". The wax should never be disturbed and new

applications, if needed, should be made one or more times each growing season until the scions are well established and the wounds are healed. Before waxing, it is usually advisable to wrap waxed tape or a heavy cord around the top of the stock near the cut surface, thus tying in the scions to prevent the stock from gapping open and destroying the contact of the growing parts. After 5 or 6 weeks, when growth should be well started, the tape or cord may be removed; otherwise, if it be very strong, it is likely to girdle the stock.

Fig. 9.—Trunk of an 8-year-old top-grafted apple tree, showing stock which has outgrown the scion.

A paper bag is also often placed over the cleft graft and waxed surfaces and tied around the stock to lessen the evaporation of moisture from the scions and stock. In about a week or ten days, growth should start and the sacks should be removed. At the end of the first or second season if all of the scions are growing, the number should be reduced to one, because two or more growing from the same point may develop a bad crotch. Where more scions are needed, however, to heal over a large wound, they should be left for a longer period. If the scions are pruned rather severely each year, their growth will be greatly checked and they may be left longer without any ill effects to assist in healing over wounds.

THE BARK GRAFT METHOD

It is essential in this method of grafting that the bark separate readily from the wood. Consequently, for best results it is usually advisable to do the work in the spring just as the buds are starting growth.

The limbs to be grafted are sawed off in the usual manner, leaving short stubs. There are several slightly different methods used in preparing the scions. Just as satisfactory a method as any, however, is to prepare the scions wedge shaped, as described under cleft grafting. Many, however, cut the scion with a straight splice or with a shoulder and splice.

If the bark of the stock is in the proper condition (slipping easily) the scions may be inserted without difficulty between the bark and the wood. It is usually necessary to insert 2 or more scions between the bark and wood to induce rapid healing of the stub. If the stock is large, the scions may be placed at intervals of 3 or 4 inches around the stub, to facilitate the healing of the wound. If the bark of the stock does not slip readily, a slit about ½ inch long, made at the edge of the stub will make the insertion of the scion easier. The scions should be tied firmly to the stub by means of waxed tape or stout cord to hold them in place. Small tacks are also sometimes driven through the scions into the stock to help hold the scions firmly to the stub. All exposed or cut surfaces should be covered with grafting wax. The tape or cord should be removed after a few weeks or as soon as the scions are well established, in order to prevent girdling.

THE NOTCH METHOD OF GRAFTAGE

The "notch method" of making the cleft graft first came into prominence in the Northwest. A coarse-toothed saw is used and the desired notch is sawed out instead of split. The scions cannot be made wedge shaped, but must be whittled to fit the notch. If one side of the scion is made thinner than the other one, then the scion can be forced in tightly until the inner edges meet closely. The wedge is usually made sidewise, with the splint toward the center of the tree. Tie and wax the wounds as with other methods of graftage. The advantage claimed for this method is that it does not injure the stock badly by splitting it, and as a result it heals more quickly.

THE SIDE CLEFT GRAFT METHOD

The "side graft" is very good for top-working small trees or grafting small branches. The scion is prepared as in the cleft graft except that the wedge is very short. The limb or stock receives a diagonal cut almost to the pith. This cut is then opened by bending the limb and the wedge shaped scion is inserted, using care to make the right contact between the two cambium layers. When the scion is in place the end of the limb

is released and its spring action holds the scion in place. No tying is necessary. The original branch is then removed just above the insertion and the whole union and wound are covered with grafting wax.

DANGER OF CLEFT GRAFTING

Hardy, vigorous varieties of apples may be more successfully cleft grafted than weaker growing sorts. Varieties susceptible to blister canker are likely to be seriously injured unless they are growing vigorously and the cut surfaces are small, carefully sterilized and kept covered with grafting wax or a good tree wound paint. If more than two or three years are required for the healing over of cut surfaces there is great dan-

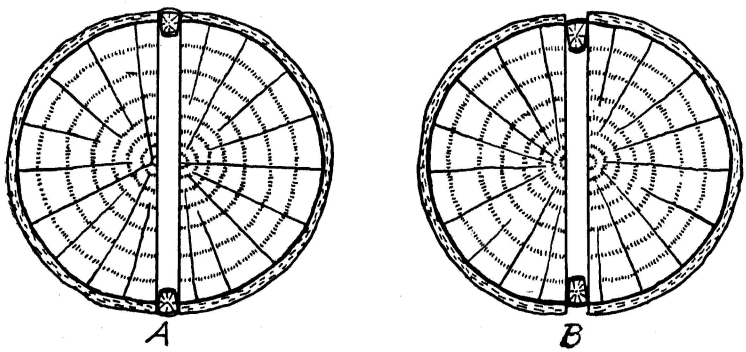

Fig. 10.—The wrong and right way to place scions in the split when cleft grafting. The scions may fail when not properly placed. If the bark of the stock is thicker than that of the scion it is very important that the scion be set in far enough to allow the inner bark or cambium layers of each to match or come together. (A) Scions improperly placed, as the inner bark or growing layers are not in contact, although the surfaces are flush. (B) Scions properly placed, having been pushed in far enough to give the right contact between stock and scion. To give the best contact the scion should be slightly thicker on the outside than the inside.

ger of disease entering the grafted branches and destroying them. For this reason, it is usually advisable to confine the cleft grafting operation to limbs or branches of not more than 2½ to 3 inches in diameter. It is always dangerous to cleft graft apple trees 18 to 20 or more years old. If old trees are grafted, the cuts for the grafts should be made higher in the tree tops, in order to make use of limbs of not more than the diameter mentioned above.

BRIDGE OR REPAIR GRAFTAGE

Bridge graftage is made use of in repairing injured tree growth and is of no value in propagation. Many trees are injured by rabbits, field mice, or other animals, by the careless use of implements in the orchard and by diseases. In the treatment of such injury the bridge graft is often very valuable. Its use is not nearly as widespread as it should be.

Unless about one-fourth or one-third of the bark of bearing tree

trunks has been removed down to the wood or cambium layer, bridge grafting is not usually necessary. Where rabbits have gnawed the bark of the tree trunks practically all the way 'round but have not peeled it to the wood except in spots here and there, bridge grafting as a rule is not needed. An application of house or barn paint (white lead and raw linseed oil) applied to the wounds only, will generally prevent drying and assist materially in healing the wounds. Trees which appear to be badly damaged by girdling will frequently heal their wounds quickly if paint or grafting wax is used properly in covering the wounds.

If the injury occurs in winter the wounds should be protected by a coat of paint to prevent drying. The grafting should be done in the spring as soon as the bark will peel freely. During the growing season, the operation should be performed as soon as the wound is found.

Trees from 1 to 2 years old, inclusive, which have been completely girdled or the bark removed down to the wood all the way round are usually handled most successfully by cutting them off a few inches above the graft and allowing one sprout to grow from above the graft. The best time to cut the trees back is just as growth is starting in the spring. With trees from 3 to 5 years of age, it is usually advisable to saw them off near the ground and cleft graft the stub to the desired variety; while for trees 5 or more years old, bridge grafting is generally the best method to employ.

The operations of bridge grafting are as follows:

1. Cleanse and cut away all irregular tissue to form a straight wound on both the top and bottom of the girdle or injury. The girdled area may be painted with either white lead and raw linseed oil or grafting wax.

2. Cut a slit just beneath the bark and slightly into the wood at opposite points at the edge of both the top and bottom of the girdle. This may be accomplished by pushing a grafting knife upward beneath the bark and then downward beneath the bark.

3. Select strong, vigorous scions of the current season's growth. They should be a little longer than the girdle is wide. Both ends of the scions are whittled to a wedge shape, making the wedge about 1½ inches long.

4. Insert the base of the scion into the lower slit.

5. With one hand holding the base of the scion in position, bend the scion until the upper end may be inserted at the upper slit. When both wedge-shaped ends of the scion have been inserted, the scion itself should be slightly arched. The spring in the arched scion will assist in holding it firmly in place.

6. Small brads or tacks may be used to fasten the ends of the scion in place.

Fig. 11.—An apple tree girdled by rabbits. Enough of the cambium or growing layer near the wood was left to make bridge grafting unnecessary. The wounds were painted with white lead and raw linseed oil and they were practically healed over during the following season with no apparent injury.

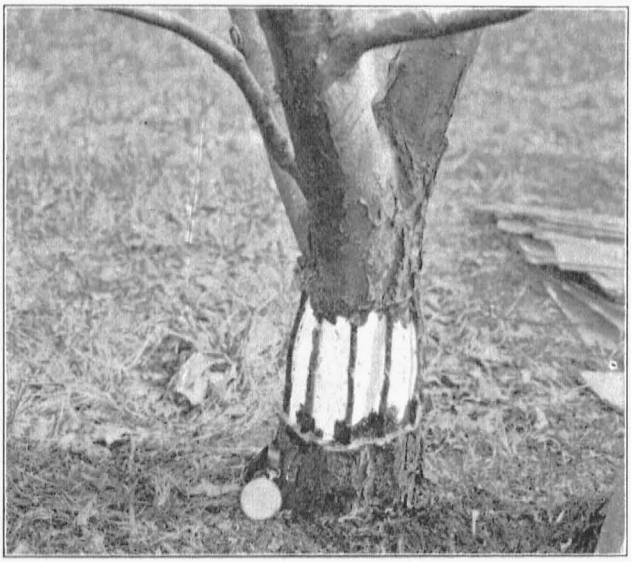

Fig. 12.—A girdled apple tree about 14 inches in diameter with the scions in place bridging the girdled area. Note that the rough, irregular edges of the bark bordering the wound have been trimmed back evenly, and the girdled area has been painted with white lead and raw linseed oil. The wounds made in inserting the scions are covered with grafting wax, which may be used to cover all wounded parts.

7. Insert more scions at intervals of 1½ to 2 inches until the injury is covered or the tree has been surrounded, if completely girdled.

Carefully wax the wounded tissue where the scions were inserted. Wax or paint may be used as a covering for the girdle. Rewax or paint as often as necessary to keep the cut surfaces and wounds covered.

Any kind of a fruit tree that may be propagated by grafting can usually be successfully bridge grafted. Apples and pears, however, are more often bridge grafted than other kinds of fruits. Peaches graft less readily than the fruits mentioned, but the plum and cherry should lend themselves fairly well to this method of graftage.

Fig. 13.—An apple tree bridge grafted about 8 years ago. Most of the scions covering the girdled area have grown together and the wounds will soon be completely covered with new wood.

MAKING AND APPLYING GRAFTING WAX

Many formulae have been evolved for the making of grafting wax, most of which are good and effective. The formula which has been used for years by the Missouri College of Agriculture is as follows:

Common resin	4 pounds
Beeswax	2 pounds
Beef tallow	1 pound

A harder wax may be made by using 5 pounds of resin, 2½ pounds of beeswax and 1 pound of tallow, while a softer wax may be prepared by increasing the amount of tallow in the standard formula from 1 pound to 1½ or 2 pounds. Melt all of the ingredients in a vessel over a slow fire, stirring thoroughly. Lump resin should be pulverized before using. When the resin, beeswax and tallow are dissolved and thoroughly mixed, remove from the fire. After the mixture has cooled somewhat and is of the right consistency for use with a brush, it is ready to apply. The wax may be stored for future use in the container in which the ingredients were melted.

Grafting wax is also frequently prepared and stored as follows: Heat over a slow fire and mix thoroughly the ingredients mentioned above. After the mixture has cooled slightly, pour it into a vessel of cold water. Grease the hands with tallow to prevent the wax sticking to them, and as soon as the wax is cool enough to handle remove it from the water and pull and work it as in preparing molasses candy. The working should be continued until the wax becomes smooth and changes to a lighter color, after which it is usually too stiff to pull readily. The wax may then be rolled into balls of suitable size and stored until desired for use. It will keep indefinitely. To use the wax after it has cooled, remelt by means of heat. Paraffin may be substituted in the same amount and used successfully instead of beeswax in the formula given above.

Charcoal wax is popular among some growers. The formula and method of preparing are as follows:

Resin	5 pounds
Beeswax	1 pound
Powdered wood charcoal	½ pound
Raw linseed oil	1 gill

Melt the beeswax and resin, add the charcoal and stir vigorously to prevent the formation of lumps. Then add the linseed oil and stir again, after which the wax is ready for use.

The application of grafting wax should leave the wounds air and water tight. Its uses may be enumerated as follows:

1. To keep out all diseases, rots, cankers, etc. and insects such as the borers which infest wounds.
2. To keep the cut surfaces moist and fresh, for if they are allowed to dry out the graft or bud cannot grow.
3. To prevent an excessive flow of sap from the wounds.

The best and most efficient method of applying grafting wax is with a brush. The wax should not be hot enough to injure the wood, but must be warm enough to run freely into crevices and cracks. A good melting pot consisting of a small cup or basin inserted in the top of a kerosene

burning lantern may be purchased from orchard supply houses. An improvised equipment may be used, however, by building a small fire in an old tin pail and suspending a small basin over the top.

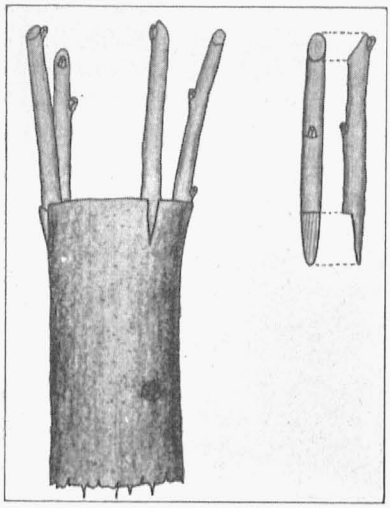

Fig. 14.—The bark graft, showing the method of cutting the scions and inserting them in the stock.

Paraffin may be used instead of the grafting wax made from resin, beeswax and tallow. The following advantages are claimed for it: It requires no preparation for use other than melting, hardens quickly, is cheap and easily obtained and may be used to cover the entire scion as well as all cut or exposed surfaces. During the spring and early summer, the ordinary form known as "para-wax" used for sealing jars of jelly and jam is satisfactory. In the hottest weather, paraffin of at least 60° C. melting point is required.

WAXED TAPE AND STRING

Waxed tape may be prepared by tearing cotton cloth into strips about ½ inch wide, making the strips into rolls and then soaking in hot grafting wax. When the cloth is thoroughly saturated with the wax, remove the rolls and store for future use.

Waxed string is prepared by soaking in hot grafting wax the balls of twine to be used. When the twine is completely saturated with the wax the balls should be removed. After cooling, the string is ready for use or storage.

PROPAGATION OF PEARS

Seedage.—Pear stock is grown chiefly in Europe. Nurserymen like the French stock because the growers transplant soon after the trees start growth, which generally produces a more branched root system. French pear seeds are saved in much the same manner as apple seeds. There are regions in France where pear cider is made extensively and the seeds are saved for propagation purposes. Where it is necessary to remove the seed by hand it is more expensive.

Some Kieffer pear seedlings are raised in the United States and most of the seed comes from the canneries of Maryland and New Jersey. Japanese stock, which is growing in popularity, usually comes direct from Japan, although some of it comes through French and Dutch im-

porters. Pear seeds are treated like apple seeds for planting and the same planting suggestions apply to both.

Graftage.—The pear is generally propagated by whip grafting on whole roots. It differs from the apple in that it should be grafted on whole roots instead of piece roots and the union should be made at the crown. The scions are made about 4 to 6 inches in length. For best results the wounds should be completely covered and sealed with hot grafting wax. To prevent injury, as soon as the wax is spread, the graft is dropped into a tub of cold water to cool it quickly. The pear grafts are stored and planted in the same manner as are apples but, because of their greater length, they are somewhat more difficult to handle. If for any reason the waxed strings do not decay within a reasonable time after transplanting, they should be cut to prevent girdling. The pear may also be budded, top grafted or bridge grafted in the same manner as the apple.

Dwarfing Pear Trees.—Pear trees grown on pear roots are called normal or standard; pear trees grown on quince roots are dwarfed. As with apples, the only use for dwarf pear trees is for novelties or as ornamentals on the lawn. Duchess, Louis Bonne, Anjou, Bartlett, Seckel and Kieffer are varieties adapted to dwarfing.

PROPAGATION OF QUINCES

Quince stock may be propagated from seed, but the resulting stock is inferior; and the method is seldom used except to furnish seedling stock for budding. They are generally propagated in one of the following four ways: by cuttings of the ripened one-year-old wood or from pieces of roots treated like cuttings; mound layers; root grafting; or budding.

(1) Hardwood cuttings are used by nurserymen who have light, warm soils. These are made like currant cuttings and treated like grape cuttings. The cuttings are stored, handled and planted like apple grafts. In planting, only one or two of the top buds should be left exposed above the soil.

(2) In mound layering, the old plant is induced to throw out a growth of roots from the crown. This may be accomplished by cutting back the old plants to encourage new growth, the crowns being scarred with a knife or hoe and a mound of earth thrown up around them. After the growing season the mound is dug away and the sprouts are cut off and replanted in a nursery row for a season's growth, after which they are ready for transplanting in the orchard.

(3) Root grafting is employed as with apples. To assist the cuttings in becoming established, pieces of apple roots may be spliced onto the scions, but these are often removed when the nursery tree is transplanted into the orchard.

(4) When budding is employed, the seedlings are grown in the manner described for apples. The time and method are also similar.

DOUBLE-WORKING OR DOUBLE GRAFTAGE

The process of double-working fruit trees has caused a great deal of discussion and comment in late years. It is a method for reworking trees to avoid many of the troubles affecting the trunks and crowns of apple trees, as collar rot, fire blight and winter injury. Some varieties such as Grimes, are notoriously susceptible to crown troubles. The method may be used to produce straight trees instead of straggling ones or to give vigor to poor or weak growers. Pear and apple trees are most often double-worked.

Trees of a known resistant variety with a good root system such as Minkler, Arkansas, Northern Spy and others are propagated in the usual manner. They are generally allowed to grow for 1 or 2 years. Before growth starts the next season the trees are cut off about twenty inches above ground and cleft grafted or whip grafted to Grimes or the desired variety which is being propagated. With this operation completed, the trees have been worked twice, hence the term "double-worked."

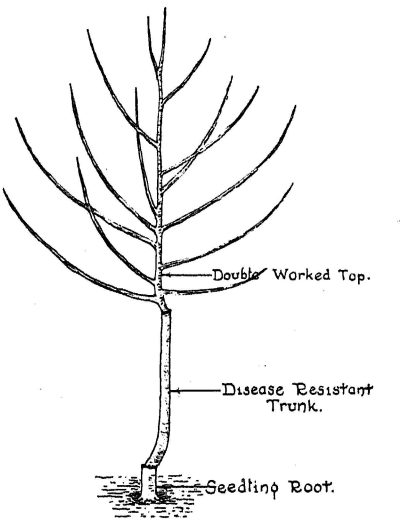

Fig. 15.—Double-working or double-graftage illustrated.

In some localities the work is done by budding during August or early September. The bud is inserted in the hardy variety at a height of about 20 inches in whips of wood of the current season's growth. If the buds fail to grow, the trees may be whip grafted the following spring. If scions on trees which have been grafted fail to grow, the trunk of the tree can be cut off near the ground in the spring and a whip or sprout allowed to grow. This whip can be budded in the late summer of that same season. By using this combination of the two methods of propagation, there will be no loss of time in case of bad luck with either method.

Another method consists of allowing the hardy tree serving as the stock to grow from 3 to 5 years and form its main scaffold branches. These main branches may be sawed off early in the spring, leaving stubs about 16 or 20 inches in length, which are cleft grafted to the desired variety. By this method the trunk and the crotches of the scaffold

branches are made up of the hardier sort. A stronger tree and one which is less likely to disease in its main stem and framework is thus produced.

PROPAGATION OF PEACHES, CHERRIES AND PLUMS

Budding is practically the only method employed in the propagation of stone fruits such as peaches, cherries, plums, etc. Apples, pears, quinces, walnuts, pecans, hickories, citrus fruits and others are also propagated extensively by budding. Budding work is usually done during the late summer upon seedling stock grown for the purpose. If the seedlings are not large enough to bud at that time, they should be cut back

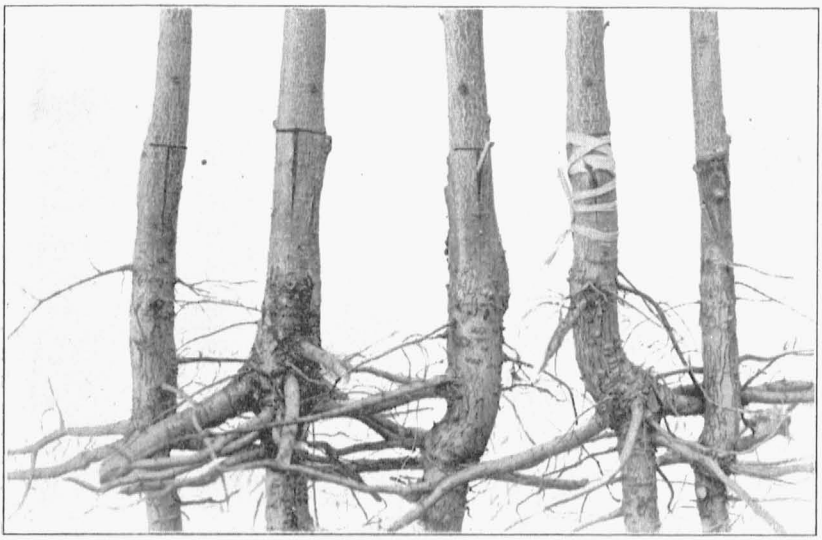

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Fig. 16.—One year-old seedling peach trees, showing stages in the process of budding. Reading from left to right (1) shows the T-shaped cut, (2) shows the bark slightly raised for the insertion of the bud, (3) shows the bud inserted with the leaf stem or petiole of the bud still attached, (4) shows the bud properly wrapped with raffia (string may be used instead), (5) shows the bud after growth has healed all the wounds. In the spring after growth starts the seedling trees should be cut off just above the inserted bud.

to the ground early the next spring and allowed to grow new wood for budding the following August or September. The branches of old trees may also be cut off in the spring and buds inserted into the new growth which springs up. Buds will generally succeed better if inserted in wood of the same season's growth. Peaches are frequently budded upon seedling plum stock, as the plum will thrive in a heavier soil than the peach. The plum may also be budded upon the peach. The seed for growing peach stock comes almost exclusively from the native seedling peaches of the southeastern part of the United States.

Seed Stratification.—Peach seeds and other hard-coated seeds are

often stratified in the fall or early winter and allowed to freeze and thaw to break the hard seed coats. When seeds are stratified on a small scale, shallow boxes with holes in the bottoms to give drainage may be used. Sand and seeds are placed in alternate layers in the box until it is filled or the work is finished. The box is then placed flat upon the ground in the garden or other enclosure on a well-drained place where the seeds may be subjected to the alternate freezing and thawing of winter. It is usually advisable to screen the box to prevent damage by rodents and to mulch moderately with straw to prevent injury by too severe freezing. By spring the seeds should have cracked open ready to plant.

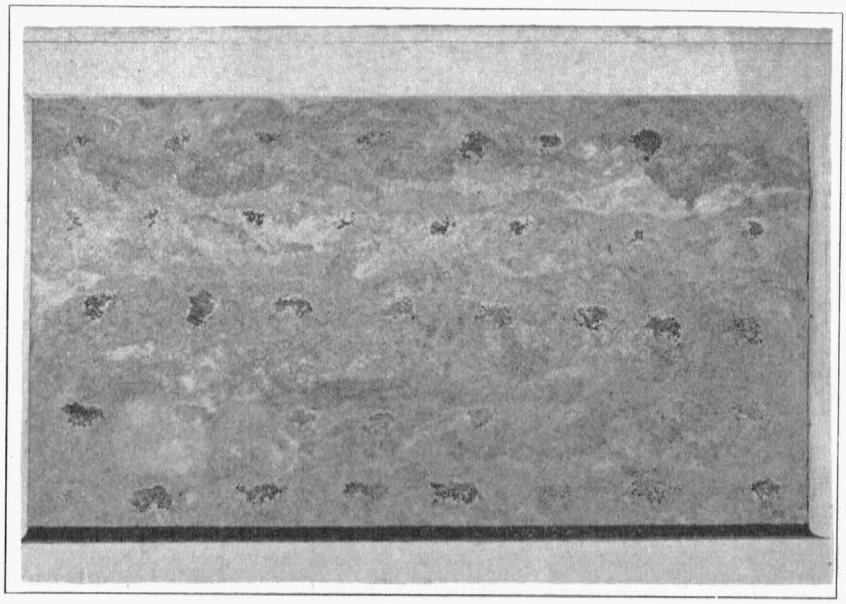

Fig. 17.—Seed Stratification. Black walnuts stratified in a box of sand. Note the layers of sand and nuts. Soon after collection the box of stratified seeds or nuts should be placed on the ground in a well drained place and allowed to freeze. The hard shells of seeds are cracked when subjected to freezing weather. This makes germination and growth possible in the spring.

Some nurserymen plant peach seeds in the open ground in the fall. Where this is done care should be taken to have the soil soft in the spring so that the tender shoots can come up. A large percentage of peach seeds planted in this manner may not grow until the second season. The seeds should be planted about 4 or 5 inches apart in the row 1½ to 2 inches deep and at a distance of about 3½ to 4 feet between the rows.

Method and Time of Budding.—Since the method of budding apples, peaches and other fruits is practically the same, one description of shield budding, which is the method generally used, will apply to all. Budding is usually done any time from the latter part of July until about the mid-

dle of September. However, the time usually best suited for the work is during August. The work is sometimes done in June, in which case it is called "June budding". The method is the same whether June budding, summer budding or fall budding. The bark must be loose and easy to peel, for the operation to be performed rapidly and successfully.

Shield Budding.—A bud stick consisting of a twig of the current season's growth having several buds is selected from the variety that is to be propagated. The leaves are removed, leaving a portion of the petiole to serve as a handle in inserting the bud. A T-shaped cut is made as near the ground as possible on the north side of the seedling stock to shield the bud from the sun. A shield-shaped piece of bark is then cut away from the budding stick, including a bud in its center. The bud is inserted in the T-cut by carefully raising the bark from the wood slightly and pushing the bud downward until it fits squarely and smoothly against the wood beneath the incision of the bark. After the bud is inserted it is tied in place with raffia or cotton twine. In about a week or ten days when the bud has grown tight, the string or raffia is cut on the opposite side from the bud, to prevent girdling. The inserted bud remains dormant until spring, when it should start growth. The top of the seedling is then removed just above the bud and the sprouts which may arise below the bud are carefully removed several times during the growing season to stimulate and force the inserted bud into active growth. After one or two years the budded tree should be ready for transplanting.

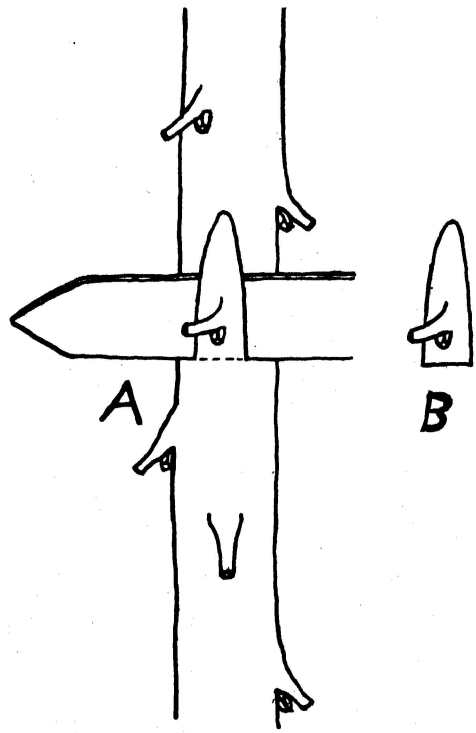

Fig. 18.—Removing the shield-shaped bud for insertion in the stock. (A) The budding "stick" turned up-side-down. The knife is then placed above the bud and pushed under it, cutting slightly into the wood, after which the knife is removed and a cut is made just through the bark below the bud at the point indicated by the dotted line. Using the leaf stem or petiole as a handle, the bud is peeled from the wood and should be immediately inserted in the T-shaped cut of the stock. (B) The shield-shaped piece of bark containing the bud.

June Budding.—The shield budding method is used. If the seedlings are large enough, the budding work may be done in late May or June. When this is true, the process is known as "June budding." The buds will be set after a very few days if they are going to grow. The tops should then be promptly removed just above the inserted bud. By the end of the growing season the top growth from the inserted bud may produce a tree large enough for transplanting in the fall or the following spring and the trees are known as "June buds."

Kinds of Budding.—The principal kinds of budding may be named according to the various methods of doing the work. In addition to shield-budding, described above, there are twig or spur budding; flute, patch, or veneer budding; plate budding; ring or annular budding and other methods. Shield budding is a great deal more important and much more common than the other kinds of budding. In fact, the other methods are not used except in cases where shield budding does not give satisfaction.

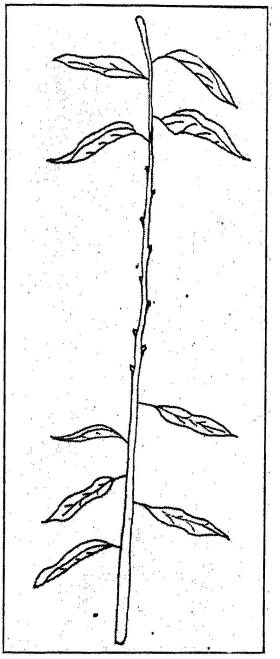

Fig. 19.—A peach "budding stick" or twig. That portion of the twig from which the leaves have been removed represents the best buds for budding work.

Flute, patch or veneer budding consists in the removal of a rectangular piece of bark from the stock and the immediate replacement of a similar shaped piece of bark of the same size from the scion, bearing a bud of the variety to be propagated. Special equipment or devices are available to facilitate the cutting of uniform pieces of bark, although the work may be successfully done with a good sharp knife.

Ring or annular budding is similar to flute budding. Instead of removing a piece of bark as in flute budding, a ring of bark is removed all the way around the tree or branch. This is then replaced immediately with a similar ring of bark bearing a bud which has been removed from the scion.

Spur budding, patch and ring budding are made use of in budding thick-barked trees like hickories, pecans, walnuts, etc. Spur or twig budding on such trees generally gives more satisfactory results than shield budding. Spur budding differs from shield budding only in that a spur or short twig containing one or more buds is left on the shield-shaped piece of bark instead of one bud.

In plate budding, two longitudinal cuts parallel to each other and

of equal length are made in the stock. The upper ends of the cuts are joined by making a cut in the opposite direction. The bark is then lifted, forming a rectangular flap 1 to 1½ inches long which is still attached below to the stock. A bud on a piece of bark from the scion is cut to fit the space, inserted at once, covered with the flap and tied. The flap is often cut so that a part of it may be fitted on each side of the bud.

Tying Buds.—In order to prevent the bud from drying out, it is very important in all kinds of budding that the two growing layers be held firmly together. Various materials have been used for tying buds, but string is the most common. Raffia, a kind of grass, is also used ex-

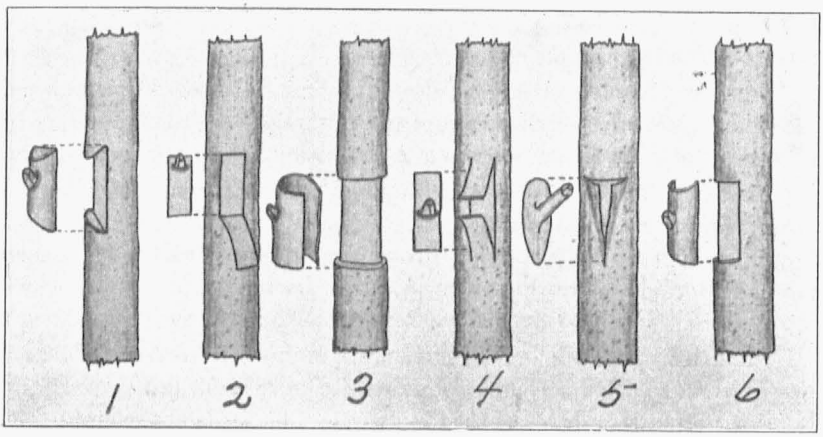

Fig. 20.—Uncommon Methods of Budding. (1) chip; (2) plate; (3) ring or annular; (4) H-budding; (5) prong; (6) flute.

tensively. When raffia is used it is soaked for a few hours and tied while wet. Three or four wraps are generally made above and below the bud. The main object is to keep the string tight in order that all portions of the bark be held firmly in place.

In 3 or 4 weeks, the bud should grow and the union ought to be sufficiently complete to allow the removal of the wrapping material. When the ties begin to bind severely, they should be removed at once; otherwise the bud may be killed by girdling. It is important, therefore that the buds be given careful and timely attention.

LIMITS OF GRAFTAGE

Propagators have generally limited graftage to plants which have a growing layer (cambium) beneath the bark layer, because successful graftage depends upon the rapid growth and union of the growing layers beneath the bark of both stock and scion.

Fruits botanically related like the apple, pear and quince can usually be intergrafted or budded successfully. Between varieties of the same species as apple upon apple the process is still easier. The peach is frequently budded upon the plum and likewise the plum upon the peach. In most cases the stone fruits may be interbudded and grafted without difficulty, although in some instances it is not practical, as the growth is uncertain, slow, and the union between stock and scion is poor.

Trees on Their Own Roots.—Trees are said to be on their own roots when they are produced from seeds, cuttings or otherwise than from grafting or budding. In other words, such trees have roots of the same wood as their trunks. When grafted or budded trees develop roots from the scion while the stock or original root ceases to function, the trees are said to be upon their own roots.

Standard Trees.—Trees which make their full growth and normal development for the species are said to be standard trees. They may be upon their own roots or the roots of a stock which does not dwarf them.

Dwarfed Trees.—Trees are usually dwarfed when grown in the open by grafting or budding them upon slow growing stocks. For example, the pear is dwarfed when grown upon quince stock. Trees may also be dwarfed by growing them in boxes, barrels, tubs or pots which are too small for the normal development of the root system.

French Crab Stock.—This is the kind of stock most generally used in this country. Nurserymen sometimes import seed and grow stock, but more often they buy the seedling trees. The seeds are secured from cider apples grown on seedling trees in France. Normandy, in France, is the main apple growing region.

HANDLING, PLANTING AND EARLY CARE OF FRUIT TREES

Every year a large number of nursery fruit trees either fail to grow or make a very unsatisfactory growth on account of careless handling or delay in setting. The trees may have been grown well in the nursery and represent the best stock. The digging, storing, packing and shipping methods may have been the best. If the trees are poorly handled upon arrival and are not transplanted properly they may be a disappointment, in which case the nurseryman is often blamed when really the fault is with the purchaser and planter. To obtain the best results with nursery trees the following practices should be observed:

(1) As soon as the trees are received, examine the roots to see if they are moist. When they are not, moisten them at once and keep them so until transplanted. The roots should never be allowed to dry out or be exposed to the drying action of the wind and sun for even a few minutes. When planting, the roots of the trees may be kept in a barrel part-

ly filled with water or they may be covered with damp packing material or wrapped in damp gunny sacks.

(2) If the trees cannot be planted immediately upon arrival they should be heeled-in as soon as possible. This is accomplished by digging a shallow trench and covering the roots of the trees and a foot or more of the lower parts of the stems with moist earth. It is important that the ties of the tree bundles be cut and the trees spread out in the trench so as to allow the moist soil to come in close contact with the roots. This will prevent air spaces and later drying out of the roots. When the trees are spread out in the trench, the varieties may be distinguished by marking and driving stakes between the different lots.

(3) Should the trees be badly dried out when they arrive, bury them completely in damp, but not wet earth. If left in the ground from 4 to 6 days they may be restored to the proper condition for planting.

(4) The square system of laying off the ground for planting the orchard is generally used because it is less difficult and more satisfactory. The distance of planting apple trees varies on account of soil, variety, pruning practice and climatic conditions. The distance of planting ranges therefore from 30 by 30 feet on the thinner soils to 40 by 40 feet on the richer and more productive soil types. Most growers make the mistake of planting too close. A distance of about 32 feet for the less fertile soils and about 36 feet for the better soils is generally satisfactory. Pears are usually planted from 20 to 27 feet apart each way; peaches, 18 to 22 feet; plums, 18 to 20 feet; cherries (sour), 18 to 20 feet; cherries (sweet), 20 to 27 feet; and quinces, 15 to 20 feet.

(5) Leave as much root system as possible in transplanting. Where one or more roots are too long to be set without bending it is well to cut them back moderately. In all cases, however, the holes should be dug deep and wide enough to accommodate the root system of an average vigorous tree without undue crowding. It is not necessary to use dynamite in preparing the holes in the soil for transplanting fruit trees. If the subsoil is wet, the dynamiting may actually do more harm than good. Tight, impervious soils which are said to require dynamiting are generally unsuited for an orchard. What is most needed in the preparation of the land for an orchard is thorough, deep plowing and tillage, such as is given the soil in preparing it for a good truck crop or grain crop.

(6) Plant the trees about an inch deeper than they stood in the nursery row. After the first shovelful or two of soil is placed on the roots, tramp well after each additional shovelful is added. The secret of success in transplanting trees is to thoroughly compact the soil around the roots. The last portion of soil added should lie loose to prevent surface baking.

(7) Transplanted trees are pruned to establish a balance between the tree tops and the root systems which were pruned in digging. One-year-old apple and pear trees are usually cut back at planting time to a height of 28 to 36 inches from the ground, while the main branches of two-year-old trees are thinned to about three or four which are cut back to about 10 or 12 inches in length. The main stem or leader is generally shortened to a height of 36 to 40 inches from the ground. The roots of young trees are generally cut back to a length of 8 to 12 inches; and diseased roots or badly mangled roots should be removed.

The transplanted cherry and plum trees will usually be smaller than the apple and pear trees but should be pruned in about the same way. Peach trees should be pruned more severly and are generally headed back to about 18 inches.

There are no good reasons for high-headed trees. The Missouri Station has shown that low-headed trees exhibit a more vigorous condition and greater trunk and root development than high-headed trees. In general, the lower the head the more profitable the tree. Spraying, pruning and harvesting operations are made easier and less expensive.

The so-called corrective pruning, during the first few years in the orchard, is done largely by thinning out interfering or competing branches and cutting back rangy branches. Since such pruning need not be severe it does not delay bearing or reduce the size of the trees but helps to establish well balanced and satisfactory scaffold branches.

(8) Under Missouri conditions fall planting of hardy fruit trees and most hardy deciduous trees and shrubs has given better results than spring planting. Late fall planting has also given better results than early fall planting. Late spring planting has given as good results as early spring planting, provided the trees are kept dormant until they are planted.

The Missouri Station has also observed that trees heeled-in for planting may be held dormant until late spring, sometimes early June, by lifting them out of the trench, turning them over and again heeling them in, repeating the process as often as their buds show indication of starting.

(9) The young trees should be given, during the spring and early summer, frequent and thorough cultivation by plowing and hoeing. It is usually advisable to continue cultivating until the trees are from 6 to 8 years old. If for any reason it is impractical to cultivate the entire space between the trees, hoeing or plowing a strip 5 or 6 feet wide about the trees will be of value. The best results are usually obtained by cultivating the whole area between the rows up until about the first of July, when the cultivation should be discontinued to allow the trees to mature properly for winter.

Where a vigorous growth is not being made, 10 or 12 shovelfuls of barnyard manure spread around the trees commencing a few inches away from the tree trunks should be helpful. The application should be made early in the spring and worked into the soil by plowing and hoeing.

If barnyard manure cannot be obtained, nitrate of soda may be applied just as growth is starting in the spring at the rate of about ¼ to ½ pound for trees 1 to 3 years old. For trees 4 to 6 years of age, 1 to 1½ pounds may be used. The nitrate of soda should be sown broadcast in a circle around the trees on top of the soil about 10 inches away from the tree trunks. Ammonium sulphate may be used instead of nitrate of soda. Since it has a higher nitrogen content, use about four-fifths of the amount suggested of nitrate of soda. As the trees grow larger the fertilizers should be applied to the soil under the spread of the branches or between the rows. On soils needing fertility, to maintain a strong growth and secure best results, fertilization and cultivation are generally required each year until the trees are from 8 to 10 years old.

(10) To keep the foliage of young apple trees free from injury by diseases and insects, two summer sprays should be applied in Central and North Missouri and not less than three or four should be made in South Missouri. The first application should be applied about the time the bearing apple trees are in full bloom or shortly after, while the later sprays should follow the first one at intervals of about 2 or 3 weeks, using the same spraying materials that are employed in spraying the bearing orchard. Practically all young orchards are infested by San Jose scale and where this insect is present a dormant spray should be made almost every year any time after the leaves drop in the fall and before they appear in the spring. The spraying of non-bearing trees should be continued until the bearing period is reached when additional summer sprays should be applied.

PEDIGREED NURSERY STOCK

"Pedigreed" stock, so-called, is that produced from trees or plants which have made in the past a special performance record and are considered superior as regards yield, vigor, hardiness and other factors. There has been much difference of opinion in reference to the value of such stock; and still, in the minds of some interested in horticulture the question has not been settled.

Investigations at many stations have shown, however, that "pedigreed" or improved nursery stock is rarely, if ever better than the original variety from which it was derived. It is possible that with extra care and attention to the details of propagation and culture, the "pedigreed" trees might be more suitable for planting. Trees from low yielding parents would no doubt be just as satisfactory if given the same treatment.

Whitten, of the Missouri Agricultural Experiment Station, found in 1918 that there was no significant difference between the total yield of Ben Davis apple trees propagated from high yielding parents and low yielding parents. The bearing habit was not transmitted.

Likewise, strawberries at this Station propagated by runners (buds) for ten generations gave no evidence that the high or low yielding habit of the parent plant was transmitted. In other words, the offspring from high yielding plants were no more productive than those from low yielding parentage. The variations exhibited in the offspring were also found to be just as great as those in the original stock.

SUMMARY

1. Few growers will take the time and pains required to propagate fruit trees successfully. The average grower, therefore, will generally secure the best results by purchasing his fruit trees from a reliable nurseryman.

2. The best fruit trees obtainable are in the long run the cheapest. It is false economy to plant inferior or low grade stock.

3. Graftage is practiced for the following reasons: (1) to multiply fruit trees on an extensive scale, to supply a demand or trade; (2) to change undesirable and unprofitable varieties to suitable sorts; (3) to prevent diseases on susceptible sorts; (4) to repair damage done by rodents, cultural implements and storms; (5) to adapt varieties to different soil conditions; (6) to perpetuate certain kinds or varieties, because fruit trees do not generally come true from seed.

4. The principle of graftage is to unite the scion with the stock or root in such a manner that growth takes place and a perfect union is formed.

5. The essentials of graftage are that the scion and stock be congenial; the operation be done at the right time and under proper conditions; the cambium of scion and stock be in close contact; and the wounded surfaces be protected to prevent evaporation.

6. The different grafting operations may be classified as root, crown, trunk and top graftage.

7. Root grafting is usually performed during January or February, top grafting just before or just after growth starts in the spring, while budding may be done any time when the bark will peel

8. Scion wood consists of well matured wood of the current season's growth. It may be stored in damp sand or sawdust and placed in a cool cellar or cold storage until needed. Scions may also be stored horizontally in an outdoor callus pit.

9. The principal tools required for grafting and budding are hand shears, grafting chisel, budding and grafting knives and a mallet.

10. Since the apple does not generally come true from seed, it is propagated almost entirely by whip and tongue grafting and shield budding.

11. In making the whip graft, a sloping cut about 1½ inches long is made on one side of the upper end of the seedling apple root. The same kind of a sloping cut is made on the lower end of the scion. The knife is then placed on the sloping cut about ¼ or ⅓ inch from the end and a tongue is cut here on both scion and stock. The root and scion are then pushed together, the tongues interlocking. It is important to see that the growing layers of stock and scion come together at least on one side. The point of union of stock and scion is now wrapped with No. 18 or 20 knitting thread or raffia.

12. The grafts are packed in bundles of 50 to 100 each and stored in damp sand or green sawdust and placed in cold storage, a cool cellar, or a callus pit. In early spring, as soon as the soil will do to work, the grafts should be planted in the nursery rows, leaving only one or two buds above ground. Frequent and thorough cultivations are required during the summer in order to secure a good growth. If the trees reach a height of 2½ to 3 feet or more they may be dug and transplanted in the orchard during the late fall or early winter. The trees may be left in the nursery row, cultivated another season and transplanted the following fall, winter or next year as two-year-old trees.

13. An investigation at the Missouri Station covering a period of 20 years, regarding the relative value of whole-root and piece-root Jonathan apple trees showed no material difference in growth and production. This work emphasizes the fact that the grower should be more interested in growthy, vigorous trees with well developed root systems than in the question whether the trees were propagated from piece roots or whole roots.

14. The main reasons for top graftage are to increase the vigor of the tree or to change the variety. To make the work a success, the operation must be carefully performed at the right time, and subsequent attention must be given.

15. Bridge or repair grafting is generally resorted to in order to save the life of trees which have been girdled by rabbits or field mice. It is not a method of propagating fruits.

16. The pear and the quince, like the apple, are generally propagated by whip and tongue grafting and shield budding. The details of the operation may differ slightly.

17. Double-working consists in grafting or budding the tree twice in order to overcome disease or secure greater hardiness.

18. The stone fruits are propagated almost entirely by shield budding during July, August and early September. Careful attention must be given to the details of the operation to be successful.

19. Graftage is limited to plants which have a cambium or growing layer beneath the bark layer. Fruits botanically related, like the apple, pear and quince, can usually be intergrafted or budded successfully. For the most part, the stone fruits may also be intergrafted or budded. In some instances it is not practical, because the resulting growth is uncertain, slow, and the union between stock and scion may be very poor.

20. Directions should be followed carefully, regarding the handling, planting and early care of fruit trees.

21. Pedigreed nursery stock is rarely, if ever, better than the original variety from which the trees were derived. The bearing habits of certain high and low yielding varieties of apples and strawberries are not transmitted.