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The Pecan in Texas

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The Pecan in Texas

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Pecan production in Texas has gradually been increasing with improvement in orchard and grove management. Thousands of acres planted or top worked to papershell varieties have not yet reached commercial production. There are also thousands of acres of seedling trees that have been improved by clearing and thinning that are already helping to increase production.

Only a little more than 10 per cent of the seedling groves in Texas have been cleared or improved, yet the annual average production of seedling nuts for the 10 years, 1929-38, was about 23 million pounds as compared with an average of 18 million pounds for the years 1919-28. If all the seedling groves in the state were improved by clearing or other methods, the present production of seedling nuts might easily be doubled or trebled. With trees in the variety orchards coming on, it is possible that Texas might have an annual total production of 50 to 75 million pounds of nuts within a few years.

As production in Texas and other states has increased, prices have gone down. This price decline is due not only to increased pecan production, but to increase in production of other United States nuts and to the importation of nuts from foreign countries.

The table showing production and price of pecans* shows that the annual average production of the improved varieties was 58.7 per cent greater for the years 1932-36 than for 1922-26, while production of seedlings rose 17.1 per cent. Meanwhile the price declined 65.6 per cent for improved varieties and 54.4 per cent for seedlings.

Years*	Ave. Price Varieties*	Ave. Price Seedlings*	Ave. Production Varieties	Ave. Production Seedlings
1922-26	40.2¢ lb.	16.02¢ lb.	10,192,000 lbs.	40,948,000 lbs.
1932-36	13.8¢ lb.	7.3¢ lb.	16,180,000 lbs.	47,966,000 lbs.

With the increase in pecan production, competition from other nuts grown in the United States and abroad, and other factors tending to lower the price of pecans, the grower must produce regular pecan crops at the lowest possible cost if he is to continue in business. Some of the orchards in unproductive areas may have to be abandoned, and it is certain that new orchards should be planted only where soil and climatic conditions are favorable.

*Price received by growers.

There is plenty of good pecan land in Texas, and there is little reason for planting pecans where they will not have a fair chance to produce economically. The purpose of this publication is to help growers select suitable soils and locations, and to aid in the improvement of the innumerable seedling groves in the state.

PECAN SOILS AND ORCHARD SITES

Next to climate and rainfall, nothing affects the pecan as much as soil. The pecan is a deep-rooted tree, and it wants plenty of moisture, but it will not stand poorly drained or water-logged soils. Regardless of the depth of the taproot, most of the feeding roots are found in the top three or four feet of soil where is stored most of the available plant food.

The pecan thrives on a wide variety of soil types. It does well in sandy soils of acid reaction, in heavy soils of alkaline reaction, and in all gradations between these types. No matter what the soil types, the best trees grow in soils that are well drained, fertile, deep, and pervious to water. Whatever other qualities the soils may have, these four are essential for economic pecan production. Good pecan land can be bought at about the same price as ordinary farm land, and since the cost of the land is usually much less than the cost of developing an orchard to bearing age, it is poor judgment to endanger the success of the orchard in order to save a few dollars in the initial cost of the site.

The alluvial soils along streams generally meet the requirements of good pecan land, and in these locations are found most of the seedling pecan trees of the state. However, some of these river or creek bottom lands are unsuited to pecans because of poor drainage. The presence of either willow trees or crayfish holes in undisturbed areas is a reliable sign that soils are unsuited to pecan tree growth. Pecan roots require good aeration and do not penetrate a water-logged soil. This does not mean that an occasional overflow is harmful to the orchard. If overflow water can drain into a porous substratum and allow air to reenter the soil, the land is usually enriched by the elements of fertility and organic matter deposited by the flood waters, but land that is regularly supersaturated almost to the surface for long periods each spring usually is unfit for the growing of pecans.

In some valleys will be found gravel deposits below the surface of the soil. If these deposits are thick and are of coarse gravel the land may be excessively drained and, therefore, not suitable for pecans.

Some of the sandy upland soils are suitable for pecan production, but in order to justify planting them the soils should be fertile and deep enough to hold a large amount of moisture. It is preferable to have a least 1½ to 3 feet of sandy soil underlain by a porous clay subsoil. If the soil supported a thrifty growth of large timber before clearing and still has enough fertility to grow good crops of cotton and corn it may be planted

to pecan trees, provided they are given ample space at all times. In many cases it will probably be advisable to set the trees along terraces where moisture and plant food elements may accumulate.

Soil Moisture

Pecan trees should have ample moisture throughout the growing season. For this reason it is desirable to select a soil that allows deep rooting. An annual rainfall of 30 to 40 inches may be sufficient for a good type of upland soil provided the trees are spaced sufficiently far apart and clean cultivation is given after the winter cover crops are plowed under in the spring. Without moisture-conserving practices, an annual rainfall considerably greater than 40 inches may be insufficient.

River or creek bottom lands are usually better supplied with moisture than nearby uplands since they may receive the benefit of run-off and overflow water. The trees may also benefit from a water table underneath if it is not too deep and its level does not fluctuate greatly so that the distribution of the roots may be adjusted to it. Although bottom land supplies more moisture than upland, a grove or orchard on bottom land that is sodded requires more moisture than an upland orchard that is cultivated, because the grasses compete with the pecan trees for moisture.

Unlike most plants the pecan tree does not show a deficiency of moisture by the wilting of leaves or shoots. This may be due to the deep taproot which absorbs sufficient moisture from the subsoil to prevent wilting, but it seems also to be due in part to the nature of the tree. However, the fact that the leaves and shoots do not wilt, does not mean that the pecan tree may not suffer from drought. If there are weeds or other plants growing adjacent to pecan trees they wilt when a moisture deficiency occurs. The pecan tree begins to suffer from lack of moisture as soon as other plants, for its main feeding horizon in the soil is the same.

How to Judge a Pecan Soil

The pecan may grow on most any kind of soil, especially when planted as a yard tree, but the presence of large pecan trees on or near a certain tract of land does not prove that the soil is suited to economic pecan production. A few pecan trees may be widely scattered on a tract of land and may develop into large trees even though the soil lacks the qualities necessary for regular, heavy nut production. As a rule, lands on which pecan trees did not grow naturally, such as the gulf coastal plains and the blackland prairies, are unsuited to pecan orcharding. The poor sandy uplands are unsuited as are lands that are too droughty or too wet. The land most certain to be good for pecans is alluvial soil with trees on it that have produced well over a period of years. This land should be judged by trees that grow at a considerable distance from the stream bank since the soil along the bank is usually better drained than that further away. Most of the overflow land in the native pecan regions is capable of producing thrifty, productive trees.

Before spending a large sum of money for a tract of land for growing pecans, the prospective planter should consult with well informed parties regarding its adaptability for the purpose. The statement sometimes made that pecans will grow and produce on any good cotton land is not based on facts.

DEVELOPMENT OF AN ORCHARD FROM NURSERY TREES

Planning the Orchard

The planting of a pecan orchard is the beginning of an enterprise that, under favorable circumstances, will continue in effect throughout the lifetime of the planter. Therefore, the orchard should be planned with much care.

Spacing the trees. The distance apart at which pecan trees are set ranges from 35 feet on squares, or 35.5 trees per acre, in some orchards of West Texas to as much as 70 feet on squares, or 8.89 trees per acre in some river valley soils of South and East Texas. In the fertile alluvial soils of the southern and eastern parts of the state where the rainfall is abundant, the growth of the trees is rapid and crowding takes place much sooner than in the drier areas when the trees are planted the same distance apart. The trees usually do not begin bearing as early in the humid areas because of the greater rate of growth and because of the varietal differences is precociousness. Furthermore, the various fungus diseases are more severe in a damp climate, and ample space is an important factor in their control. On the other hand, in the western orchards surplus pecan trees may be used in the manner of interplanted fruit trees since the trees do not grow so fast and varieties may be selected that are prolific at a relatively young age and size. The western varieties apparently also lend themselves to dwarfing by pruning, and it is possible that by following this practice they may be kept relatively small for a long time to prevent crowding.

While it is important to provide sufficient space to prevent the trees from crowding above the ground, it is of equal importance that ample space be provided for the root systems. The lateral root system of a pecan tree spreads at a rate at least twice that of the branch spread. Therefore, the root systems will begin to be crowded long before the branches overlap. In planting an orchard or in topworking a grove of young trees, the trees should be spaced far enough apart so that no crowding of the root systems will occur for a period of twelve to fifteen years, and provisions for thinning should be made at the time of planting or topworking so that the desired varieties may be left when the stand of trees is thinned.

The production of nuts should be approximately proportional to the number of trees per acre so long as there is ample space both above and below the ground for each tree. An orchard of closely spaced trees will yield proportionately more nuts during the early years of the orchard than one in which the trees are widely spaced. However, the advantage of early production gained from setting more trees per acre is offset to a con-

siderable extent by the higher cost per acre of developing the trees to bearing age. With limited funds it is probably desirable to set the trees further apart so that intercrops may be grown on the land between the tree rows and thereby pay part of the cost of developing the orchard. The cost of the trees per acre will also be lower because fewer trees are required.

If the planter is financially able to plant and care for a large number of trees, the maximum number per acre that may be planted will depend largely upon the precociousness of the varieties grown and the suitability of the orchard site. Probably in no case should trees be planted closer than 35 feet apart on squares, and a distance of 40 to 60 feet is usually advisable.

Where the soil to be planted is suitable for the production of fruits such as the plum or peach, and where the fruit can be marketed profitably, it is a common practice to interplant pecan trees with fruit trees. In such orchards the pecan trees are usually set from 50 to 70 feet apart on squares and three times as many fruit trees set in between at 25 to 35 feet. In some instances the fruit trees are planted between the pecan trees in one direction only and the wide space between the tree rows used for row crops.

Provision for thinning. Under favorable conditions pecan trees eventually grow to enormous sizes and it would be impractical to space the trees so far apart that they would never become crowded. In the average orchard the trees are likely to begin crowding when they are 15 to 20 years old at which time thinning is necessary. In some cases the size of trees may be reduced by pruning back the branches, but as yet this method has not been used extensively enough to justify its recommendation. Therefore, every orchard should be planned so that the stand of trees may be thinned uniformly and still leave the desired proportion of the best adapted varieties. A method of thinning is illustrated in Figure 1. The number of trees per acre for different distances of planting, and the number of trees after thinning are given in Table 1.

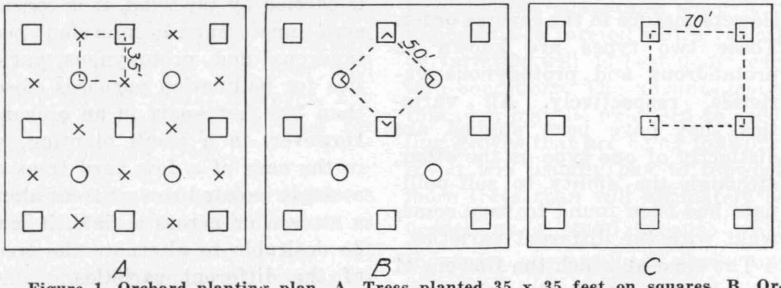

Figure 1. Orchard planting plan. A, Trees planted 35 x 35 feet on squares. B, Orchard after first thinning. Trees are now approximately 50 x 50 feet on squares. C, Orchard after second thinning. Trees are 70 x 70 feet on square.

⊡—Permanent Trees
O—Semi-permanent Trees
X—Temporary Trees

Table 1. Number of Trees Per Acre at Various Distances of Planting in the Square System Before and After Thinning.

Original Setting		After first thinning		After second thinning	
Distance apart	Trees per acre	Distance apart	Trees per acre	Distance apart	Trees per acre
Feet	Number	Feet	Number	Feet	Number
35	35.56	49.50	17.78	70	8.89
40	27.22	56.56	13.61	80	6.81
45	21.51	63.64	10.75	90	5.37
50	17.42	70.71	8.71	100	4.35
60	12.10	84.86	6.05	120	3.02
70	8.89	99.00	4.44	140	2.22
80	6.81	113.02	3.40	160	1.70
90	5.38	127.28	2.69	180	1.34
100	4.36	141.42	2.18	200	1.09

Provisions for pollination. In the pecan the catkins are the staminate or pollen producing flowers. The pistillate or nut producing flowers are clusters of inconspicuous flowers that appear on the terminals of new shoots shortly after growth begins in the spring. As a rule the pecan is not adequately self-pollinated because most of the staminate and pistillate flowers of a variety do not mature at the same time. In some varieties the period of pollen shedding precedes the major period of stigma receptivity. In other varieties the two kinds of flowers mature in the reverse order. These two types are known as protandrous and protogynous varieties, respectively. All varieties that have been studied are distinctly of one type or the other, although the ability to self-pollinate has been found to vary somewhat with the different varieties.

The time at which the flowers of a variety mature depends to a considerable extent upon the time the tree starts growth in the spring, but in most cases the pollen of protandrous varieties is shed just at the time the stigmas of protogynous varieties are receptive, and the pollen of protogynous varieties is shed just at the proper time to pollinate stigmas of protandrous varieties. Therefore it is necessary that protandrous and protogynous varieties be interplanted and it is preferable to lay out the rows in an orchard in an east-to-west direction, or across the direction of the prevailing winds.

Owing to the great quantity of pollen produced by an average pecan tree, and the long distance it is carried by the wind, it is considered unnecessary to interplant protandrous and protogynous varieties for pollination purposes closer than 300 feet apart in an orchard. However, in a small planting, as in the case of a few yard trees or a single isolated row of trees along a stream or across a field, it may be desirable to alternate the trees of the different varieties.

The relative dates of pollen shedding and stigma receptivity of some of the better known varieties are given in Table 2. (See page 65)

Planting plans. After it has been decided what varieties are to be used and the distance apart the trees are to be set, a planting plan should be made. This plan should take the form of a map of the orchard, and the varieties should be marked in at the places they are to be planted, as in Figure 1. Three varieties are used in this plan, although two or more than three may be used. This plan provides for systematic thinning, for pollination, and for a selection of varieties at the time of thinning. The temporary trees which are expected to be removed after 12 to 15 years should be selected from prolific, early bearing varieties in order to get several good crops from them before the first thinning is necessary. These trees comprise 50 percent of the entire planting. The semipermanent trees are usually selected from varieties that are prolific and fairly early bearers because it is expected that these trees will be removed after 20 to 25 years, but the early bearing and prolific varieties may also be used for the semipermanent trees. The permanent trees are usually selected from the best commercial varieties producing large nuts of good quality that are not as precocious as the others but that bear well after several years. However, any desired variety may be used for the permanent trees.

After about 15 years the trees will need to be thinned if spaced as suggested in Figure 1A. At this time the temporary trees may be removed as shown in Figure 1, B, leaving the other trees approximately 50 x 50 feet on squares; or, if desired, the permanent and semipermanent trees may be removed at this time leaving the temporary trees.

At the second thinning, alternate rows of trees are removed which leaves the remaining trees 70 x 70 feet on squares as shown in Figure 1, C. If the temporary trees were removed at the first thinning there is now a choice of permanent or semipermanent trees at the second thinning.

In case it is desired to leave largely one variety in the orchard after thinning it is necessary to plant one or more varieties to serve as pollenizers. This can be accomplished by planting one or two proper varieties in two adjacent rows about every 8 or 10 rows in the orchard. By a study of the diagram and the thinning plan it will be easy to place the pollenizer varieties so that the proper one will be left after the trees are thinned regardless of which variety is left at the time of thinning.

The above plan may be modified so as to give a choice of one, two, or more varieties at the time of thinning, which in many instances is a distinct advantage since it is impossible to foretell which variety or varieties will do best under certain conditions. The advantages of this plan may be extended to seedling groves that are being topworked. It will usually pay to topwork more trees than will ultimately be needed as a stand because when the trees are cut back their tops are much reduced in size and the land will support additional trees. By topworking twice as many trees as will be needed when the tops

are rebuilt to normal size the production will be increased in proportion to the number of trees, while the tops are small and probably of more importance than this, is the fact that a choice of varieties can be made when the stand of trees is thinned.

Transplanting the Trees

The pecan is considered difficult to transplant but methods of growing, digging, packing, transplanting and of caring for the transplanted trees have advanced so far that large plantings are now sometimes made with practically no loss of trees.

Selection of trees. In order to respond well to transplanting, a tree should be in a vigorous condition. A tree stunted in growth during the year prior to transplanting is in a weakened condition and cannot be expected to start growing vigorously in the spring. Such trees are also more likely to be attacked by borers than vigorous trees.

There are differences of opinion as to the size of tree that is most economical to transplant. Large trees when properly cared for come into bearing more quickly than small trees but their purchase price is higher. Therefore, the question should be decided according to the funds available to the planter. Small trees may be very satisfactory for transplanting but are undesirable if their size is due to inherent lack of vigor. Thus, in a nursery row those trees that have made good growth may be expected to grow faster after transplanting than trees that have made poor growth under equally favorable conditions. This fact has led many nurserymen to cull their seedlings before the rows are budded or grafted. It has also led to the planting of seed nuts that have been found by trial to give a high percentage of vigorous seedlings. In the central and western part of Texas nuts of the Hollis, Oliver, Success, Daisy and Texas Prolific varieties, as well as of certain seedling trees, have been found to possess superior merits for producing seedling root stocks, while the Moore variety is used to a great extent by nurserymen of the southeastern states.

Nursery trees are usually planted in commercial orchards when the rootstocks are 4 to 6 years old and the budded or grafted tops are one or two years of age, although older trees are used to some extent. Regardless of age, the tree should be vigorous and stocky and of a size commensurate with its age.

Laying off the land. The saying that "a thing of beauty is a joy forever" applies to the pecan orchard, and it may also be said that crooked rows in an orchard are a source of regret forever. Unless the acreage to be planted is very small it is recommended that a surveyor's transit be used to lay off the rows for a pecan orchard. This requires one man to sight through the transit and two men to carry the measuring tape and set the stakes. It is exceedingly difficult to set stakes in rows that are straight in cross directions without the use of a transit.

Digging the holes. After an orchard has been staked out in perfect rows the tree rows may still become crooked if the trees are not set where the stakes were driven;

Figure 2. Planting Board. A, Stake in notch at center of board where tree is to be planted. B and B′, Stakes in notches at ends of board to hold it in place. The stake A is removed when the hole is dug. When the tree is to be planted the board is replaced between stakes B and B′ and the tree trunk is held in the central notch until the hole is filled with soil.

therefore, use should be made of a planting board, as illustrated in Figure 2. A planting board is made from a 1 x 6 straight pine board 8 feet long, a notch is made at each end and one at the exact middle of the board as shown in Figure 2. The notches should be made so that the three stakes will be in a straight line when placed in the notches. Before a hole is dug the central notch of the board is fitted to the stake where the tree is to stand, after which a stake is driven down in the notch at each end of the board. When the tree is planted the board is replaced between the two outward stakes and the tree trunk is fitted into the central notch, thus placing it in the hole at the exact location of the original stake.

Pecan trees are set in both large and small holes. In heavy soils holes about 3 feet in diameter at the top ordinarily give better results than holes of the post-hole-type. However, in the lighter soils of the state post holes have been practically as satisfactory as larger holes. For large trees it is necessary to use the larger holes in order to accommodate the larger root systems.

Post holes for planting pecan trees are dug with a drop auger or post hole digger and are made 10 to 15 inches in diameter at the top and about 3 to 3½ feet deep.

Setting the trees. Before the trees arrive from the nursery a stake at each hole should be numbered as to row, number of tree in the row, and the variety to be set in the hole in conformity with the orchard planting plan. The variety name may be written on the stake or a daub of paint of a certain color may be used for identification.

So far as is known, there is little difference in the response of pecan trees transplanted during late December, January, February, or early March. However, poor results may be expected if trees are dug from the nursery before they have defoliated naturally in the fall. For this reason, transplanting from January 15 to March 1 is considered the best practice.

It is desirable that the trees be planted immediately upon arrival from the nursery. The holes should have been dug and the crew for planting should be in readiness. As each tree is taken from the bundle all bruised ends of roots should be cut off smooth and any long roots should be cut back to fit the hole in which the tree is to be set. The entire root system should then be dipped into thick clay mud to protect the roots from drying while the trees are hauled to the field and set in the holes.

In case the trees cannot be planted within three or four days after

they are received from the nursery, they may be "heeled in" by placing the roots in a shallow trench and covering with several inches of moist soil. This prevents the roots from drying out and also prevents heating which might occur in the bundles. However, if the trees can be planted within three or four days they can be kept in good condition by wetting the bundles occasionally with water and storing in a cool place.

Pecan trees are usually planted about 2 inches deeper than they stood in the nursery. When a tree is planted in a large hole, the lateral roots should be straightened into their normal outward position as the hole is filled with soil. The soil should also be packed to prevent excessive settling later and to eliminate air spaces around the roots. Only fertile, mellow, top soil should be used to fill the hole. A basin should be made at the top and the soil settled thoroughly by watering, but this may be delayed until all the trees are transplanted if the soil is moist.

For post hole plantings the lateral roots must be pruned shorter than for large holes, but they should not be cut closer to the tap root than 3 to 6 inches. Since the soil can not be packed readily in these holes and cannot easily be worked under the roots by hand, it is necessary to use water to settle the soil around the roots. It is preferable to add water as the hole is filled with soil and the tree should be shaken occasionally as the soil settles around the roots.

After the trees are set in the orchard and the tops are cut back the trunks should be loosely wrapped for a distance of 12 to 15 inches above the ground with burlap or heavy paper, which is tied loosely. This protects the trees from rabbits, winter injury, and from sunscald the following summer. It may also prevent the trees from being attacked by wood boring insects.

Aftercare of transplanted trees. The pecan tree is very slow to develop new roots after transplanting as compared with other commonly transplanted trees. Due to the loss of the original feeding roots and the slow development of new roots it is very helpful to the newly transplanted tree if the size of the top is reduced in proportion to the loss sustained by the root system. Heavy pruning of the top will often save trees that would not survive transplanting if all of the top were left on. It has been found best to cut back the top to one-half or one-third its original height. Trees that are cut back in this manner when transplanted almost invariably overtake the growth of similar unpruned trees, and the percentage of trees lost in transplanting is usually reduced.

It is highly important that the trees be supplied with adequate moisture during the first summer in order to facilitate their establishment in the soil. A tree that becomes well established during the first summer will make more growth during the next year than one that merely survived. This advantage will be retained in subsequent years and result in earlier nut production. If the season is dry the trees should be watered. Watering need not be oftener than once every 4 weeks if sufficient

water is applied each time to thoroughly soak the ground around the tree and to the full depth of the root system. The cost of watering trees during the first year is relatively small and is one of the most profitable investments a planter can make.

Sunscald. Newly transplanted pecan trees that are making very little growth are susceptible to sunscald at the ground line when exposed to the sun. This is especially true when such trees are watered during the heat of the day. To avoid this possibility the wet ground should be covered with dry soil or straw after the water has soaked in. A straw mulch in the basin around the tree is very helpful during the first year after transplanting, serving both to conserve moisture and to keep the soil cool. It is also desirable to allow the trees to branch low so that the trunk is shaded. Sunscald is also prevented by loosely wrapping the lower part of the trunks of the trees with burlap or paper soon after transplanting.

Winter injury. The cambium of young pecan trees is sometimes injured by low temperatures during the winter. Such injury is confined to the area just above the ground line, usually extending upward on the trunk not more than 4 to 12 inches. Serious damage may be indicated by a bursting of the bark and a very brown cambium at the affected area. Lesser damage will result in the discoloration of cambium and unless the bark is cut into, will not be noticed until the next spring. The tops of winter-injured trees will either fail to grow out in the spring or will start with a weak growth, depending upon the extent of the injury. In either case sprouts usually develop below the injured portion of the trunk.

If the cambium is not completely killed the tree is capable of healing the injured places and eventually will recover. However, the trunks of the injured trees are very susceptible to attacks of borers and much care is necessary to prevent serious damage from these insects. Experience has shown that it is better to cut a severely damaged tree to the ground and develop a new tree from a sprout since it will usually grow more rapidly than the injured tree.

Apparently winter injury occurs most frequently in trees that make vigorous growth in the late fall and fail to mature before frost. Trees that are grafted below the ground line are much more susceptible to winter injury than budded trees because the rough seedling bark on the latter for a short distance above the ground offers considerable protection from freezes. Wrapping the trunks of trees for a distance of 12 inches above the ground with several layers of burlap or heavy paper will prevent winter injury to a considerable extent. Withholding water from the trees in the late fall, in case the trees are in a lawn or are irrigated, may check the late growth and thus prevent winter injury.

Training Young Trees

The observation of numerous forest grown pecan trees throughout the state has tended to create the following erroneous ideas in the minds of pecan orchardists, first, that the pecan tree should be head-

ed high and second, that no training of orchard trees is needed other than the removal of all the lower limbs to the height desired for heading the tree. It may be true that too much pruning, or the wrong kind, is worse than no pruning but a certain amount of judicious training of a young pecan tree is often of inestimable value in its development into a shapely tree with a strong framework.

Heading the trees. In the young planted orchard it is desirable to have the trees headed close to the ground. This means that the first permanent branch of the tree should arise at a point on the trunk not more than 2 to 3 feet from the ground. Trees headed low are desirable from the standpoint of orchard management because they are easier to spray and prune, and it is easier to harvest the nuts since the trees do not grow so tall. Low-headed trees also come into profitable bearing earlier than high-headed trees because larger bearing tops are produced earlier. The trunk and other framework are more stocky than in high-headed trees and this tends to prevent crooked growth and bending in the direction of the prevailing wind. This is especially important in the western part of the pecan belt.

Framework of the tree. The framework of a pecan tree is defined as the trunk and main branches and should be strong enough to withstand great strains. The difference between a strong frame and a weak one may eventually mean the difference between a badly broken or split tree and a tree not seriously damaged when subjected to the fury of a tropical hurricane,

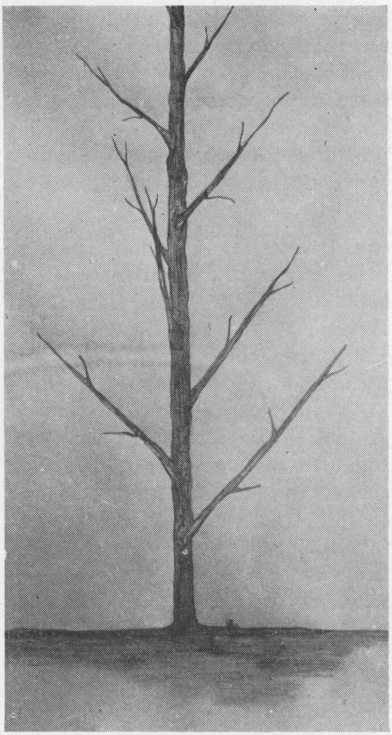

Figure 3. Illustration showing ideal spiral arrangement of branches on the tree trunk.

a local storm, or the weight of ice which may freeze on the branches in winter. Even the weight of a heavy crop of nuts while still green may cause breakage of limbs or splitting at weak crotches.

It is generally considered that the strongest trees are those of the central leader type, in which the main branches are arranged in spirals about the central leader as illustrated in Figure 3.

To train a young pecan tree to this type, select if possible as the first permanent branch above the ground one that points in the di-

rection of the prevailing summer winds and at the height at which the head is to be started. Approximately 18 inches higher up on the trunk select another branch at a point approximately 2/5 of the distance around the trunk. The third branch should be 2/5 of the distance around the trunk from the second branch and about 18 inches higher. The other branches of the framework are located in the same manner. Usually four or five such branches are all that are necessary, and if desired the leader may be cut out above the last scaffold branch thereby converting the tree into the modified leader type. Such trees are strongly built, but do not grow quite as tall as trees of the central leader type. However, after four or five branches have been trained for the framework, orchard trees usually will grow naturally into desirable trees without removal of the leader.

In the training of young trees to the proper form, several years are required to complete the selection of the main scaffold branches that are to make up the tops of the trees. Every tree is different in its manner of branching and must be given specific thought and attention in training. In practice it will be found that it is impossible to find branches on a tree that conform exactly to the ideal in location vertically or longitudinally on the trunk; however, it is well to keep a definite pattern in mind and conform as nearly as possible to it in training the trees.

Types of forks. The pecan tree usually makes strong forks. The one most commonly found is the two-prong fork in which one prong is larger than the other. It is a strong fork if the angle between the two prongs is wide, but is weak if the crotch angle is narrow. See Figure 4, A.

Many forks formed by two prongs of equal size occur in pecan trees and may be weaker than the average fork formed by two prongs of unequal size. Such a fork is weak if the angle is sharp enough to cause pinching of the bark between the two prongs and result in poor intergrowth of the wood fibers on the inside of the crotch, as shown in Fig 5, B. It is strong if the crotch angle is wide enough to prevent such pinching, as shown in Figure 4, B.

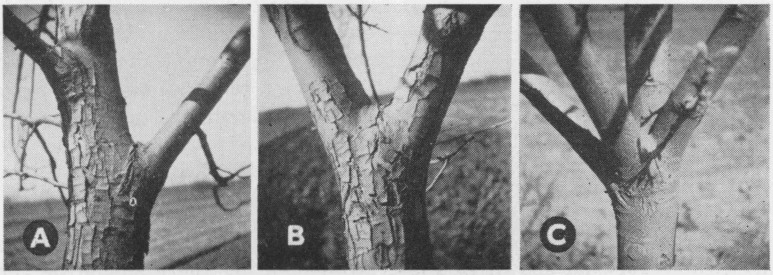

Figure 4. Types of forks: A, Strong fork formed by two prongs of unequal size, and with relatively wide angle between the prongs; B, strong fork formed by two prongs of equal size and with wide angle crotch; C, four prong "crow foot" fork.

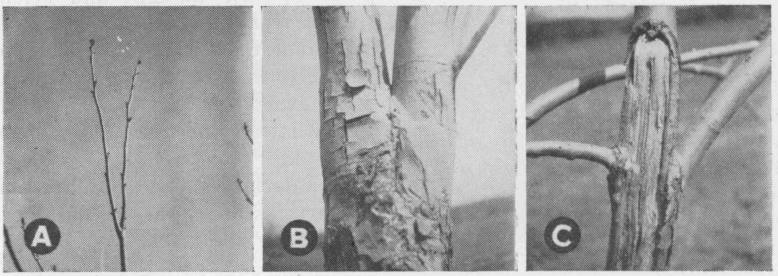

Figure 5. A sharp angle fork. A, Beginning of fork; B, fork showing bark pinching between prongs; C, fork after splitting.

A less common fork is the **crow foot** in which three or more limbs join, none of which is much larger than another, as shown in Figure 4, C. This type of fork is likely to split if subjected to severe strain.

A fork consisting of one strong shoot and one or two small ones, as shown in Figure 6, A, requires no attention. In a fork of two equal prongs, Fig. 6, B, one prong should be cut back to about one-third the length of the other. In a fork of three equal prongs, two of the prongs should be cut back to about one-fourth their original length, as shown in Figure 6, C. In a fork of four or more prongs, all of the prongs should be removed entirely except two or three, all but one of which should be cut back severely, as shown in Figure 6, D. In some cases it may be necessary to remove all but one prong.

It is usually advisable to cut off the tips of important shoots, such as the central leader, in the dormant season so as to remove the cluster of buds on the terminal end. If these grow out the result is an undesirable fork as shown in Figure 7, B, but if the tip is removed the bad forks are eliminated as shown in Figure 7, A, and the new terminal can be started in the direction desired by cutting back to a bud pointing in that direction.

Pruning and training transplanted pecan trees. Since the transplanted tree is cut back to a stub at the time of transplanting, the terminal shoot which is required to produce the central leader is likely not to grow in a vertical direction unless the tree is cut to a bud facing the prevailing summer winds, or unless the shoot is trained in a vertical direction by tying it to a stake. It is desirable to cut off the transplanted tree at a point about two inches above the terminal bud because the end of the stub will dry out and die back for a short distance. If the topmost bud does not grow out, the leader can be made from the next bud below. No attempt should be made to force a terminal bud by removal of other shoots or buds on a newly transplanted tree since the tree needs all the leaves that are produced by all the shoots.

During the first summer after transplanting there should be very little interference with the growth of the tree since it is important to

have shoots growing all the way up and down the trunk. However, it is very desirable to train one of the shoots in a vertical direction to form the leader of the tree. If none of the shoots grow upright naturally, a good shoot near the top of the tree should be tied to a stake to draw it into an upright position. No pruning should be done in summer other than pinching out tips of shoots when necessary to shape the tree properly.

During the first winter after transplanting, the lateral branches should be cut back so as to force more growth into the leader and the higher branches. These lateral branches should not be cut back to less than 4 inches in length at this time. The leader should be cut back to a bud pointing against the prevailing summer wind unless it is already leaning in that direction. Only a few inches of the leader should be cut off unless it is un-

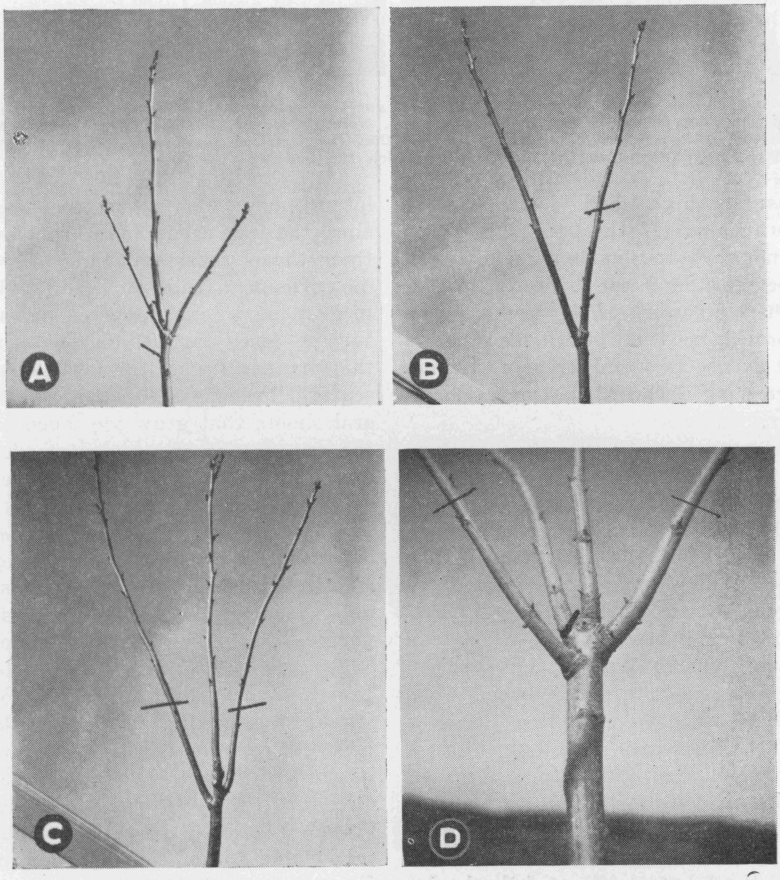

Figure 6. Illustrations showing how to correct bad forks in young pecan trees. A. A strong fork that requires no pruning; B, cut back one prong as shown; C, cut back two prongs; D, remove one prong and cut back two.

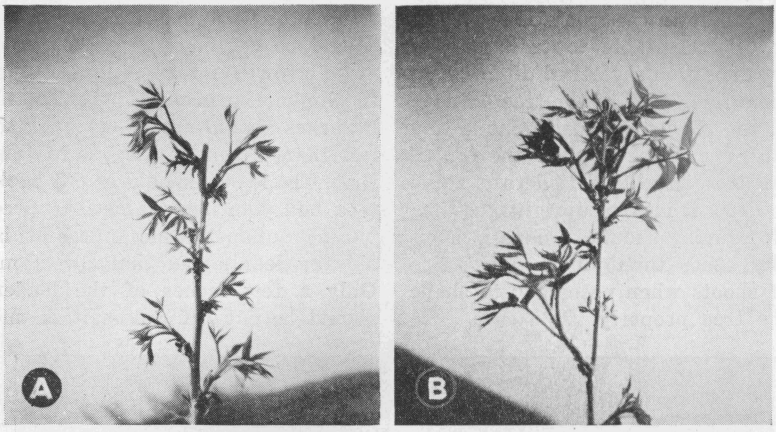

Figure 7. Types of growth from shoots cut back and not cut back. A, Terminal end of shoot cut back; B, terminal not cut out. Note cluster of shoots at terminal end of branch that was not cut back. Also note that the terminal shoot on the branch that was pruned grows in the direction in which the bud was pointing.

usually high and lacks proper branching. If the tree is high enough, a permanent branch may be selected at the desired point for the framework of the tree and this branch need not be cut back unless it is necessary to prevent it from growing ahead of the central leader.

During the second summer after transplanting it often happens that the central leader leans too much away from the direction of the wind. This may be corrected by tying the leader to a stake or cutting back the tip of the shoot to a bud pointing towards the direction of the wind. In order to cause the shoot to grow out at a sufficient angle the leader should be cut back about 3 to 6 inches, since removing the tip only will not change the direction of the new shoot to an appreciable extent. The removal of the longer portion of the leader also tends to force out shoots from lateral buds which is very desirable since the tree needs more branches than those necessary to produce the permanent framework. In rapidly growing trees it is often necessary to force out lateral shoots in this manner for use as permanent scaffold branches. The tips of lateral shoots that grow too much at the expense of the central leader may be pinched out in the summer so as to check their growth.

During the second winter after trees are transplanted they are usually large enough for the first permanent branch to have been selected and for the central leader to have been trained in an upright position. Subsequent training consists in keeping the central leader growing in an upright direction, in selection of the necessary permanent branches, and in correction of objectionable forks. Usually four or five permanent branches are all that it is necessary to select and

train because after this has been done the tree will grow naturally into a desirable shape. The branches other than those of the permanent framework should be trimmed back so that they are shorter than the permanent branches. If necessary some of these may be removed after the tree trunk is 3 or 4 inches in diameter. By leaving these branches the leaf area is increased. This results in a stockier tree and also causes the permanent branches to grow in the proper direction and to form fewer undesirable forks. A tree trained after the above manner and a tree pruned to a high head are illustrated in Figure 8.

In young trees where no training of branches or removal of undesirable forks has been done, corrective pruning may eliminate some of the bad forks and improve the arrangement of permanent branches. However, if a tree has been neglected until the faults cannot be corrected without very severe cutting, it is often advisable to leave it alone since too severe pruning may do more harm than good.

One of the most common practices in the pruning of young pecan trees is that of cutting off all the limbs to a height of 5 or 6 feet above the ground. This practice makes an undesirable orchard tree, as has been mentioned, and retards the growth and stockiness of the tree and delays the production of nuts. If the tree is grown in a lawn where it will of necessity

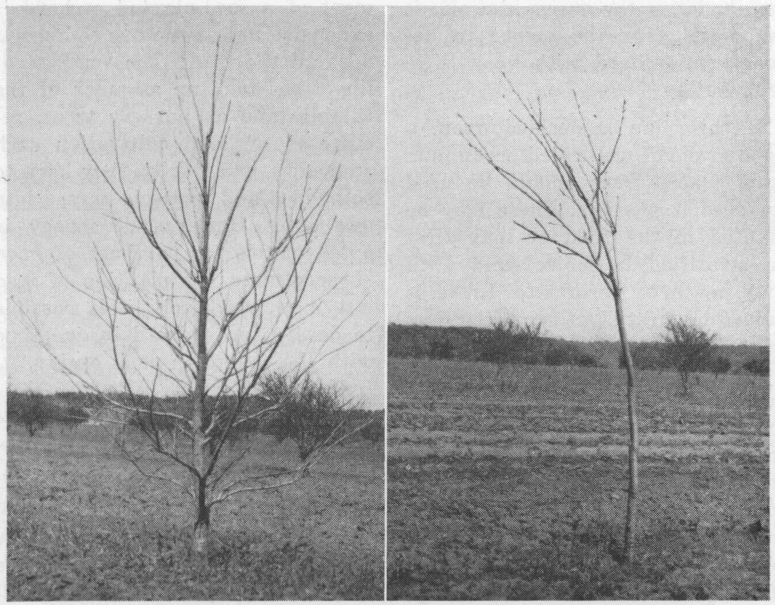

Figure 8. The effect of removing all the lower limbs of a young pecan tree. A, No lower limbs were removed. Note the sturdiness of the tree and that it is not bent by winds. B, Tree pruned to a high head. Note slender trunk and tree leaning from wind. Trees are the same age and growing in the same orchard.

have to be headed high, the heading may be done after the tree has grown to be vigorous and stocky. Therefore, this method of pruning young trees should be avoided under all circumstances.

DEVELOPMENT OF AN ORCHARD FROM SEED

The planting of a large orchard with nursery trees necessitates considerable expense for trees, labor of transplanting, and care of the trees during the first year. For an orchard of the average size this requires a greater sum of money than many farmers are able to supply. In such cases seed nuts may be planted where the trees are to stand, or in a small nursery from which the trees may be transplanted in due time. By growing and budding the trees himself, it is possible for the owner to develop an orchard with very little cash outlay.

If this plan is decided upon, a good grade of well filled pecan nuts from tested trees should be used for seed if possible. These may be planted in the field or may first be stratified in moist sand until they begin to germinate. Little is gained by first stratifying the nuts except that their exposure to rodents is delayed. However, the nuts should be planted early, preferably before January 1. If planted in the field, three to six nuts should be planted at each point where a tree is to stand. These should be planted 5 or 6 inches below the surface of the ground and covered about 3 inches deep, leaving a depression for collection of rain water. The planting of several seeds at each location increases the possibility of a stand and allows a choice of seedlings, thus making it possible to eliminate the weaker ones. After the end of the first year's growth, the best seedling at each location should be selected and all others removed. The seedlings should be budded or grafted to the desired varieties when they attain sufficient size since the nuts produced by seedling trees are almost certain to be of inferior quality.

If the owner has money to invest, is certain that he has good pecan land, and is a good manager, it will probably be advantageous for him to plant good nursery trees and take care of them. An orchard of nursery grown trees will be two or three years ahead of a seed-planted orchard, and the development of a seed-planted orchard is expensive unless the owner himself does all the work. The small seedling trees take up as much of the tillable land as nursery trees, require more hand cultivation such as hoeing, and finally, they have to be budded and the buds nursed into new tops. However, if money is not available for purchase of good nursery trees, the planting of seed is a method whereby it is possible to develop an orchard in due time with the minimum cash outlay.

MANAGEMENT OF PLANTED PECAN ORCHARDS AND GROVES

Cultivation of Planted Orchards

Although the pecan is a native forest tree in Texas, it responds readily to proper methods of cultivation and many young pecan orchards have failed largely because they have not been properly cul-

tivated. As a general rule, cultivation should be very shallow, not exceeding a depth of 3 or 4 inches at any time, and during the spring and summer should be no deeper than is necessary to kill weeds and grass. Ordinarily cultivation should start in the spring at the time winter cover crops are turned under, or if no cover crops are grown, then as soon as the first crop of weeds and grass is becoming fairly rank. This will ordinarily be from April 1 to 15 but in some instances it may be as late as May 1. The disc harrow is suitable for the cultivation of pecans and is used extensively for this purpose. If intercrops are grown in the orchard, the seedbeds are prepared and the crops cultivated at the usual time, and with suitable implements, but deep plowing should be avoided even in the dormant season.

In general, the young pecan orchard will require more frequent cultivation than older orchards because the older trees tend to hold weed growth in check by shading and by competition for moisture and plant food elements. In either case, disking or plowing should be frequent enough to prevent rank growth of weeds or grass. The number of cultivations per season will depend upon the fertility of the soil, the types of weeds and grasses on the land, seasonal conditions, and the size and spacing of the trees. With average trees 15 to 20 years old, and where winter cover crops are grown, the cover crops may be turned under in the spring, one or two shallow cultivations made in the summer, and then the final cultivation effected when the land is prepared for planting the winter cover crop the latter part of September. Thus, two of the cultivations required are accomplished in preparing the land for the winter cover crop and in turning under the cover crop in the spring. Where no cover crop or intercrops are grown, the cultivations should be at about the same times in the year, except the final one which should be about the first of September. In some cases the weeds are mowed during the summer and one cultivation given in the spring and one in the fall, a method which seems to be satisfactory in the older orchards. The primary purpose of cultivation is to destroy weed growth and in this way conserve the moisture and plant food elements of the soil for the pecan trees. Scientific experiments have shown that transpiration of plants is responsible for the greater portion of the loss of moisture from soils, and that the loss from evaporation is nearly as great from cultivated soils as from those not cultivated provided the soils do not crack. In case soils crack, the cultivation will fill up the crevices and help to prevent the evaporation of moisture. However, it cannot be too strongly emphasized that the greatest competitors of pecan trees for moisture may be weeds or grasses if they are allowed to make much growth in the orchard. Therefore, cultivation or mowing should be frequent enough to prevent rank growth of these plants in the orchard.

Cultivation of Groves*

If pecan groves are brought under cultivation the process should be very gradual since in such groves the ground is usually covered with a mulch of leaves or other organic matter which shades the ground and conserves moisture. The feeding roots grow near the surface of the soil under these conditions and may be destroyed by plowing, thereby disturbing the normal functioning of the tree. To plow up a large amount of these roots and expose the top soil to direct sunshine is detrimental and is usually followed by severe rosette. However, if the grove is gradually cleared, and gradually brought under cultivation by very shallow disking at first, the root systems of the trees will usually adjust themselves to the new conditions without appreciable effect on the normal tree functions. It is usually advisable to keep weeds and undergrowth mowed during the first one or two summers following the clearing of a grove, with perhaps one light disking in the spring and another in the fall.

Trees on sandy types of soil are less likely to be affected by rosette when brought under cultivation than are trees on clay soils. This is probably due to less alkalinity and to a deeper feeding root system in the sandy soils. Although a zinc spray will control pecan rosette, many of the seedling trees are so large that spraying is impractical with the ordinary spray equipment. Therefore, great care should be exercised in changing a grove from an uncultivated to a cultivated state, in order to avoid the occurrence of rosette. If the change is sufficiently gradual, little trouble will ordinarily be experienced.

After once becoming adapted to cultivation the grove may be handled in the same manner as the planted orchard of similar development in age and size of trees.

Sodding Groves

Many pecan groves in the state are on land subject to overflow and where the land would erode badly if brought under cultivation. In such cases it may be necessary to sod the land with some suitable grass to prevent erosion. During the growing season the weeds, grass, and other vegetation may be mowed or sheep and cattle grazed on the land to keep down the vegetation. It is usually necessary to mow once or twice during the summer even though the land is grazed because livestock do not eat all of the different kinds of vegetation present.

Under ordinary conditions it is not advisable to undertake the development of a pecan orchard from small trees under sod conditions, because the trees make slow growth and it is extremely hard and expensive to protect them from livestock. Older trees do better under sod conditions than young trees, and the value of the pasture may offset the ill effects of the sod on the performance of the trees. The sod will also prevent soil erosion by flood waters.

*The term **grove** is used to designate a tract on which the pecan trees are irregularly spaced, as in nature, as contrasted to an **orchard** where the trees have been planted in rows. All groves in the state are of seedling trees or trees that have been topworked to varieties.

One of the most common permanent pasture grasses in Texas is Bermuda. In some instances bearing pecan trees do well in Bermuda grass sod and in others they do not. Where Bermuda grass does not already occur in a grove it is doubtful whether it should be planted in preference to a less vigorously growing perennial grass, such as Buffalo grass. In deep sandy soils along creek or river banks it probably would be preferable to use Bermuda grass because it acts as a soil binder to prevent erosion, and the moisture supply of such soils is usually relatively abundant. On the heavier soils, Buffalo grass or Johnson grass may be preferred. In connection with the selected perennial grass, winter crops such as burr clover, sweet clover (**Melilotus indica**), Giant Southern burr clover, and winter rye grass may be grown for winter grazing and to furnish additional organic matter to the soil.

If the weeds and other vegetation are kept under control in the spring and summer to prevent excessive competition with the pecan trees for moisture and plant food elements, the soil fertility of the grove may be kept up by the organic matter from grasses and weeds, the liquid and solid manure distributed over the land by the grazing livestock, and the silt deposited by the overflow waters from the streams. Under this system a profit may be reaped from both the trees and the livestock. However, best results cannot be expected by clearing a pecan grove of competing timber, or thinning the stand of trees and sodding the land, if the grasses, weeds, and other vegetation are allowed to damage the pecan crop seriously by competing with the trees for plant food elements and moisture.

Intercrops

In the development of a pecan orchard from transplanted trees or from small topworked seedlings the trees do not occupy all the space during the first several years. Since it is necessary to cultivate these trees, and as they do not bear an appreciable amount of nuts during this period of development, it is usually desirable from an economic standpoint to grow intercrops between the tree rows from which some revenue is obtained to help defray the expenses of caring for the orchard. The cultivation of the intercrops takes care of all of the area of the orchard except the space allotted to the tree rows.

Among the crops that may be used for intercropping are row crops, preaches, plums, berries, melons, and vegetables. Of the row crops generally utilized as intercrops, cotton has apparently been preferable to corn or sorghums. This is perhaps due to the fact that the root system of the cotton plant is less extensive and deeper than that of corn and sorghum, and therefore its competition for moisture and plant food elements is less. It should be pointed out also that cotton is usually given cleaner cultivation than corn or sorghum, thereby eliminating weed and grass growth which may easily be as important in the competition for moisture and soil nutrients as the intercrop itself.

In the selection of an intercrop for a pecan orchard the grower should consider the adaptability of the crop to his soil and climatic conditions, its market value, whether it can be grown and handled economically under his system of farming, and its probable effect as a competitor for moisture and plant food elements during the growing season of the pecan trees.

If sufficient moisture and fertility are available, any row crop with the exception of sorghum may be used as an intercrop, but in most sections of the state there is usually insufficient moisture to support both the pecan trees and an intercrop of high moisture requirements, especially after the trees have attained bearing age. For this reason those intercrops of high moisture requirements such as corn, sorghum, or rank growing vegetables should be avoided.

Where intercrops are planted a strip of at least six feet on each side of the tree row should be left vacant the first year. Each year thereafter this space should be increased as the trees grow larger. The lateral or feeding roots of pecan trees spread at a rate about twice as great as the branch spread. Therefore, if this be kept in mind and space for the trees provided accordingly, little or no damage to the trees will result from intercropping and the owner will derive some revenue from such cash crops to help defray the expenses of developing the orchard. In general, it may be stated that from the standpoint of moisture competition an early maturing crop is preferable to one maturing late, provided that its root system is not so extensive as to greatly deplete the soil of its fertility, since there is more likelihood of an adequate supply of soil moisture from rainfall in the early part of the season.

Cover Crops

Any crop that is grown for the purpose of being returned to the soil, either in the green or mature state, is called a cover crop. The growing of such crops is an economical way of increasing or maintaining the nitrogen and humus content, improving the moisture holding capacity and the physical condition of soils, as well as a means of preventing soil erosion and the leaching of the soil nutrients.

Summer cover crops. In the sections where stinkbugs occur, summer legumes such as cowpeas, crotalaria, lespedeza, and soybeans are hosts to these insects and should not be grown in bearing orchards. The stinkbugs prefer to feed upon the legumes but after the legumes die they may move to adjacent pecan trees to feed upon the nuts. The insects puncture the shells of the nuts thereby causing black pit or kernel spot, and the damage to the nut crop may be serious if the stinkbugs occur in large numbers, as is often the case.

It is not recommended that summer cover crops be grown in pecan orchards, except in young orchards where the trees do not occupy all of the land, unless irrigation facilities are available. If such crops are grown under ordinary conditions they should be handled like row crops or other intercrops in that sufficient space should be left in the tree rows so that the crops will not seriously

compete with the pecan trees for moisture and plant food elements. Cover crops suitable for summer planting are cowpeas, velvet beans, soybeans, sesbania, crotalaria, lespedeza, and others. In some cases these crops may be used jointly as cover crops and cash crops, the peas or beans being harvested and the stalks turned into the soil. These may then be followed by a winter cover crop sown about the first of October. In general, it is not advisable to attempt growing a summer cover crop in a bearing grove, because the trees need all the available moisture and soil nutrients to support their growth and mature a crop of nuts. There are two distinct periods in the development of the pecan nut. The first is the period of growth in size, and extends from blossoming until about the first of September; the second is the period of filling or kernel development and begins about the first of September and ends when the nut is fully mature and ripe. A bearing pecan tree makes most of its growth in the early spring. Therefore, if there is too much competition for moisture and plant food elements in the spring and summer, the tree cannot make normal growth and the nuts cannot attain normal size, whereas if there is a shortage of these materials in the early fall the nuts cannot fill properly. For these reasons, it is generally considered that bearing pecan trees alone constitute a sufficient crop for the land to carry, and attempts to grow any other crop in the orchard during the growing season of the pecan trees is not good practice.

Winter cover crops. Winter cover crops fit in admirably in a system of management for pecan orchards. The crops are seeded shortly before the date of nut harvest and this leaves the ground clean so that harvesting is simplified. The crops make most of their growth while the pecan trees are dormant and are turned into the soil in the spring where they form a mulch near the surface, thereby increasing the water holding capacity of the soil. As this organic matter decomposes, the plant food elements are released and are available to the pecan trees. Under average favorable conditions a winter cover crop can be expected to yield 5 to 12 tons of green matter per acre. In case of a legume this amount of green matter would contain about 50 to 120 pounds of nitrogen per acre, which is equivalent to the amount contained in 300 to 750 pounds of 16 percent sodium nitrate fertilizer.

Winter cover crops should not be allowed to mature in the pecan orchard but should be turned into the soil not later than the time the grains attain the early dough stage or when the legumes blossom. If the land is subject to drought the crops should be turned under earlier. In bearing orchards where no summer intercrop is grown, it is preferable to turn the crops so that the stems are cut up and about half buried in the soil. In this way the material rots slowly and at the same time serves as an excellent mulch for retaining moisture. The land should be left smooth after turning the cover crop in order to be effective as a mulch, and to do this it may be necessary to disk the land at right angles to the direction of the first plowing. The mulch formed by the green crop not only re-

tains moisture but also tends to prevent excessive temperatures in the surface soil. On coarse, sandy soils where plenty of rain occurs in summer the cover crops should be disked down and allowed to decompose on the surface of the ground. Otherwise the organic matter decomposes rapidly and may leach out of the soil.

Selection of a winter cover crop. Under conditions where legumes make satisfactory growth they are preferred as cover crops because of the nitrogen-fixation by bacteria that live in nodules on the roots. However, under some conditions in the state legumes have not made satisfactory growth, and in such cases it is desirable to use small grains such as rye, barley, oats, or wheat. These crops add organic matter to the soil and free-living organisms are able to fix atmospheric nitrogen in the soil during decomposition of the crops when they are turned under. Therefore, a high-yielding non-legume that is ready to turn into the soil in early spring should be more desirable as a cover crop than a low-yielding legume, or one that makes most of its growth very late in the spring. Barley is an early maturing non-legume and yellow flowering sweet clover (**Melilotus indica**) is an early maturing legume.

Winter cover crops should be planted from October 1 to 15 in order that the young plants may become established in the soil before freezing weather. This insures a better yield early in the spring and also gives better winter coverage of the land. It is preferable to plant the seeds with a drill, but fairly satisfactory results may be obtained by broadcasting them. The grains and larger legume seeds when broadcast should be disked into the soil about 4 inches deep, but for small seeds like the clovers the cover is best accomplished by harrowing lightly. The legume seeds should be inoculated with a reliable brand of commercial inoculant when planted to land not previously growing the legume. Some authorities advocate the inoculation of legume seeds regardless of whether the same legumes grew on the land the previous year.

Fertilizers

There are many pecan trees in the state planted on land that is not fertile enough to make nut production profitable. In such cases the only immediate remedy is the application of commercial fertilizers. Cover cropping also should be started in such orchards but the results from cover crops are not immediate, and it may require several years of both cover cropping

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Below is given the rate of seeding for some winter cover crops:

	Seed per acre
Rye	**1½ to 2 bushels**
Wheat	**1½ to 2 bushels**
Barley	**1½ to 2 bushels**
Hairy vetch (Vicia villosa)	**20 to 30 pounds**
Sweet clover (Melilotus indica)	**15 to 20 pounds**
Hubam clover (Melilotus annua)	**15 to 20 pounds**
Giant Southern burr clover	**15 to 20 pounds**

and applications of fertilizer to bring the soil fertility up to a level sufficient to support good growth and fruiting of the trees. In the case of young trees on poor land it may be necessary to use fertilizer in order to obtain a normal rate of growth and development of the trees. It is not considered profitable to rely entirely on the use of commercial fertilizer for growing pecans because it is expensive, but fertilizer may often be used profitably to supplement other means of increasing or maintaining the fertility of the soil. A good winter cover crop program supplemented with the proper amount of commercial fertilizer should change many marginal pecan orchards to profitable enterprises where the troubles are due to lack of soil fertility.

While conditions vary greatly in different orchards, the general fertilizer formula that seems to be suitable for pecan trees is a 4-8-4 or 6-12-6 (N-P-K) mixture. The amount applied per tree should be about 1 or 2 pounds to each diameter inch of tree trunk up to 5 or 6 years of age. For older bearing trees the amount should be about 2.5 pounds for each year of growth of the tree. The fertilizer may be broadcast evenly over an area somewhat exceeding the branch spread of the tree and disked or plowed into the soil or it may be applied with a fertilizer distributor. The fertilizer should be applied in early spring, usually during the first half of March.

Where legumes are grown as winter cover crops it is usually desirable to apply the phosphate fertilizer in the fall at the time of seeding, and the nitrogen and potash in the early spring. The legumes respond well to phosphate, thereby increasing the yields. When the cover crops are turned under and have decomposed, the phosphate they have absorbed is released again in the soil and is available to the pecan trees.

If available, farm manure may be used as a fertilizer for pecan trees. It contains a low percentage of the nutrient elements as compared with some commercial fertilizers and is considered to be deficient in phosphoric acid. This means that when manure is used it may be necessary to supplement it with about 100 pounds of 20 percent super-phosphate per ton. The commercial fertilizer equivalent of the average ton of manure can be purchased for $1.25 to $2.00 and the cost of its application is much less. However, the greater part of the value of manure is indirect. Manure contains organic matter which improves the physical character of the soil, as well as the moisture holding capacity, aeration, and temperature relations. Manure also has a favorable effect upon soil microorganisms which are instrumental in making plant nutrients in the soil available for immediate use.

The composition of manure varies widely, depending upon the kind of animals from which it comes, the food of the animals, the amount of straw or other litter, the amount of leaching, and other factors. Therefore, it is difficult to state the rate at which it should be used. If a limited amount is available more benefit will be derived from it when it is applied at a low rate

per acre than at a high rate because of its beneficial effect on the soil even in small amounts. The light applications can be supplemented with commercial fertilizers to supply the deficiency of nutrients. If large quantities are available the manure may be applied at the rate of 5 to 8 tons per acre. It should be pointed out that excessive application of stable manure may induce rosette in pecan trees.

Manure may be applied in early spring and should be disked or plowed into the soil to prevent loss from surface washing.

PROPAGATION BY BUDDING AND GRAFTING

The pecan is similar to most fruits in that the varieties do not come true to seed. For this reason the propagation of varieties is accomplished by the asexual methods of budding and grafting. These two methods are different forms of grafting and differ only in the operations performed, the final results being the same.

Budding is the art of removing a section of bark containing a bud group, the whole of which is commonly termed a **bud**, and transferring it from one tree or branch to another in such a manner that the two parts will unite and the bud grow into a shoot. In grafting, part of a shoot containing one or more buds is transferred from one tree or shoot to another so that the two will unite and the bud or buds grow into shoots.

The **cambium** is a layer of thin-walled cells situated between the bark and the wood, along which the bark may be peeled when these cells are active. When the cambium is injured, as in budding and grafting, a spongy wound tissue known as **callus** is formed and unites the separated parts to reestablish normal sap-conducting tissue. Success in all forms of grafting depends upon the union of the wound tissues of the stock and scion.

Classes of Budwood

In order for budding to be successful it is necessary that good buds be used, therefore the beginner should become familiar with the different kinds of budwood. Current-season buds are the buds on the shoots of the current season's growth. Figure 9, A. These are used almost exclusively for budding the shoots produced during the summer following removal of the top of cut-back trees, and may also be used successfully on stocks more than one year old if they are in a vigorous growing condition. Immature buds should not be used. Immaturity is indicated by a tender, green bark or a watery cambium layer. When the buds are mature the bark is firm, dark in color, and the wood is hard. In no case should the budwood be more vegetative, or sappy, than the stock to be budded.

Current-season buds may be used by July 1 and as long thereafter as the bark will slip from the wood. The smoothest and most mature buds are found on the basal end of the bud stick. Any immature or knuckled buds on the terminal end should be discarded. The term **knuckled** refers to a bud situated upon a considerable gnarl in the wood as shown in Figure 9, E. This causes a pocket underneath the bark when the bud is removed.

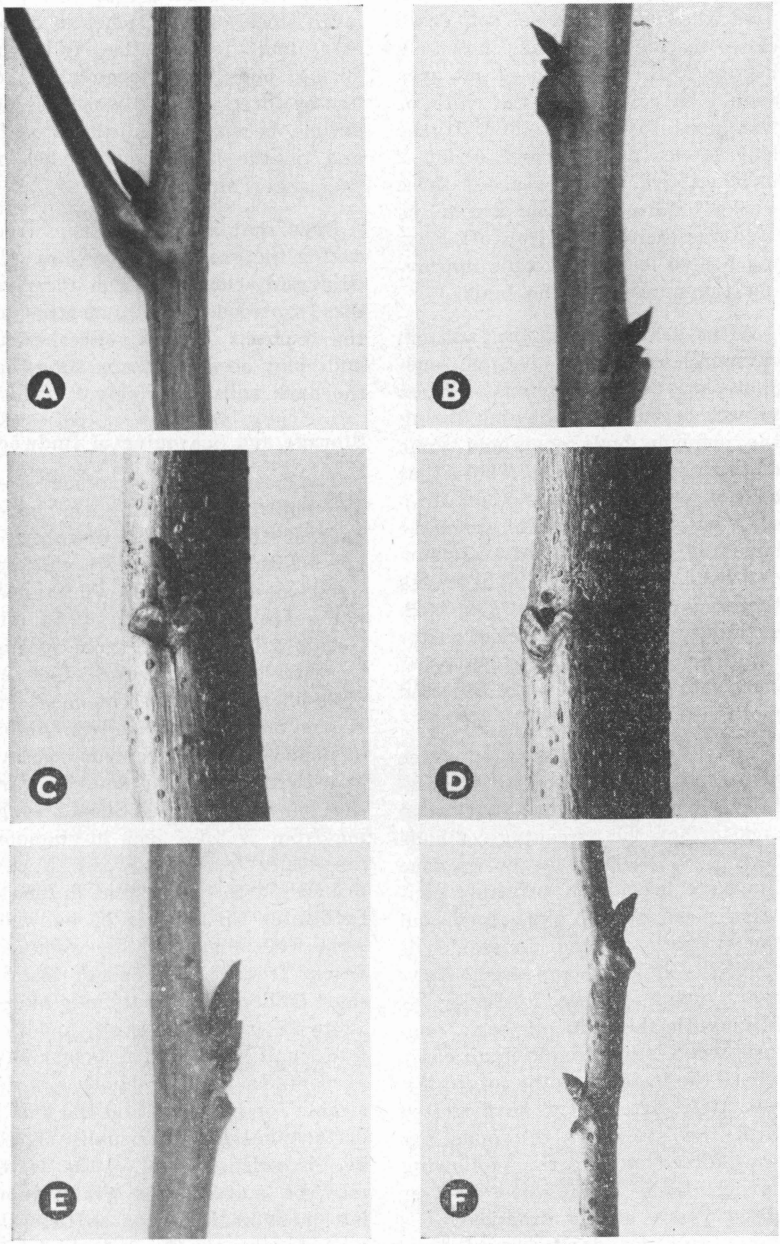

Figure 9. Some types of buds. A, Current-season bud; B, current-season bud with leaf petiole cut down for budding; C, a plump, well developed bud that will force easily; D, bud too small to force readily; E, a poor bud, wood too gnarled under bark; and F, bud stick too small for ordinary use.

When current-season buds are used the leaf stem is cut down close to the bark, as shown in Figure 9, B. The exposed cut area should be covered by the cloth or wax used to seal the bud. If the leaf stems are cut off about 2 inches above the base about three weeks before the buds are to be used the stems will drop off leaving healed leaf scars, thus improving the quality of the buds.

After leaf fall in the autumn current-season buds become one-year-old dormant buds. When growth begins the following spring the primary buds open and some of them produce shoots. Those that do not produce shoots soon drop off. After this loss of primary buds the wood is called two-year-old wood. A year later it is called three-year-old wood, etc. The bark gradually becomes thicker after the first year and the buds become more and more imbedded and more difficult to force.

Buds from wood two or three years old may be used as successfully as buds from one-year wood and, in fact, the percentage of buds that live is often larger because the bark is thicker, probably contains more stored plant food and the pockets on the underside of the buds have disappeared. However, owing to the difficulty of forcing the buds in old bark, one-year wood is preferable in all cases where the buds are to be forced immediately after they have united with the stock. If the buds are not forced until the following spring, buds from wood two or three years old is practically as good from the standpoint of forcing as those from one-year-old wood. When buds are to be set on large stocks 2 to 3 inches in diameter and forced the following spring, buds from large sticks of two-or three-year-old wood are desirable because it is easier to fit and tie the large bud patches on the larger stocks.

Buds that are taken from trees during the growing season are called **freshly-cut** buds. The term refers to wood older than that of the current season. Freshly-cut buds may be used at any time that the bark will peel freely.

Storage and Seasoning of Budwood

The best time for cutting storage budwood is during the latter part of the winter, preferably in late February or early March. Budwood cut early in the winter does not season as quickly or as uniformly after removal from storage as that cut just before the sap rises in the spring. The most desirable budwood is that from vigorous shoots of the previous season's growth and usually is found toward the top of the tree. Shoots ranging from ⅜ to ¾ inch in diameter are desirable for budwood. A pole pruner six to twelve feet in length facilitates the cutting of budwood since with it most of the wood can be cut from the ground or from a short ladder. The shoots may be cut 12 to 18 inches in length and tied into small bundles. The larger basal portions of the shoots are desirable for budwood and the smaller terminal growth usually should be discarded. Some of the latter may be suitable for graft wood, but most of it is not sufficiently well developed. Graftwood should be cut into lengths of 6 to 8 inches.

The bundles of budwood should be tied tightly near each end so that the sticks will not be loose enough to twist about in handling. As each bundle is tied a cut of approximately an inch in length should be made into the wood on one of the budsticks and the name of the variety written on it with a lead pencil. After the budwood is cut, tied, and labeled, it should be placed in moist shingle tow, sphagnum moss, peat moss, or equal parts of shavings and sawdust. The material in which the bundles are packed should not be so wet that water can be squeezed out of it but should retain sufficient moisture to prevent drying out of the budwood in storage. Lard cans with good fitting lids are preferable to wooden boxes as containers since they do not permit drying out of the budwood and yet allow sufficient aeration. The budwood should be held in cold storage at 32° to 38° F. where it remains in a dormant condition until ready for use at any time throughout the growing season. Current-season or freshly-cut budwood may be held in storage for several weeks at 32° to 38° F. When cold storage is not available, budwood may be kept for several days when packed in moist shavings or peat moss mixed with chunks of ice the size of a baseball.

Grafting wood should be cut at the same time as budwood and stored in the same manner.

Budwood from cold storage is dormant and must be seasoned before the bark will peel so that the bud patch can be removed for use. The seasoning is accomplished by packing the budwood in moist moss, wood shavings, or sawdust, and holding it at a temperature of 80° to 85° F. Under these conditions the budwood usually will be ready to use within four or five days, but in early spring it may require a little longer. The budwood should be used soon after it is seasoned, or returned to cold storage because buds from overseasoned budwood usually give poor results.

The Patch Method of Budding

The principal budding method used in the propagation of pecans is the patch bud. This consists in peeling a rectangular patch of bark containing a bud from the bud stick and placing it onto a peeled place of similar dimensions on the stock, tying it down firmly so that the cambiums are pressed into contact, and then sealing to prevent drying out. The successive steps in the procedure of patch budding are illustrated in Figure 10, and the instructions for each step are as follows:

(a) Make parallel cuts across the stock with a budding knife or tool having parallel blades spaced about 1 inch apart; follow by a longitudinal cut across the right end of the parallel cuts.

(b) With the same budding tool make parallel cuts on the bud stick above and below the desired bud and then longitudinally on each side. As each longitudinal cut is made raise the bark a part of the way towards the bud.

(c) Remove the patch of bark containing the bud.

(d) Raise the severed bark on the stock.

(e) Insert the bud patch underneath the raised bark of the stock.

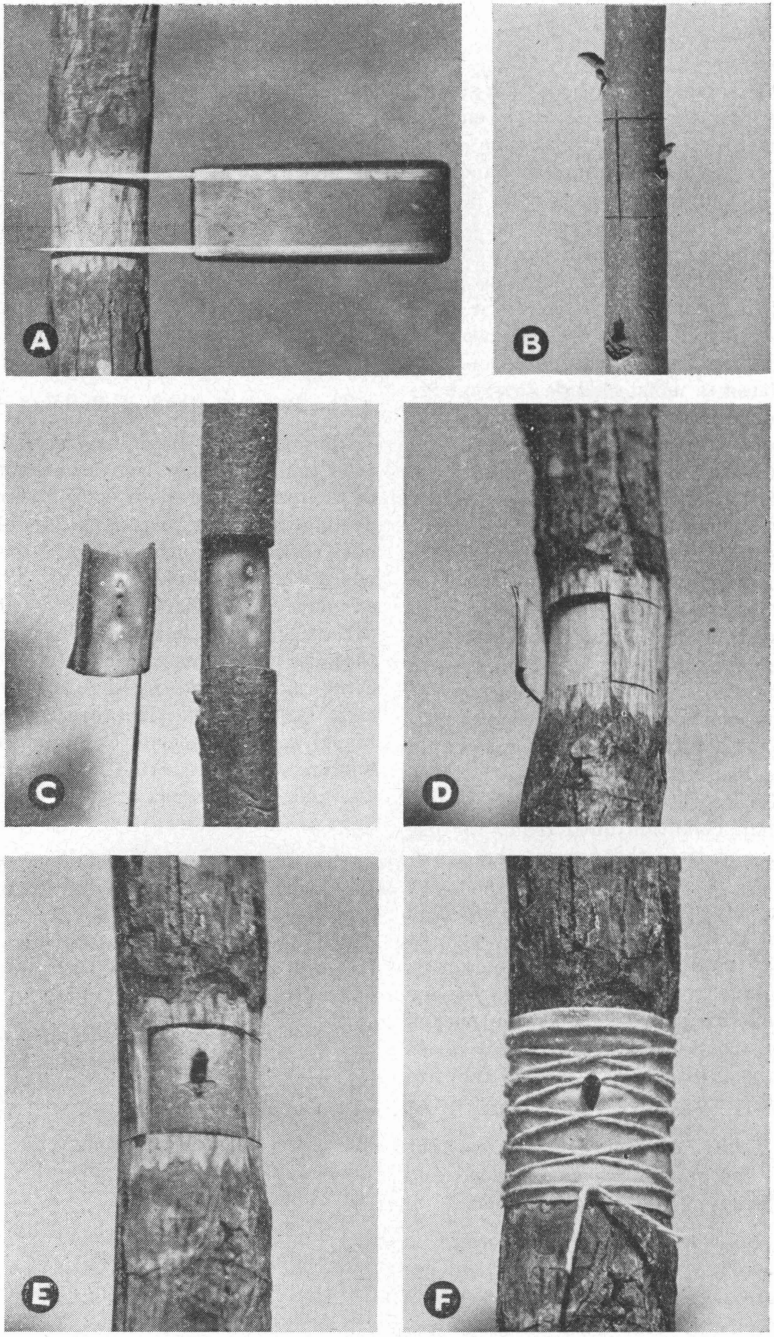

Figure 10. Successive steps in patch budding. A, Make parallel cuts across the stock with budding knife. Follow with a longitudinal cut at right end of parallel cuts. B, Make parallel cuts above and below the bud on bud stick with same budding knife, and make longitudinal cuts on each side of the bud. C, Remove the bud. D, Raise the bark on stock. E, Insert bud patch underneath raised bark on stock fitting it snugly at right side. Tear off bark of stock so that it slightly overlaps bud patch at left side. F, Cover the area with a rectangular patch of waxed cloth, allowing bud to protrude through a hole in the cloth, and tie down firmly with strong twine.

The bud patch is fitted snugly at the right side and the raised bark of the stock is torn off so that it slightly overlaps the bark of the bud patch on the left side.

(f) Cover the area including the bud patch with a rectangular piece of waxed cloth, allowing the bud to protrude through the hole in the center of the cloth, and tie down firmly with strong twine.

Paring bark on stock. If the stock is considerably larger than the bud stick the bark should be pared so that it is of approximately the same thickness as that of the bud stick as shown in Figure 10, A. This makes it possible to tie the bud patch down firmly. No overlapping of the bark of the stock on the bud patch should be allowed if it prevents the strings from pressing firmly on the bud patch after it is in place.

Removing the bud from the bud stick. The bud should be taken from the bud stick without splitting the bark and with as little injury as possible to the cambium underneath. The knife blade should be used to push up the bark on each side of the bud without sticking the blade underneath the bark to pry. The bud should then be grasped firmly between the thumb and first finger and may usually be lifted off. If it does not respond to this effort, the bark may be pried loose by inserting the knife blade underneath it, but great care must be exercised to avoid unnecessary injury to the cambium. The transfer of the bud from the bud stick to the stock should be performed without delay after the bud has been removed because the cambium cells die quickly upon exposure to the air.

The bud patch is usually cut so as to take a strip of bark not less than half-way around the bud stick since a higher percentage of the buds will live if the patches are relatively wide.

Tying. For the tying-in of buds cotton twine of 4-ply or stronger is recommended. Wraps should not be spaced more than ¼ inch apart and should pass across the waxed cloth both above and below the bud patch as well as across the patch itself. The strings should draw the patch firmly against the cambium of the stock, especially at the point of the leaf scar. The tying should be started either on the upper or the lower end of the waxed cloth—not in the middle.

Either of two methods of tying may be used. In one, the first wrap is made with the middle of the string. An equal length of string is held in each hand and the ends are passed from one hand to the other at the back and at the front of the stock as the tying proceeds. In the other method wrapping is started at one end of the string and is completed with the other end. The ends of the string are held in place by the first and last loops made in wrapping.

When to remove the strings. The strings should be released after the wound of the budding operation has healed, as indicated by the filling in of the cavities around the bud patch with wound tissue. The length of time required for wounds to heal differs according to the activity of the tree and the size of the wound. The strings are usually

cut three weeks after budding by drawing the knife blade across the strings at the back side of the stock or opposite the transplanted bud. If the stock has not grown enough during this period to cause the strings to indent the bark through binding it is better to delay cutting the strings for one to two weeks. On large stocks the strings should remain tied longer than on small stocks, especially if the buds are not to be forced immediately.

Forcing. If the bud patch makes a union with the stock it will appear green when pricked with a knife blade. The bud within the bark patch may then be assumed to be alive and established as a part of the tree. The beginner often thinks the work is now complete, but without the additional procedures of **forcing** and **aftercare**, of the buds the work done thus far will prove entirely useless.

Buds occur in the axils of the leaves and most of them remain dormant for many years. The bud that is transplanted to a stock by budding also remains dormant except under certain conditions. To induce it to start growth and to continue in growth the procedure known as **forcing** is usually necessary. In this procedure the stock is cut off above the bud, usually at a distance of 3 to 6 inches. This causes the buds on the stock to start growth. Several of these buds are usually forced into growth and should be removed at weekly intervals so as to restrict the growth to that of the transplanted bud. Shoots from seedling buds on the stock are usually the first to appear and often must be removed at intervals during a period of several weeks before the transplanted bud is forced into growth.

When to force buds. The natural time for new growth to start in the pecan tree is in early spring and every effort should be made to force all transplanted buds at this time. The buds are more readily forced into growth then and the season's growth is greater than that from buds forced later because the growing season is longer. If the buds and sprouts are removed from the stock in early spring even very small or old buds that are well imbedded in the bark of the bud patch can be readily forced into growth, whereas if the forcing is delayed until later in the season the transplanted buds often fail to grow, or may make little growth during the remainder of the season.

When buds are set at the time the bark begins to slip in the spring or for a period of 1 to 2 weeks thereafter, but before the leaves appear, the stocks may be cut off at the time of budding. The stored plant food in the stock is sufficient to effect a union of bud and stock and the buds will be forced into growth. If budding is done later in the season the stock should not be cut off until after the bud has made a union (except as specified for current-season shoots, page 39) because the leaf activity in such cases aids in callus formation, counteracts bleeding, and helps to retain the vigor of the stock. However, the stock may be cut off to force the buds as soon as the unions have been effected if the tree is still growing vigorously.

Good judgment is often required to decide whether to force buds at the time the strings are cut or to let them remain dormant until the following spring. If the stock is a small tree less than 3 inches in diameter and the entire top is to be cut back to force the bud, it may be cut back and the bud forced as late as June 1. If a larger tree has been budded on several branches, it is usually better not to force the buds after May 1 because (1), large trees are injured more than small trees by removal of branches and leaves during the growing season; (2) if only part of the branches are removed the buds are likely to force poorly, or not at all, since the sap flow is diverted from the stubs to the foliated branches; and (3) if the buds are left dormant and are forced with the beginning of growth the following spring, they will eventually overtake those forced late in the previous season because the tree will be more vigorous as the result of retaining the leaves throughout the previous season.

When the shoots of cut-back trees are budded with current-season buds in summer the shoots on which the buds are set are usually partly cut back at the time of budding, but no other growth should be removed from the tree. In this procedure relatively little of the entire leaf area of the tree need be removed. The cutting back of the stocks prevents the rapid binding of the strings and forces a large percentage of the buds into growth.

Aftercare of buds. After the bud had been forced into growth further attention is required, in order to develop the growth properly. The shoot growth from the bud must be directed so as to form the desired branch or tree. Seedling growth must be controlled to prevent it from choking out the new shoot or interfering with its growth or direction. Eventually no growth should remain on the tree except that from the one or more buds used to topwork it. However, except in the case of small trees, the removal of the seedling growth should be brought about gradually as the new top develops. This will be further discussed in another part of this bulletin.

The first rapid growth of the shoot from the bud is inclined to become top-heavy and is easily broken out at the point of union with the stock. One of several methods may be used to prevent loss of shoots in this manner. The safest method is to tie the shoot to a substantial stake. For this purpose a strip of cloth should be used in tying to prevent injury to the tender shoot, since a thin string will injure the shoot as the wind rocks it back and forth. The stake may consist of an ordinary stick tied or nailed to the stock. Plaster laths make suitable stakes since they are straight, can be nailed to the larger stocks, and are inexpensive. If the shoot is on an upright branch the stock projecting beyond the point where the bud was set may be used as a stake while the shoot is small. The latter may also be used on small trees, or stakes may be driven into the ground beside the tree.

Another method to prevent breaking out of shoots consists in cutting out the tip of the shoot before

it becomes top-heavy. This checks the growth, giving the stem time to strengthen, and causes branching which is usually desirable.

When to use the patch bud method. Since the success of budding depends upon the union of the cambium of the bud patch with that of the stock, it is necessary that budding be done when the cambium is active. After the leaves are shed in the fall the cambium is practically inactive until the time the buds begin to open in the spring and the bark can be peeled. Thereafter activity increases rapidly, reaches its height a few weeks after the opening of the buds, and then gradually diminishes. Patch budding should not be done during the period of high cambium activity because the conditions are unfavorable for the buds to live and grow. The budding may be done either before or after this period, but the most favorable conditions for successful budding of stocks of all sizes are found at the time the bark begins to peel in the spring. Conditions at this time also are the most favorable for forcing the buds.

When patch buds are set during the period of high cambium activity, the sap may ooze into the wound. This is commonly termed **bleeding**, and is said to result in souring or **drowning out** of the buds, causing their death. The bleeding is aggravated by knife gashes that extend into the wood of the stock but may occur without such cuts. Whether the loss of buds under such conditions is actually due to fermentation of the sap or to an incompatible condition of the cambiums is not known, but it is known that such conditions are unfavorable for budding. At the time buds are susceptible to drowning, the cambium is thick and spongy, and the surface appears watery when the bark is lifted. The bleeding is largely avoided if the stock is not cut off until the bud has made a union with the stock. It is probable that more bleeding occurs in small stocks than in large ones.

There is a period of very low cambium activity shortly before the bark ceases to peel and buds set at this time seldom live unless taken from well matured budwood. However, if good budwood from cold storage or other well matured budwood is used the budding may be very successful.

The shoots of trees cut back the previous winter are suitable for budding in the summer after the cambium activity has slowed down to such an extent that danger of bleeding has passed at which time the shoots are said to be mature. If the trees are young and the stocks are small, the bark is thin and consequently a large number of shoots grow out early in the season. These may be sufficiently mature for budding by July 1. On large trees that are cut back to large stubs having thick bark, the shoots may not be ready for budding until August 15, or even later. Cut-back trees are often budded too early. The best success with these trees is obtained by budding them shortly before the bark ceases to peel on the shoots, or usually from August 1, to September 1.

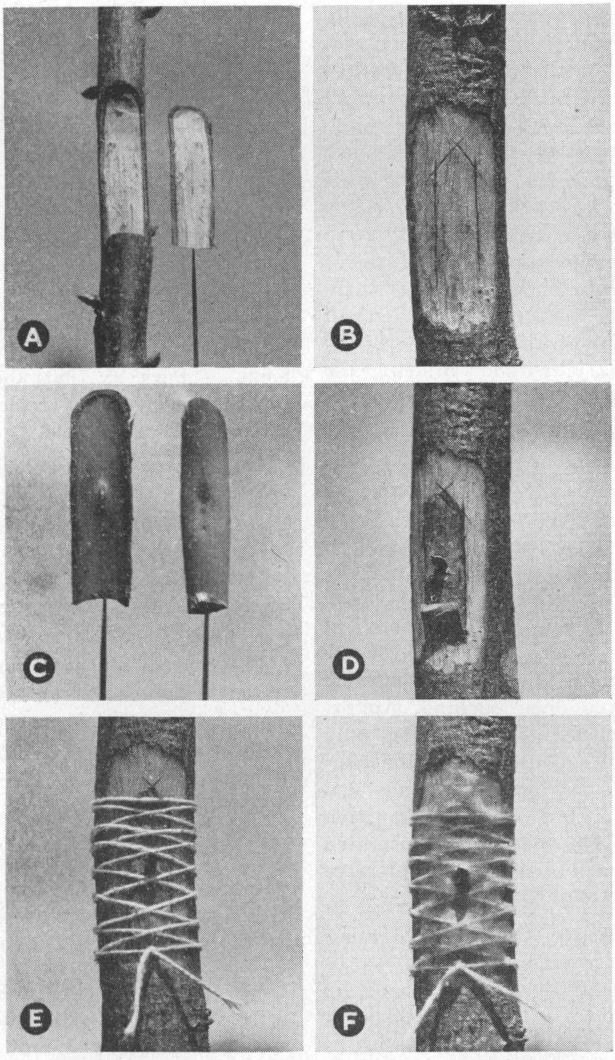

Figure 11. Successive steps in cut-and-slash budding. A, Remove bud from bud stick together with wood underneath. B, Make an inverted V cut on the stock and two parallel downward cuts spaced as far apart as width of bud patch. C, Hold the bark at the rounded end and pull the wood from underneath the bud patch. D, Raise bark segment on stock and insert the bud patch underneath. After the bud is in place, trim the overlapping bark so that one-fourth inch overlaps the lower end of the bud patch. E, Tie with twine. F, Seal with melted paraffin.

The Cut-and-Slash* Method of Budding

During the budding season the pecan propagator is occasionally called upon to use budwood not suitable for the patch-bud method because the bark will not peel. At such times a form of the patch bud known as the cut-and-slash method may be employed. In this method the bark containing the bud, together with the wood, is cut from the bud stick in the form of a long chip. With the proper technique, the wood may be pulled out from beneath the bark, forcefully if necessary, without injuring the bud or bark.

The usefulness of the cut-and-slash method is not limited to the above conditions but may also be used when the bark peels. Many of the best propagators employ it to a large extent, though not exclusively of the patch bud. The same physiological conditions of stock and scion that are favorable for patch-budding are favorable for cut-and-slash budding. An ordinary pocket knife is the only tool required, and due to the simplicity of the operation buds can be set a little faster than in patch budding. The method is illustrated in Figure 11 and the successive steps are described below:

(a) Remove the bud, together with the wood underneath, as illustrated. In removing the bud make a deep cut on the bud stick so that the bud patch will be as wide as possible. For best results, the bark strip should be cut about 1½ to 1¾ inches long with the bud in the center.

(b) Make an inverted V cut on the stock and follow by two parallel downward cuts spaced as far apart as the width of the bud patch. If the bark on the stock is thick, pare it to the thinness of the bark of the bud.

(c) Hold the bark at the rounded end, and pull the wood from underneath the bud patch.

(d) Raise the severed bark segment of the stock and insert the bud underneath. If necessary, trim the sides of the bud to fit the slot, or widen the slot. After the bud is in place, trim the overlapping segment of bark so that about one-fourth inch overlaps the lower end of the bark of the bud.

(e) Tie as in the patch-bud method.

(f) Seal with melted paraffin. Instead of the melted paraffin rectangular pieces of waxed cloth may be used. In this case tying follows the application of the waxed cloth.

The cut-and-slash method is not suited to budding large stocks owing to the difficulty of properly tying down the small segment of bark. Neither is it suitable for current-season buds with attached leaf stems.

The directions for cutting the strings, forcing the buds, and after-care of the buds are the same as those for patch budding.

The Inlay Bark Graft Method

In a study of defective graft unions Sitton[1] found that most of the grafts had united with the stock only at the lower end of the scion. Many were damaged by borers because of excessive callus for-

*This method was originally called cut-and-sash.

[1]Sitton, B. G. Grafting the Pecan. Southeastern Pecan Growers Assoc. Proc. 31: 59-61 1937. (Abstract.)

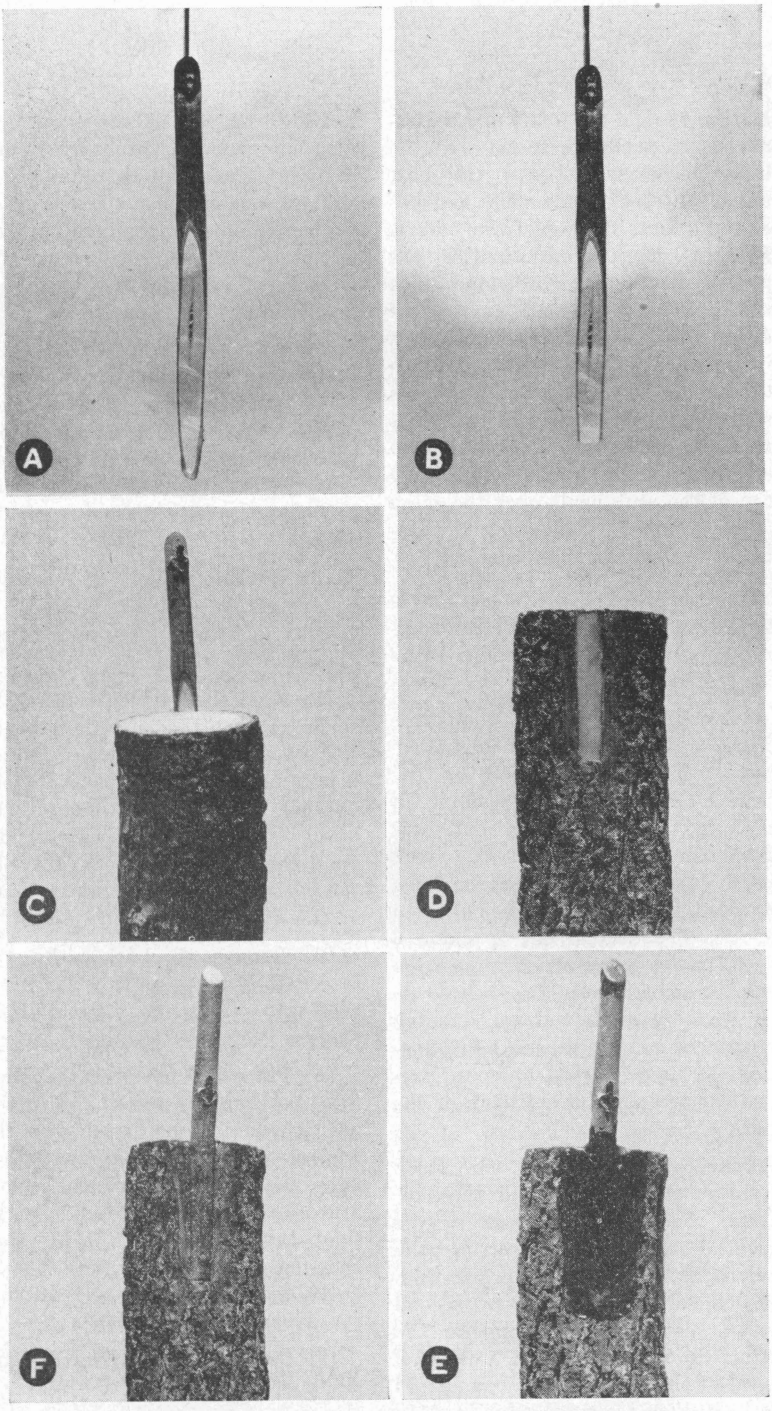

Figure 12. Successive steps in inlay bark grafting. A, Cut the scion to a straight bevel. B, Cut the tip end of the bevel straight across where it is about 1/8 or 3/16 inch thick. C, hold bevel firmly against the smooth bark of the stock, allowing about ½ inch of the bevel surface to extend above the end of the stock. Inscribe the pattern of the scion on the bark of the stock with a knife blade. D, Remove the bark. E, Place the scion in the prepared recess and fasten with two nails, one driven near the end of the stock and the other near the lower end of the scion. F, Cover the exposed areas, including the end of the scion and the end of the stock, with melted grafting wax (Grafting wax on No. 3 page 60).

mation around the graft and underneath the bark. He found that the inlay bark graft gave the best union of stock and scion and resulted in less damage from borers. By this method no cavities are produced under the bark and since there is only a small amount of space between the two cambiums, it is quickly filled with callus to the tip of the stock which promotes rapid healing. Nails hold the scion firmly against the stock and this strengthens the union. After the top of the stub heals over the scion is very securely anchored and practically safe from breaking out.

The inlay bark graft method is illustrated in Figure 12, and directions for the successive steps are given below.

In order to have a stock free from splits and peeled bark, remove the upper portion of the branch by making two cuts. In making the preliminary cut, saw from the under side of the stock until danger of splitting has been avoided, then complete the cut from above. The second cut is made 6 to 12 inches below the first by sawing straight across the stub so as to leave a smooth surface. The stub should be held with one hand during the last saw strokes to prevent any peeling or splitting of the bark.

Smooth the end of the stock lightly with a knife and then remove the scaly, dry bark at the location selected for setting the scion. If the stock is larger than 2½ inches in diameter a second scion should be set opposite the first; if larger than 4 inches, a total of three or more scions should be set. The extra scions aid in healing the top of the stock and also increase the probability that a living graft will be obtained. If the stock is cut just above a small branch or dormant bud, the growth of either of these will serve the purpose of keeping the stock alive and healing the wound. To make the graft proceed as follows:

(a) Cut the scion to a straight bevel on one side and to such length that the part that is to extend beyond the end of the stock is from 2½ to 3½ inches long, according to the diameter of the scion.

(b) Cut the tip end of the bevel square across where it is about ⅛ to 3/16 inch thick, according to the diameter of the scion.

(c) Hold the beveled side of the scion against the smooth bark on the stock in the position in which it is to be set. In this position about ½ inch of the apical end of the bevel surface should extend beyond the end of the stock. Inscribe the pattern of the scion on the bark of the stock with a knife blade.

(d) Remove the bark within the inscribed lines so as to make a recess into which the scion will fit snugly.

(e) Place the bevel of the scion into the prepared recess and fasten with two nails, one driven near the end of the stock and the other near the lower end of the scion. The nails may be started into the scion before placing it in the slot. Flat-headed nails of gauge No. 18 or 19 and ¾ inch long are suitable for average size scions.

(f) Cover the exposed areas, including the end of the scion and the end of the stock, with melted

grafting wax. (Grafting wax No. 3, page 60).

Scion Wood. Since the buds are not removed from scion wood the selection of the wood is not so difficult as that of bud wood. Mature shoots of one—or two-year-old wood of relatively large size, ranging from ⅜ to ½ inch in diameter, are generally selected for scion wood. These should be taken from vigorous trees. Poorly developed shoots or the immature terminal ends of shoots should not be used. Dormant scion wood from cold storage is used almost exclusively for bark grafting. After the wood has been taken from cold storage it should be used before the bark will peel. Scion wood is stored in the same manner as bud wood. See page 34.

Size of stocks. The bark graft is best suited to stocks ranging from 1½ to 3 inches in diameter. Stocks smaller than 1 inch in diameter can be budded faster than they can be grafted. Stocks larger than 4 inches in diameter are objectionable because the wounds are difficult to heal. However, where there is no alternative, stocks considerably larger than 4 inches in diameter may be grafted provided several scions are set on each stub.

When to graft. Bark grafts may be made at any time when the cambium of the stock is active, but it is usually considered inadvisable to continue grafting later than 45 days after the bark can first be peeled in the spring. In the early part of the season more stored plant food is available to the grafts and they also have a longer growing season than those set later. Some of the disadvantages in grafting after the tree is in full leaf may be enumerated as follows: (1) The growth processes are suddenly checked in proportion to the amount of leaves removed when the stock is cut, and the checking of the sap flow may result in sunscald if the weather is hot and sunlight strikes the bark. (2) Weakening of the tree will result from the development of new shoots and leaves. (3) The growth of scions set late is usually poor for the above reasons.

When grafts are made under conditions where the cambium is very active and the sap flows strong, bleeding may result in the same manner as in budding and may cause the scions to die. This is especially true if the entire top of the tree is removed. For this reason, if it is necessary to graft trees when bleeding is likely to occur, some of the branches should be left to counteract this trouble by drawing upon the sap flow.

Aftercare of grafts. One of the distinct advantages in bark grafting lies in the fact that the scion will make its initial growth without the procedure of forcing which is necessary in budding. There is no need of visiting a graft until about three weeks after it has been made. At this time the scion should have started growth if the operation was successful. Seedling sprouts will be found starting on the stock, and none of these should be allowed to crowd the scion or interfere with its proper direction of growth. At the same time, the development of some leaves other than those of the scion should usually be allowed, the number depending upon the amount of growth

on limbs not cut away, the size of the tree, and the time in the season. As a general rule, if more than half of the top was removed in grafting, ample foliage may be provided by allowing sprouts to grow on the trunk of the tree and on the stocks where they do not interfere wtih the scions. On small trees it is usually not necessary to leave many sprouts for this purpose.

The elimination of the seedling growth should be accomplished gradually. If the trees are small so that only one to three grafts are used to make the new top, most or all of the seedling growth may be removed at the end of the first season. In large trees it is usually advisable not to remove all seedling growth until the end of the third season. (See **Topworking Large Trees by Grafting**, page 57).

After the grafts start growth the resulting shoots may grow so rapidly that they become top-heavy and break out. This may be prevented by tying the shoots to stakes, or the tips of the shoots may be pinched out during the growing season.

Healing the wounds. A stub that extends an appreciable distance beyond the last growing branch soon dies. For this reason the scion should make a union at the end of the stock on which it is placed. The extension of the scion bevel beyond the end of the stock causes the new bark and wood to form over the end of the stock as the scion grows. If the stock is not over 2½ inches in diameter, one graft will heal the wound in due time. If the stock is from 2½ to 4 inches in diameter it is necessary to provide an additional scion or a seedling branch on the opposite side to keep the stock alive. This scion or branch should not be allowed to grow as rapidly as the first and its growth rate can be regulated by cutting it back occasionally. When the wound has healed this scion or branch should be sawed off flush with the end of the healed stub. If a stock larger than 4 inches in diameter is grafted 3 or more scions should be used. All but one of these should be dwarfed by cutting back and should eventually be removed when the end of the stub has healed over since their function is to help heal the wound.

The Modified Inlay Bark Graft Method

A modification of the inlay graft is recommended for stocks less than 1½ inches in diameter because it is difficult to nail the small scions that must be used on such stocks. This form of the bark graft differs from the inlay graft in that the tip of the scion bevel is not removed but is inserted underneath the bark after being properly trimmed to expose the cambium, and the thick upper part of the beveled scion is fitted into a slot, as in the inlay method. Directions for making modified inlay grafts are explained below and illustrated in Figure 13:

(a) Cut the scion to a long bevel.

(b) Hold the bevel of the scion against the smoothed bark of the stock and mark the outline of the upper half on the stock with a knife blade. Remove the bark so as to make a slot that will accommodate the upper half of the bevel

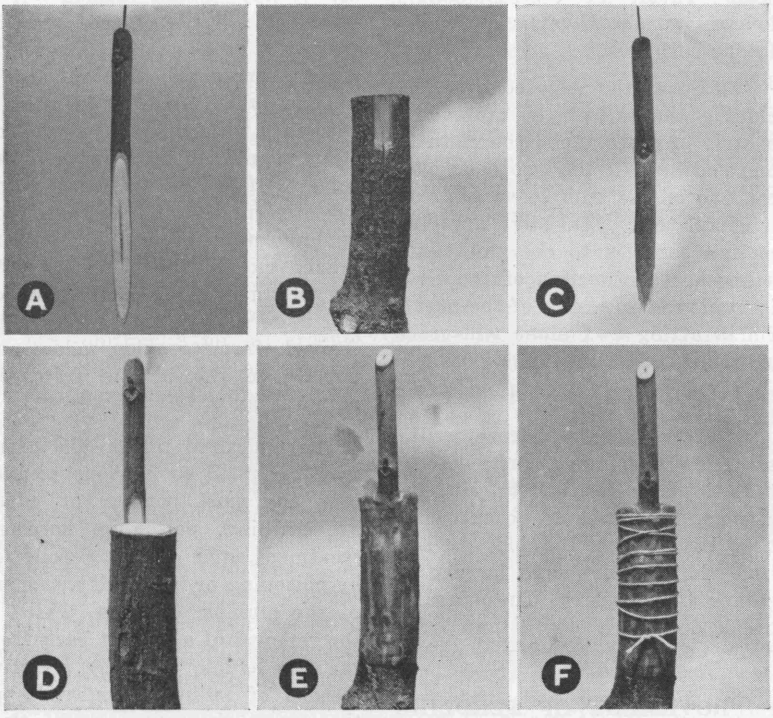

Figure 13. Successive steps in modified inlay grafting. A, Cut the scion to a long bevel. B, Hold the bevel against the smoothed bark of the stock and mark the outline of the upper half on the stock with a knife blade. Remove the bark so as to make a slot to accommodate the upper half of the bevel of the scion. Make a short longitudinal incision through the bark at the lower end of the slot and halfway between its sides so the bark will part when the scion tip is pushed beneath it. C, Trim the bark on the scion bevel so as to expose the cambium on the bark of the tip. D, Insert the scion in the prepared slot and push the tip underneath the bark along the incision below. About ¼ to ½ inch of the bevel should extend beyond the end of the stock depending on the size of the stock. E, Cover the exposed area, including the top of the stub, with a strip of cloth. Split the cloth at one end and lap over the end of the stub so as to cover it completely. Seal by applying melted paraffin to the cloth with a brush. F, Tie with strong twine.

of the scion. Make a short incision through the bark at the lower end of the slot and halfway between its sides so as to allow the bark to part as the scion tip is pushed underneath it.

(c) On the lower half of the bark side of the bevel of the scion trim the bark from the edge of the wood so as to expose the cambium at the tip in such a manner that it will contact the cambium of the bark of the stock when the scion is inserted underneath it.

(d) Insert the scion in the prepared slot and push the tip underneath the bark along the incision below. On small stocks the scion should extend beyond the end of the stock about 2 inches, and about one-fourth inch of the bevel should be exposed. On larger stocks the

scions should be correspondingly longer and the bevels exposed up to one-half inch.

(e) Cover the exposed area, including the top of the stub, with a strip of cloth. Split the cloth at one end and fit the two ends over the end of the stub so as to cover it completely. Seal by applying melted paraffin to the cloth with a brush. The function of the cloth is to prevent cracking of the paraffin. Grafting wax alone will crack on this type of graft.

(f) Tie with strong twine.

Aftercare. The aftercare is the same as for inlay grafts except that it is necessary to cut the strings. These should be cut when they have begun to bind. At this time the shoots should be tied to stakes if necessary. These grafts break out more easily than inlay grafts since they are not nailed.

IMPROVEMENT OF SEEDLING PECAN GROVES

Clearing and Thinning

The pecan is similar to other trees in that it responds favorably to practices that increase or maintain soil fertility, conserve soil moisture, and provide ample space and sunlight for the development of the trees. The purpose of clearing a pecan grove is to remove competing undergrowth and trees other than the pecan. Several methods of clearing may be followed but in all cases the eventual elimination of stumps and sprouts should be accomplished. A clean ground surface facilitates harvesting of the nuts and may aid in the control of certain insects and diseases. It also makes possible the use of any of the various implements of soil tillage that may be desired. A great number of seedling groves should probably remain in sod, in which case it is usually necessary to keep down weeds and other vegetation by mowing at intervals. If weeds are kept down, pasture grasses and legumes may become established and if these are grazed closely they compete with the pecan trees less than weeds and undergrowth, and the revenue derived from grazing adds materially to the income from the orchard land.

The undesired timber and brush may be killed by various procedures the most popular of which are girdling, poisoning, kerosene treatment, and grubbing followed by poisoning or kerosene treatment of the stumps. Girdling, which is the removal of a ring of bark from the tree trunk, is an effective method of killing large trees but the trees die more slowly than those poisoned. It is not a suitable method for killing bushes since they tend to sprout below the points of girdling. The best way to kill small trees up to 4 inches in diameter is to pour kerosene oil on the bark in late spring or early summer, completely covering the bark of the trunk for a distance of one foot above the ground. If the trees are cut in winter, the kerosene is poured on the stumps at the time of cutting. From one-fourth pint to one quart of kerosene should be used per treatment, depending on the size of the stump, after which the soil should be drawn back over the stump.

If poison is to be used for killing large trees, the following for-

mula will be satisfactory:

White arsenic (Arsenic trioxide)	**1 pound**
Lye	**2 pounds**
Water	**4 gallons**

In making this solution, first dissolve the lye in one gallon of water. Make a paste of the white arsenic by adding water and stirring. Add the paste to the lye solution slowly to prevent excessive boiling. Do not breathe the fumes given off by the hot solution. After all arsenic has been added and the boiling has ceased the volume is brought to 4 gallons by adding water.

The best time to poison trees is in mid summer. The solution is applied in a continuous ring of shallow downward axe cuts completely circling the tree trunk and penetrating the wood. The best absorption is secured when the solution is poured into the gashes immediately after the tree has been girdled. Pecan trees may not show much effects of the poison until the second season after it is applied.

Livestock that are salt hungry may lick treated trees, though this does not happen often. No cases are known where livestock have been poisoned in this manner, as the lye makes the poison unpalatable; however, as a precaution, it may be advisable to keep livestock away from the trees for a week or ten days after the poison is applied.

If the undesired timber in a pecan grove is small it is often desirable to have it grubbed out and to follow with pasturing and mowing. Such vegetation as livestock will feed on may be killed by this method and the other sprouts may be killed with kerosene as described above. Grubbing removes undesirable sprouts from the pecan grove quicker than any other method of clearing. In some cases the timber removed from the grove will pay the expenses of clearing and grubbing if sold as cordwood.

After the other timber has been removed from the grove the stand of pecan trees may need thinning. Before the stand is thinned it should be decided whether the trees are to be left as seedlings, or top-worked to varieties as a whole or in part.

Each seedling tree is different, and in the average grove there are some trees bearing nuts of good size and high quality and others that produce small nuts, or nuts inferior in percentage or quality of kernel. It is advisable to retain the good seedling trees. Before any bearing tree is top-worked it should be remembered that topworking is expensive and that there will be an interval of several years before any nuts will be produced. It should also be remembered that the difference in price of nuts of the varieties and good seedlings is constantly becoming less. Often a seedling tree is a heavy bearer and the difference in yield may offset the price advantage of a variety that yields less. Finally, there is the possibility that a variety will not be adapted to local conditions of soil or climate. Many varieties are more susceptible to fungus diseases than the seedlings of that locality. The grouping of large numbers of trees of the same variety helps to propagate virulent strains of fungi, so that the possibility of infection

is increased. In general, there has been less trouble with fungus diseases, and topworking has been more successful in the western part of the state than in the eastern and southeastern regions. This is due in part to the fact that the various fungus diseases are more severe in the humid climate and in part to the fact that pecan trees generally occur in smaller groups in the western part of the state.

Under conditions where thinning is necessary the least desirable trees may be removed, leaving a grove that produces a superior grade of seedling nuts. This practice is to be commended where the advantages of topworking are in doubt. The grower usually receives no more for small quantities of superior seedling nuts than for those of general orchard run, but if he has a large quantity of the superior nuts he may expect to receive a better price for them.

When a seedling grove is first cleared of a heavy growth of timber it is usually desirable to allow the pecan trees to become accustomed to the changed conditions during a period of several years before much, if any, additional thinning is done. This will allow time to observe the individual trees as to the quantity and quality of nuts they produce and will also allow time for branches to develop on the trunks of high headed trees. After this has taken place, the trees that were formerly devoid of branches except at the top of the tree will be in a much better condition for topworking, or for bearing large crops in case they are not topworked. Of course, if the trees were not greatly crowded before clearing, this period of adjustment is unnecessary.

In the average seedling grove the trees are spaced irregularly and are of various sizes, which often makes it difficult to decide which trees to remove. If none of the trees are to be topworked it is generally considered much more important to retain the most desirable trees from the standpoint of vigor, quality of nut, and yield than to obtain the best spacing. A clump of 2 or 3 trees will produce well if surrounded by sufficient open space to provide for the feeding roots. The tops of such a clump of trees will eventually develop into the shape of a single large tree. However, if it is planned to topwork some or possibly all of the trees in the grove the selection of trees for removal should be made so that the remaining trees will be spaced as uniformly and regularly as is possible.

Selection Of Trees For Topworking

Trees in pecan groves vary so greatly that the exercise of good judgment is of more importance than any set of rules in deciding which trees to topwork. In case the grove consists altogether of non-bearing young trees, the cost of topworking is so small that it is profitable to include temporary trees between trees selected for the permanent stand. These temporary trees may be removed from the grove when the permanent trees are large enough to occupy all the space.

If the grove consists of a mixture of bearing and small trees it is possible to make grave mistakes in the selection of trees to

topwork. As a rule it is considered much wiser to topwork a tree 12 to 24 inches in diameter, if it is suitable for topworking, than to cut it down to make room for a small tree. When the top has been reestablished on a tree one foot in diameter a yield of 25 to 50 pounds of nuts should be obtained as a moderate crop, while a tree two feet in diameter should produce more than 100 pounds under similar conditions. Ordinarily it requires from 15 to 20 years for a 2-inch tree growing under sod conditions to attain a diameter of one foot, and 30 to 40 years to grow to a diameter of two feet. Therefore, the labor or money spent in topworking the larger trees is usually more profitably invested than that spent in topworking small trees. It is only when a large tree is dangerous to climb, failing in vigor, or has a frame ill-suited to topworking that its removal to make room for a small tree is justified. Of the bearing trees selected for topworking, low yielding trees or those that bear nuts lacking in quality should be topworked first, but only those trees that are healthy should be selected for topworking regardless of their size.

Topworking Large Cut-back Trees By Budding

In most cases it is impractical to set buds in the large branches of pecan trees. For this reason such trees are headed back and buds set on the shoots that develop on the stubs. This method of topworking is simple and conflicts little with other farm labor at the time the various operations must be performed, and is recommended for general use by growers.

Cutting back the trees. The decision as to where to cut off the branches is important and requires some study of each tree before the operation is started. In most cases it is desirable to retain as much of the framework of the tree as can be done without difficulty in climbing and without risking the breaking of branches with the consequent danger to the workman. Trees should not be cut back severely in preparation for topworking. The reasons for this are as follows: (1) The object of topworking is to obtain a greater income from the tree. The income from the tree will depend upon the size and bearing capacity of the new top as well as the price per pound of the nuts produced. The less severely a tree is cut back the more quickly the top is rebuilt, and the sooner it will produce profitable crops. (2) A wound of 4 inches or less in diameter heals readily while larger wounds may result in damage by wood-rot fungi due to the difficulty of healing the larger wounds. The more severely a tree is cut back the greater the number of the large wounds. (3) A large stub has a thick bark and the shoots that come through it can not readily push the bark aside; as a result many new branches become bottle-necked at this point and are easily broken out. The pinching also favors entry of wood-boring insects at the base of the shoot which may damage them to such extent that they break out. These difficulties may be largely avoided by removing the thick bark with a chisel, but this is an expensive and tedious operation. A small stub has a thinner bark and the sprouts are much better anchor-

ed. (4) The less severely a tree is headed the more leaf area it will have, and consequently the food reserves of the tree are more nearly maintained so that the vigor of the tree is not greatly disturbed by the topworking process. (5) A tree top may be sawed out in less time and with less labor by cutting where the branches are small. (6) Small branches are easier to remove without splitting the stubs than large ones.

It is not intended to assert that branches should always be cut off as far out on the tree as it is possible to climb. It may be desirable to cut some branches shorter in order to keep the frame of the tree reasonably symmetrical, or in case of tall trees it may be desirable to reduce their height. However, severe cutting of a tree merely to save labor in budding is never justified. After the propagator has climbed into the tree it is relatively little more work to set or care for the additional buds required for the tree that is cut back properly. Under ordinary circumstances the value of the tree per additional bud established in topworking is much greater than the cost. The individual who reduces the labor of budding by cutting back his trees too severely will likely find that he has reduced the yield of nuts in much greater proportion that the saving in labor.

In cutting back a tree for topworking, the points at which the branches are cut off can be de-

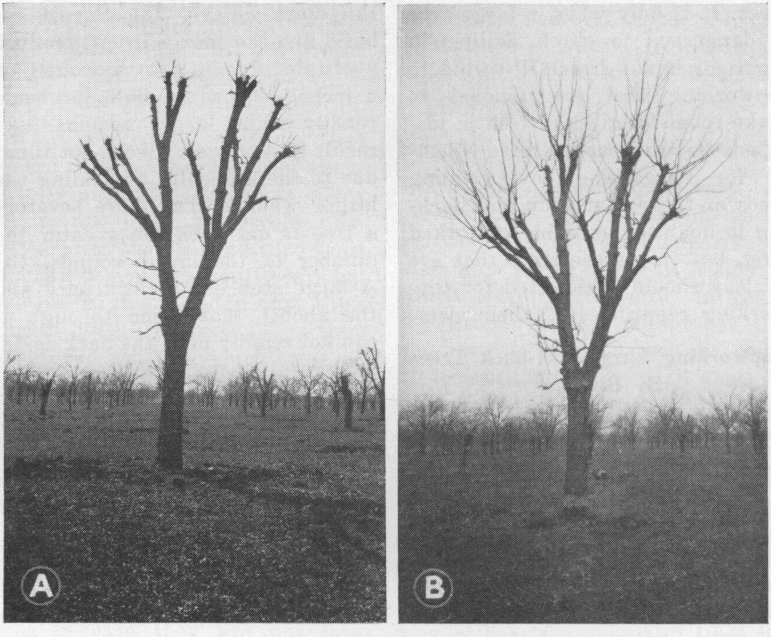

Figure 14. A tree 16½ inches in diameter topworked by budding. A, Tree cut back in March, and sprouts budded the following August. Photographed in March of the next year after seedling growth was cut back. B, Same tree photographed one year later showing growth of budded top and the seedling growth cut back.

Figure 15. The development of trees topworked by budding. Photographed 6 years after cutting back. A, Same tree as shown in Figure 14 which was cut back properly. The largest cuts made in cutting back were not over 4 inches in diameter and have healed. B, Tree 18.3 inches in diameter, same age and cut back and budded at same time as tree A. The average diameter of wounds made in cutting back was 6 to 8 inches. Wounds have not healed due to wood rot and new top is too small for profitable nut production. This is typical of results of cutting back trees too severely.

termined after climbing into the tree; however, a study of the tree from several angles before climbing it often aids the workman in his decisions. The lower branches should be removed first so that the upper branches may fall without obstruction. To avoid splitting the stubs a branch should first be sawed from the lower side until the saw begins to bind and then finished from the upper side. Before making any cut, the convenience with which the resulting stub may be reached for budding and pruning should be considered. A location that is easy to reach with the saw may be inaccessible to the propagator since he must get close to the end of the stub. In branches extending outward horizontally, or upward at an angle, the cuts should be made about 2 feet above a fork, using the fork as a saddle in which to sit. Most of the upright branches should be cut so that the stubs can be reached conveniently for budding and pruning by standing in a fork below. If possible the cuts should be made where the branches are less than 4 inches in diameter. A tree that was properly cut back is shown in Figure 14, and one that was cut back too severely is shown in Figure 15.

It is desirable to have a symmetrical cone-shaped framework of branches after the tree has been cut back, but it is of far greater importance to make small cuts that heal readily and to make cuts at points readily accessible for the work that is to follow. The new top will grow into a ball-shaped form in due time even though the framework of the cut-back tree is only partially symmetrical.

All branches in the upper part of the tree should be cut back, but near the lower part of the tree small branches that are not to be budded may be left to supply additional leaves.

Cuts larger than 2 or 3 inches in diameter should be protected with a coat of preservative paint or wound dressing. In Western and Central Texas small cuts do not require this protective coat since experience has shown that such cuts heal satisfactorily without such treatment. However, in regions of high rainfall all wounds probably should be protected.

Trees may be cut back at any time during the dormant season. After the sap begins to rise in the spring bleeding will occur where the cuts are made. This may not greatly harm the tree, but it should be avoided where possible.

Treatment of sprouts. After the tops have been cut back the trees are usually not visited again until the time they are to be budded. However, the propagator will profit by giving some attention to the developing sprouts. If a large number of sprouts are produced on a stub none of them may grow to a size suitable for budding in the summer. In such cases the sprouts should be thinned when they are about one foot long, leaving 4 to 8 per stub, according to the size of the stub. Only the sprouts from 1 to 2 feet back from the ends of the stubs should be thinned. The heavy bark at the base of sprouts that are being pinched should be removed with a chisel or heavy knife. The sprouts on the trunk of the tree should not be disturbed at this time.

When to bud cut-back trees. The proper time for budding cut-back trees is during the first summer after the vigorous growth of the new shoots has subsided. Sprouts from small stubs start growth early and may be mature enough to bud by July 15, whereas sprouts from large stubs start growth later, owing to the thick bark of the stub, and are usually not mature enough to bud before August 15. Every effort should be made to bud trees during the first summer after they are cut back since this is the quickest and easiest way to reestablish the bearing tops. If budding is delayed until the following spring the development of the top is delayed by almost a year.

At the time the strings are cut from the buds set in the summer, the shoots on which buds have died may be re-budded. If the sprouts are no longer in condition for budding at this time they should be budded the following spring and the buds forced immediately.

Budding the tree. Current-season buds put on by the patch-bud method are generally considered most satisfactory for budding cut-back trees, but buds from cold storage

may also be used successfully. One bud should be set about 8 inches from the base of each shoot budded. If the tree is still growing at a moderate rate, as indicated by free slipping of the bark on the small shoots, each budded shoot should be cut off at such a distance that 4 leaves remain above the bud. The buds in the axils of these leaves should also be cut out at this time. The object of these procedures is to force a large percentage of the transplanted buds into growth and to prevent the strings from binding too soon.

If the tree is no longer growing vigorously at the time of budding, as will be indicated by failure of the bark to slip on the smaller sprouts, it is better not to cut off the budded shoots to force the buds until the following spring.

In budding cut-back trees a sufficient number of shoots should be budded to insure the necessary branches for the new tops. It is unusual for all buds to live and there is usually some loss of buds that start growth. If all the buds grow they may be thinned if necessary. Ordinarily from two to four shoots per stub should be budded, depending on the size of the stub. This will usually insure enough branches for the new top, and thus will not only eliminate the labor of re-budding the tree but the top will develop more uniformly.

Aftercare of the budded tree. During the first winter after the tree is budded all shoots other than those with transplanted buds or shoots that may be needed for re-budding, should be cut to stubs about 3 inches long. Shoots on which the transplanted buds were forced out the previous summer should be cut off about 2 inches above the buds, and shoots on which the transplanted buds are dormant should be cut off 4 to 6 inches above the buds. All seedling buds on the budded shoots should be rubbed off. This will help to force the transplanted buds into growth in the spring.

Shortly after the buds have opened in the spring, or when the shoots are about one inch long, it is again necessary to remove all seedling growth from the budded shoots. This operation should be repeated at 10-day intervals until all transplanted buds have produced shoots at least 3 inches long. No seedling sprouts should be removed from the trunk of the tree during the spring or summer, as these produce leaves necessary to keep the tree in good condition. If the shoots grow rapidly it may be necessary to pinch out the tips when the shoots are about 10 inches long to prevent breakage by winds. This will also cause the shoots to branch, which is desirable in forming a compact new top in the tree.

During the second winter all seedling sprouts should be cut back to short stubs. At the same time all necessary pruning of bud growth should be done. Buds that have made a single long shoot should be cut back to cause desirable branching, thus preventing them from becoming top-heavy, and bad forks should be corrected by proper pruning.

The tree requires no attention during the second summer. At the end of this year's growth the budded top should be large enough to

supply the foliage that the tree needs. Therefore, during the third winter all seedling branches should be sawed off flush with the bark of the tree. A few sprouts will appear the next spring, but these may be neglected as they will eventually be choked out. If a few stubs have no transplanted buds growing on them they usually may be sawed away without unbalancing the new top.

While pruning the tree during the third winter all branch stubs should be cut back to the uppermost budded shoot, sloping the cut from the shoot downward to the opposite side. If the branch is larger than 3 inches in diameter the cut surface should be covered with a suitable wound dressing.

Topworking by Budding Trees Not Previously Cut Back

When a tree is topworked by budding the shoots that develop from cutback stubs practically the whole growing season of the first year is past before the buds can be started into growth. If the buds are set directly into the rough bark of the branches during the season before the tree is cut back, the buds can be forced into growth the next spring. In this way it is possible to obtain the nut crop from the trees in the year they are budded, and to develop a new top almost as quickly as cutting back the top prior to budding.

Budding trees prior to cutting them back is not practical for all kinds of trees. It is best suited for well branched trees of 2 to 12 inches in trunk diameter. On such trees branches small enough for budding may be reached without difficulty, which may not be possible on larger trees.

The buds may be set at any time the bark slips on the branches, which usually is from the beginning of growth until July in seasons of average rainfall. The bark of the stock should be pared thin and the buds put in by the patch bud method. It will be necessary to use buds from large sticks as smaller bud patches will not fit on the relatively large branches budded. Two buds should be set on each branch in order to allow for buds that fail or break out. On small trees it is usually not necessary to bud every branch. The strings should be cut about 4 weeks after budding. Any necessary re-budding should be done at this time, or at least before the end of the budding season.

If buds are set soon after growth starts in the spring, they may be forced immediately. For this purpose cold storage buds from one-year-old wood are desirable. If the buds are to remain dormant until the following spring, two-year-old budwood, either from cold storage or freshly cut, is preferable to one-year-old wood.

During the winter following budding all the budded branches should be cut back to about 6 inches beyond the transplanted bud, and all other branches should be cut back considerably in order to force the buds properly. After the branches are cut back to force the buds, the aftercare is the same as for trees with the tops cut back previous to budding except that in most cases all seedling shoots may be removed the second winter unless the trees are large.

Topworking Large Trees by Grafting

Large pecan trees may be topworked by cutting back the branches and setting grafts on the stubs. The trees may be cut back in the winter or the branches may be cut at the time of grafting in the early spring. When the trees are cut back in winter, they should be grafted in early spring. If the grafting is delayed sprouts will grow out on the stocks and will have to be removed to prevent them from interfering with the union and growth of the grafts. In grafting trees previously cut back, the stocks must be re-cut, sawing off at least 6 inches of the ends, and allowance should be made for this additional length at the time the tree is cut back.

If the trees are cut back at the time of grafting, some uncut branches should be left on the tree, and the later in the season the trees are cut back the more of these branches should be left. If too much of the top is cut off after the tree is in full growth the sudden checking of the sap flow, combined with the exposure of the trunk and branches to the sun, will likely result in sunscald. Very large trees that are to be grafted should be cut back completely in the dormant season because they are not adapted to the method of leaving part of the branches. On such trees the branches that are sawed out often lodge on the branches left below. Also when the latter branches are removed later they may fall on and break some of the grafts.

Aftercare of grafted trees. It is generally a good practice to tie all rapidly growing grafts to stakes to insure them against breaking out during windstorms. Plaster laths make good stakes for this purpose and can be nailed securely to the grafted stubs. In case it is impractical to provide stakes for this purpose, the tips of the grafts may be pinched out when they are about 12 to 18 inches long. This causes branching and thickening of the scions and a better union, which prevents them from breaking out easily. Scions that are nailed to the stocks, as in the inlay bark graft method, seldom break out if they are judiciously pruned back during the first year, since they usually make a strong union before the end of the first season.

During the first winter after the trees are grafted all seedling sprouts on the stubs should be cut back to about 3 inches in length, except sprouts on stubs where the scions failed to grow and which may be budded in the spring. Seedling sprouts on the trunks of the trees should be cut back to about 3 or 4 inches in length. Any bad forks should be corrected by pruning. Where two or more scions are growing on the same stub, all but the most desirable one should be cut back but not removed.

During the second winter the trees are handled the same way as during the first winter. During the third winter all of the seedling growth should be sawed off flush with the bark of the parent branch and all unnecessary scions should be sawed off even with the new bark that is growing across the ends of the stubs. As a rule, the grafted top will be sufficiently developed by this time to choke out

any seedling branches that start growth, and the topworking is considered finished.

Topworking Trees Less Than Three Inches in Diameter

Trees with trunks less than three inches in diameter at a height of five feet require only one bud or scion each to form new tops of the desired variety. However, it is good practice to set two buds or grafts on each tree so that if one fails to grow there will still be one to form the new top. If both buds or scions grow, the least desirable one may be removed at the end of the first growing season, since two upright shoots on the same stub usually form a weak crotch.

Trees with trunk diameters less than 1½ inches are usually budded, but if the trunk diameters range from 1½ to 3 inches bark grafting is probably more desirable than budding because the trees are easy to graft and the procedure of forcing is practically eliminated. The time for budding or grafting of small trees and the methods of forcing and aftercare of the buds or grafts are the same as for large trees.

Small trees accessible to livestock. The greater number of small seedling pecan trees to be topworked are on land that is pastured. Under such conditions the damage that may be done to the buds or grafts, or to the trees themselves by livestock is an important consideration and it is usually advisable to delay the topworking until the trees are large enough to be budded or grafted at a height of 5 feet from the ground. When the trees attain this size the buds or scions may be set and the lower branches left as barriers to livestock. Sometimes the top that is cut from a small tree is tied to the trunk lower down to keep livestock away from the buds or grafts.

If the trees are in clusters the one nearest the center may be topworked and those on the outside left as protection. The branches next to the topworked trees may be cut back so as to prevent crowding. Livestock are more likely to be attracted by trees that are cut back than those left growing naturally and the surplus trees in the clusters can be removed after those that are topworked have grown out of reach of the livestock.

The branches of a small tree below the point of topworking should be retained temporarily, whether needed for protection from livestock or not. The shoot from the bud or scion alone is incapable of producing as many leaves the first year as the tree needs. The seedling branches may be cut back to one-half their length during the first winter after the trees are topworked. The next winter they should be sawed off flush with the trunk of the tree.

Small orchard trees. Small orchard trees to be topworked include nursery grown trees that have sprouted from below the bud or graft, transplanted seedling trees, and seedlings grown in the orchard. Since it is desirable to head orchard trees low, these trees should be topworked when they are small. Probably the best method of topworking such trees is to set two current-season buds in the central leader of each tree

as soon as rapid growth has subsided (about July 1), and leave the buds dormant until the following spring. This procedure disturbs the growth of the tree very little since no leaves or branches are removed at the time of budding, and very little of the seedling growth need be removed to force the buds in the spring. These trees may also be budded in early spring and the buds forced immediately, if desired.

EQUIPMENT FOR PECAN PROPAGATORS

The pecan propagator should be equipped with the following articles: Budding apron, twine, pocket knife, grafting knife, parallel-blade budding knife, whetstone, pruning shears, one or two saws, saw file, waxed budding cloth, grafting wax, wax melter and brush. The apron and some of the tools are illustrated in Figure 16.

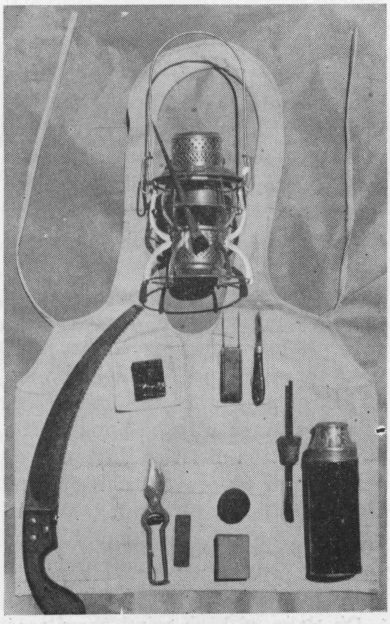

Figure 16. Apron and some tools and equipment of pecan propagators.

Parallel-blade budding knives may be purchased from nurserymen or hardware stores. A less satisfactory knife may be made by fastening two safety razor blades in a block of wood. The blades should be about one inch apart.

A small curved saw with seven teeth per inch is easily carried and is suitable for making ordinary small cuts. A large curved saw with five teeth per inch is preferable for cutting back trees. Some propagators use straight saws manufactured especially for making the larger cuts. The saw teeth need setting occasionally and should be kept sharp at all times. Sawdust tends to adhere to the saw blade when sawing green pecan wood, eventually causing the saw to bind. This difficulty may be overcome by occasionally applying water to the saw blade with an oil can.

Grafting Waxes

There are two general classes of grafting waxes: (1) those that are soft at ordinary temperatures and are applied with a paddle or with the fingers, and (2) those that are too firm or hard to apply at ordinary temperatures but are melted and applied while hot with a brush. The soft waxes are disagreeable to use because they stick to the hands, tools, and clothing. Therefore, most propagators use the hard waxes and apply them from a melter or from a vacuum bottle.

Formulae for grafting waxes.

Soft Grafting Wax No. 1

Rosin .....2 pounds
Beeswax .....1 pound
Grain alcohol (95%) 1 to 3 oz.

Melt the beeswax, then add the rosin. Stir until the rosin dissolves. After the wax has partially cooled, pour in some of the alcohol and stir. Sample the wax with a stick. Continue to add alcohol, a little at a time, until the wax is of the desired consistency.

Soft Grafting Wax No. 2

Rosin	**4 pounds**
Beeswax	**2 pounds**
Tallow	**1 pound**

Melt the tallow, then add the beeswax, and finally the rosin. This wax is often used for the preparation of cloth for budding. A softer or harder wax may be made by varying the proportion of tallow in the formula.

Grafting Wax No. 3

Rosin	**10 pounds**
Beeswax	**2 pounds**
Filler	**1 pound**

Melt the rosin and beeswax together. Then stir in the filler, for which use kiesselghur (Celite No. 110) or talcum powder (purified talc). This wax is especially good for use in sealing inlay bark grafts, and is applied in the melted state at a temperature approximately that of boiling water (212° F.). Kiesselghur is preferable to talcum powder as a filler because it does not settle out when the wax is melted.

Paraffin makes a good melted wax for sealing buds but is not suitable for grafts except when applied to a cloth covering because it tends to crack. Paraffin should not be used where it will be exposed to the hot summer sun as it will melt and in this state will likely injure the cambium.

Waxed Cloth

Waxed cloth for sealing buds is generally made by dipping strips of worn broadcloth shirts or bed sheeting into melted wax. The wax must be hot when the cloth is dipped into it. The surplus wax is drained from the cloth by drawing the cloth strip between two boards held over the wax container. Paraffin is used more than any other wax for preparing budding cloth, but some propagators do not like it for spring budding because it will not stick to the bark in cool weather. A sticky budding cloth may be prepared by using the No. 2 wax described above.

The Wax Melter

Excellent factory-made wax melters are on the market and are to be recommended for those propagators doing considerable budding or grafting. However, the cost of these melters may be prohibitive for propagators who do only a little propagation. Therefore, the following directions are given for making a melter at home: Remove the top from an ordinary kerosene lantern. Select a narrow tin can that will fit into the opening and reach about half-way down to the wick. Insert the can into the top of the lantern and fasten with wire. A one-inch varnish brush is used for applying the melted wax. Drive a nail into the handle so that the brush may be hung in the cup with the bristles just off of the bottom to prevent the bristles from getting over-heated. If no suitable container is available for the wax cup one can be purchased from a tinner.

On days of high wind the flame of the lantern may blow out re-

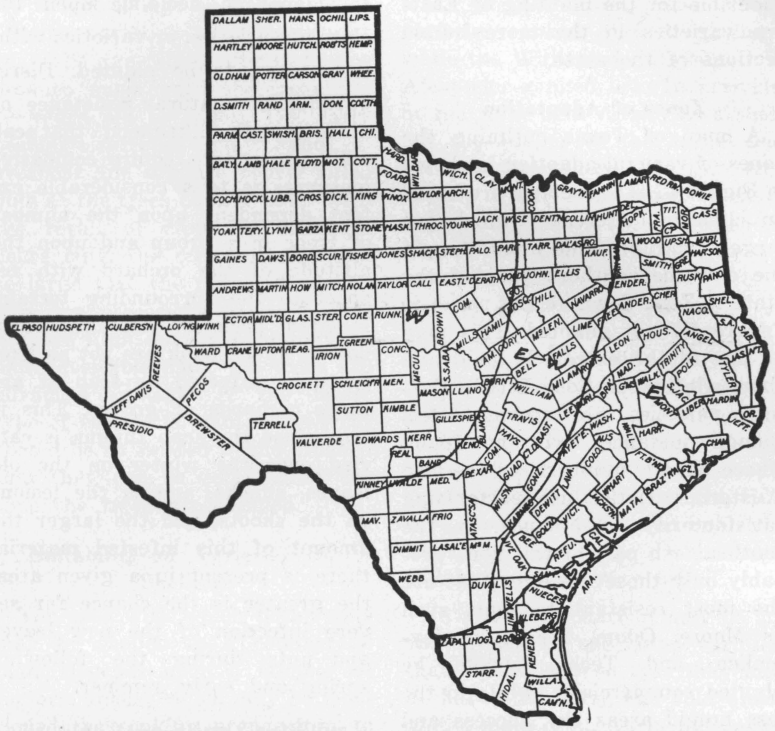

Figure 17. Map of Texas showing zones of variety adaptation. Zone E represents areas of relatively high rainfall and therefore eastern varieties are generally planted because they are more resistant to scab than Western varieties.

In Zone E-W both Eastern and Western varieties may be used except in certain lowlands where the humidity is high and where scab would attack western varieties.

In Zone W Western varieties may be used since in this area scab has not occurred to any appreciable extent. Eastern varieties also may be used in this area.

In the extreme southern part of the state is Zone S where pecans apparently are not adapted. This may be due to the extremely mild and short winters.

peatedly. This trouble may be overcome by setting the lantern into a heavy paper bag and tying the bag around the lantern near the top. Make a few small holes in the bag near the bottom to allow the entrance of air.

PECAN VARIETIES

The pecan varieties grown in Texas fall into two general classes, the Eastern and the Western. The Eastern varieties originated in the humid southern states from Louisiana to Florida while most of the Western varieties originated in the central and western part of Texas where the climate is relatively dry. The variations in climatic conditions in different parts of the state, and in some instances within the same section, largely govern the class of varieties adapted. Except in the eastern and southeastern parts of the state Eastern varieties have been much less susceptible to scab than the Western varieties, and this fact has been largely re-

sponsible for the planting of Eastern varieties in the more humid sections of the state.

Zones of Adaptation

A map of Texas outlining the zones of varietal adaption is shown in Figure 17. These zones are based on climatic differences which are largely rainfall and humidity. In the extreme southern part of the state is Zone S where the pecan is apparently not adapted. This may be due to the extremely mild and short winters. In Zone E only Eastern varieties are recommended, though instances will be found where small numbers of certain Western varieties are performing satisfactorily on uplands. In the southeastern part of this zone probably only those varieties that are the most resistant to scab, such as Moore, Odom, Stuart, Moneymaker, and Teche, should be planted commercially, while in the less humid areas the Success and Schley may be added to the list.

In Zone W the Western varieties may be grown without fear of being affected by scab everywhere except in the lower river-bottom lands.

In Zone E-W the selection of varieties should be based largely upon the experience of local growers, the number of trees to be planted together, and the fact as to whether the orchard site is on river-valley land or on upland with good air drainage. In general, the Western varieties are preferable for the uplands and the Eastern varieties for the river valleys. In this connection it is well to point out some features that should be considered in deciding upon the class of varieties, or varieties within a class, to be planted. Disregarding the natural resistance of a variety, the likelihood that scab will appear and require combative measures is to a considerable extent dependent upon the number of trees in a group and upon the altitude of the orchard with respect to the surrounding terrain. Isolated trees or trees along a narrow creek bank are not as likely to be affected by scab as are large orchards or groves. This is true since the scab fungus is carried over the winter on the old leaves, shucks, and in the lesions on the shoots, and the larger the amount of this infested material there is present in a given area, the greater is the chance for severe infection of the new leaves and nuts during the following spring and early summer.

While the Western varieties are unsuited to a humid climate, the Eastern varieties seem to be as well adapted to western as to eastern conditions. However, the Western varieties are generally preferred in the west when both production and quality of nuts are considered.

Within the northern part of all the zones discussed above except Zone S, there may be areas where frosts occur in early fall and for this reason varieties that ripen late, such as the Delmas and Oklahoma, should not be planted. In these areas also late spring frosts may necessitate planting of varieties that bud out relatively late in the spring.

Effect of Age on Bearing

Some varieties bear heavily at an early age while others do not produce much until the trees are 10 years old or older. The early bearing varieties may tend to overbear and produce poorly filled nuts as the trees become older with the result of crops in alternate years only, the crops often being so large that the nuts fill poorly. The less precocious varieties that produce high quality nuts may be more desirable after the trees are advanced in age. If the latter type of variety is planted the trees should be so located in the orchard that they can be retained at the time the trees are thinned.

Suitability of Varieties for Shelling

The ease with which pecan nuts may be shelled in a commercial plant depends upon a number of factors, among which may be mentioned the soaking preparatory to cracking, the type of cracking machine, the size and filling of the nuts, the shape of the nuts, the mechanical treatment of the cracked nuts before picking, and the skill of the picker. The thickness of the shell seems to be of little importance but shallow, open grooves in the kernel allow the shell and corky material to be released freely. As a rule, a symmetrical, oval-shaped nut cracks better than a lopsided nut or one that is very long or very round.

In preliminary tests of 30 of the commercial varieties, workers of the U. S. Department of Agriculture[2] found that the Onliwon, Delmas, Burkett, Schley, and Moore varieties ranked high as shellers, while the Williamson, Halbert, and Alexander ranked low. In arriving at the value of a variety as a sheller, the quality of the kernel and the productiveness of the tree should be given as much or more consideration than the ease of shelling. A nut with a shriveled kernel is not desirable, even though it may be easy to shell.

Ripening

Among the commercial pecan varieties there are a few that ripen early and a few that ripen exceptionally late. Among the early ripeners are Squirrels Delight, Halbert, Moore, Humble, and San Saba Improved, while the Delmas and Oklahoma ripen very late.

In a large orchard it may be advantageous to use some varieties that ripen early so that they may be harvested early and sold ahead of the main crop. Early nuts often bring a premium on the market, and the labor of harvesting is spread over a longer period. In a small orchard, it may be preferable to have all varieties ripening about the same time, whether early or late, so that less time and money is expended in guarding against crows or other depredators. Only early maturing varieties should be grown in areas subject to early autumn frosts.

Varieties

The important characteristics of some of the varieties adapted for Texas are listed. It should be pointed out that the bearing characteristics of trees, the size of the nuts, and the percentage of kernel of the nuts depend greatly

[2]Unpublished data, U. S. Pecan Field Station, Brownwood, Texas

upon growing conditions. The characteristics as outlined are for well filled nuts and may be considerably different from those of poorly filled nuts grown under unfavorable conditions.

Western Varieties:

Burkett. From Callahan Co., Texas. 40 to 60 nuts per pound. Kernel content, 54 to 58 percent. Kernel dark spotted but of excellent flavor. Round nut of distinctive appearance and, like Schley, is in considerable demand in the shell. Ripens in mid-season. Shuck is thick and slow to open after the nut is ripe. Relatively scab-resistant for a western variety, but foliage lacks vigor under some conditions. Nuts sometimes sprout on tree, which trouble is often associated with unhealthy foliage. Medium early bearer and moderately prolific. A leading variety where it is well adapted.

Clark. From San Saba Co., Texas. 60 to 80 nuts per pound. Kernel content, 53 to 56 percent. Kernel of good flavor and unusually bright and uniform color. Nut cracks well. Ripens past mid-season. An early and prolific bearer.

Halbert. From Coleman Co., Texas. 60 to 80 nuts per pound. Kernel content, 57 to 60 percent. Kernel flavor excellent, but keeping quality poor. Ripens early. Trees bear at early age. One of the most regular and prolific bearers of all varieties but often produces many faulty nuts. Very susceptible to scab.

Ideal. From San Saba Co., Texas. 55 to 75 nuts per pound. Kernel content, 54 to 58 percent. Kernel often of dark, unattractive appearance but good flavor. Ripens in mid-season. Early and prolific bearer.

Nugget. From Comanche Co., Texas. 80 to 100 nuts per pound. Kernel content, 56 to 59 percent. Ripens in mid-season. Shells almost perfectly. Kernels of attractive appearance and fairly good flavor. Not an early bearer but fairly prolific.

Onliwon. From San Saba Co., Texas, 55 to 75 nuts per pound. Kernel content, 58 to 61 percent. Kernel bright color and good flavor. Easy to shell. Ripens in mid-season. Prolific and early bearer.

San Saba Improved. From San Saba Co., Texas, 55 to 75 nuts per pound. Kernel content, 58 to 61 percent. Kernel of attractive appearance and excellent flavor. Ripens early. Late bearer but fairly prolific as trees become older. More resistant to scab than Halbert, Sovereign or Onliwon.

Squirrel (Syn. Squirrel's Delight). From San Saba Co., Texas, 50 to 70 nuts per pound. Kernel content, 53 to 56 percent. Flavor of kernel excellent. Ripens early. Tree relatively scab-resistant. An early and prolific bearer.

Sovereign (Syn. Texas Prolific). From San Saba Co., Texas, 50 to 70 nuts per pound. Kernel content, 52 to 55 percent. Kernel flavor excellent. Ripens in mid-season. Very susceptible to phylloxera and scab. An early and prolific bearer.

Western (Syn. Western Schley). From San Saba Co., Texas, 55 to 75 nuts per pound. Kernel content, 56 to 59 percent. Flavor and appearance of kernel good. Ripens before

mid-season. Bears early and is prolific.

Eastern Varieties:

Delmas. From Mississippi, 40 to 60 nuts per pound. Kernel content, 46 to 49 percent. Kernel light colored and of fair to good flavor. Ripens very late. Relatively late bearer but is prolific with increased age. Susceptible to scab in the southeastern and eastern parts of the state and to downy spot in most sections.

Mahan. From Mississippi, 40 to 60 nuts per pound. Nuts usually are poorly filled but when well developed often yield 53 to 57 percent of kernel. Ripens in mid-season. An early and prolific bearer.

Moneymaker. From eastern Louisiana, 50 to 70 nuts per pound. Kernel content, 47 to 50 percent. Quality and flavor fair to good. Precocious, prolific and nuts early in ripening.

Moore. From Western Florida, 50 to 80 nuts per pound. Kernel content, 47 to 50 percent. Kernel bright and of good flavor. Nut shells well. Ripens early. An early and prolific bearer. Vigorous grower.

Table 2. Table of Varietal Characteristics

Variety	Kernel content of well-filled nuts	Number of nuts per pound	Relative dates of Pollen Shedding	Relative dates of Stigma Receptivity	Relative time of season when nuts ripen
	Percent				
Western Varieties					
Burkett	54-58	40-60	Late	Early	Mid-season
Clark	53-56	60-80	Early	Late	Past mid-season
Halbert	57-60	60-80	Early	Late	Early
Ideal	54-58	55-75	Late	Early	Mid-season
Jersey	59-62	75-95	Late	Early	Mid-season
Nugget	56-59	80-100	Late	Early	Mid-season
Onliwon	58-61	55-75	Early	Late	Mid-season
San Saba Improved	58-61	55-75	Early	Late	Early
Squirrel	53-56	50-70	Early	Late	Early
Sovereign	52-55	50-70	Early	Late	Mid-season
Western	56-59	55-75	Early	Late	Before mid-season
Eastern Varieties					
Delmas	46-49	40-60	Late	Early	Late
Mahan	53-57	40-60	Late	Early	Mid-season
Moore	47-50	60-80	Early	Late	Early
Moneymaker	47-50	50-70	Late	Early	Early
Odom	54-57	40-60	Late	Early	Mid-season
Schley	57-60	50-70	Late	Early	Mid-season
Success	51-54	40-60	Early	Late	Mid-season
Stuart	46-49	40-60	Late	Early	Mid-season
Teche	47-50	60-80	Late	Early	Late

Odom. From extreme eastern Texas, 40 to 60 nuts per pound. Kernel content, 54 to 57 percent, with good flavor and color. Nuts easy to shell. Ripens in mid-season. Moderately prolific.

Schley. From coastal Mississippi, 50 to 70 nuts per pound. Kernel content, 57 to 60 percent. Kernels attractive in appearance, and of excellent flavor. This variety is noted for high quality of the nuts. Ripens in mid-season. Fairly prolific after the trees reach bearing age. Susceptible to scab in southeastern and eastern Texas.

Success. From coastal Mississippi, 40 to 60 nuts per pound. Kernel content, 51 to 54 percent. Kernel bright, smooth and of good flavor. Ripens in mid-season. Shuck is thin and opens well at maturity. Not an early bearer but productive as trees become older. Probably the leading eastern variety in Texas. Susceptible to scab in eastern and southeastern parts of the state.

Stuart. From coastal Mississippi, 40 to 60 nuts per pound. Kernel content, 46 to 49 percent. Kernel attractive, quality and flavor good. Ripens in mid-season. Not an early bearer but fairly prolific after trees reach bearing age. Very resistant to scab, but susceptible to foliage diseases.

Teche. From southern Louisiana, 60 to 80 nuts per pound. Kernel content, 47 to 50 percent. Quality of kernel fair to good. Ripens late. Relatively resistant to scab. A prolific variety.

Other varieties. There are a number of other varieties of promise in certain localities which may eventually replace some of those here discussed. Among such are Commonwealth, Desirable, Evans, Garner, Humble, Jersey No. 60, and Roth.

Seedlings. There are hundreds of seedling trees about the state which are prolific and bear nuts of excellent quality. However, most of the nuts from such trees are small and suitable only for shelling. These commonly receive little attention because of the false impression that only large nuts are worth growing.

Seedling trees of established value for the nuts which they produce should be preserved and given good care until it becomes clear that certain selected varieties would likely be more profitable. More than 90 percent of the entire pecan crop of Texas is sold to the consumer as kernels and the demand for shelled nuts appears likely to become greater, while that of unshelled nuts may reasonably be expected to remain about stationary or possibly to become relatively less if the demand for the shelled product becomes greater.

SOME PECAN INSECTS AND THEIR CONTROL

The Pecan Nut Case-Bearer

The insect. The pecan is the only plant on which this insect feeds. The moth is small with a gray color, flies only in late evening or at night. The case-bearer passes the winter in a hibernaculum or woven case (over-wintering worm state) and in the early spring the larvae (worms) bore into the new shoots of the current season's growth, where they feed and pupate. They emerge as small gray moths about April 20 to May 10, depending on

the earliness or lateness of the season and the section of the state. Eggs are laid by the moths on the tiny nut clusters the latter part of April or early in May. The tiny worms hatch in four to five days and at first feed for a few days on the buds just below the nut clusters. The worm stage lasts for about 25 days during which time the entire cluster of nuts may be destroyed by the worms drilling into them. A second generation may occur in late June and feed on the nuts. A third generation may appear in August but the worms do not enter the nuts since by this time the shells have hardened and the worms either feed on buds or in the green shucks of the nuts.

The control. The most effective method of control is to spray with lead arsenate at a concentration of 6 pounds to 100 gallons of water. The first spray should be applied as soon as the nut case-bearer eggs begin to hatch, which can be determined by examining the eggs on the nutlets with a hand lens. This time will vary from late April to late May, depending on the season and the section of the state. A coarse spray and not a fine mist should be used. A coarse driving spray which will push the leaves aside and be deposited on the nut stems and the branches immediately below the nut clusters is absolutely necessary if good control is to be obtained. It is useless to spray pecans unless enough pressure is maintained to accomplish that result. A second application of spray should be given in seven to ten days after the first application. In the event of a heavy rain immediately following an application, the spraying should be repeated.

In the coastal areas and in the eastern part of the state where the humidity is high it may be necessary to use dilute Bordeaux mixture with the arsenic spray to prevent the arsenic from injuring the foliage. In such case a 4-1-100 Bordeaux mixture may be prepared and the lead arsenate added to it. In case a scab or foliage disease spray program is being carried out, the lead arsenate may be added to the Bordeaux mixture when the dates of application coincide.

The equipment. For best results, power spraying equipment that will develop at least 400 pounds of pressure is essential. A spray gun nozzle that can be adjusted to throw a coarse spray a distance of 30 to 60 feet is best. For a few small trees, a barrel sprayer may be used provided the spray nozzle has a disc with a large opening to throw a coarse spray onto the nut clusters.

The Pecan Weevil

In a few sections of the state the pecan weevil does serious damage to the pecan crop in some years. The first injury of the season is caused by the adult weevils puncturing the nuts before the kernels have formed. This causes the nuts to turn dark inside and out, shrivel, and drop off. The main damage to the pecan crop is often done by the larvae in the fall. The female adult weevils drill holes into the nuts with their long beaks and deposit their eggs in the kernel. The eggs hatch and the larvae feed on the kernel until they are full grown at which time they cut a hole through the shell and shuck and immediately enter the soil to a depth of one to nine inches

were they hibernate. They may form pupae the first or second fall after entering the ground and thus there is an overlapping of generations. The immature larvae are white. The mature larvae are fat yellowish grubs with small reddish-brown heads and without legs. They are about three-eighths to one-half inch long.

Control. At present there is no control for weevils that is entirely effective. However, there are a few practices that may help to prevent serious damage. The nuts may be harvested before most of the weevils emerge and the larvae destroyed. This will mean an early harvest. The trees should be examined about the latter part of September, and sometimes earlier, to determine the infestation. The shucks on infested nuts do not open properly and if the nuts are cut open the white grubs will be found inside. The infested nuts should be threshed off the trees and placed on tight floors to keep the grubs from entering the soil. In some cases the nuts are placed on coarse screens in a chicken house so that as the grubs emerge from the nuts they are eaten by the chickens. After the grubs have emerged the noninfested nuts can be separated from those infested.

Another method that may be used is jarring the lower limbs with a mallet and letting the weevils fall on a sheet spread under the tree. This is done in July and August when the weevils are working only in the lower part of the tree and only the lower limbs up to 12 feet from the ground need be jarred. In heavily infested orchards the jarring should be done once a week.

If a flock of chickens or other fowls can be induced to range in a pecan orchard they destroy a great many of the larvae and weevils. Cultivation also will destroy some of the pupae, but the worms usually go deeper into cultivated soil to pupate than in uncultivated soil.

Obscure Scale

The obscure scale is a small insect that attacks the branches and trunks of the pecan and some other trees. Its body is covered by a dark gray circular scale-like substance which resembles closely the color of the bark, and is difficult to detect until the insects become abundant. The bark of heavily infested branches appears roughened or scaly and the branches become so devitalized that they are subject to attack by borers. The scale insects suck the sap from the bark and may become so abundant as to completely encrust the bark.

Control. The obscure scale is controlled by spray applications of a 3 percent standard oil emulsion during late January or February. This often does not result in complete control of the insect, in which case the spraying is repeated the following year. It is not advisable to make more than one application of the oil spray per year because the accumulation of oil may cause serious damage to the trees.

The Walnut Datana

There are two generations of the walnut datana produced each year. The first or spring brood of moths emerge from the ground late in

May and lay eggs on the undersides of the leaves. The eggs hatch in 9 or 10 days and the worms or larvae start feeding on the leaves. The larvae feed on the leaves for about 19 days then enter the ground where they pupate and form the moths that lay the eggs for the second generation. The second generation larvae or worms begin to appear late in July. The larvae are about 1/12 of an inch long when hatched and are green with black heads. When they reach 1/6 of an inch in length the larvae are red with white stripes along the body which is covered with conspicuous white hairs. At maturity the larvae are about 1 to 1¾ inches long, the body is black with white lateral stripes, and the hairs are very prominent.

The first generation often completely defoliates pecan trees by eating all the leaves and the second generation may defoliate the same trees when they make their appearance later. This results in weakening the trees and causes lack of filling in the nuts. Trees defoliated twice in the same season seldom bloom the next year.

Control. If the orchard is badly infested the only satisfactory control is secured by spraying with an arsenical poison. A spray made of 3 pounds of lead arsenate to 100 gallons of water will control the insect if it is thoroughly applied. The spray should be applied when each generation of the worms first makes its appearance.

If the infestation is light, or if spraying equipment is not available, the insect may be controlled on low-headed orchard trees by burning the worms or pruning out the leaves with the worms on them. These methods require a great deal of time and constant vigilance whereas one spray application of lead arsenate for each generation of the insect is sufficient to effect their control.

The spray of lead arsenate will also control fall webworms, and other leaf-eating insects.

The Pecan Leaf Case-Bearer

The leaf case-bearer has four stages of development, viz: egg, larva, pupa, and adult or moth, but the larval or worm stage causes the damage to pecan trees. The most serious damage is done in early spring when larvae emerge from their winter cases and feed upon the unfolding buds and leaves. On badly infested trees practically all the tender buds and leaves may be severely injured and the trees practically defoliated for several weeks by this insect. Since the fruiting shoots, as well as the foliage, are destroyed the nut crops are reduced and the trees are left in a weakened condition.

The larva or worm is dark green in color with a dark brown or black head, and is about one-half of an inch long when full grown. The skin is wrinkled into folds and is sparsely covered with fine long hairs.

There is only one generation of the leaf case-bearer produced each year and it is the overwintering larvae that do the most serious damage. These larvae pupate and then form moths which emerge over a long period, from about May 10 to August 1. These moths lay eggs on the undersides of the leaves. The eggs hatch in about seven

days and the larvae start to feed on the undersides of the leaves, eating out the portion between veins and along the midrib. These larvae feed sparingly on the leaves during the summer and fall and as they extend their feeding area they enlarge their little winding cases. The larvae usually grow to about one-sixteenth inch in length by fall. During the latter part of September the larvae leave the foliage and seek winter quarters around the buds. There they construct compact oval cases in which they spend the winter.

Control. The leaf case-bearer can be controlled by spraying with lead arsenate at the rate of 4 pounds to 100 gallons of water. The spray should be applied about July 15 and the spray should thoroughly cover the undersides of the leaves as this is where the insects are feeding. If there is a considerable number of overwintering larvae in the spring, as determined by the amount of damage to the trees, the trees will need to be sprayed in the summer. Therefore, the leaves should be examined closely about the first to fifteenth of July at which time brown or dead areas will be found on the leaves where the insects are feeding.

The Black Pecan Aphid

There are several aphids that occur on the pecan but only one of these, the black pecan aphid, seems to be harmful. The black pecan aphid is about one-sixteenth of an inch long and its body is practically black. In the spring young aphids hatch from overwintering eggs and move to the newly opened leaves. Here they feed and become adult aphids, all females, capable of producing live young. At least 20 generations of the female aphids may be produced during the summer. The last generation of the aphid appears as males and females which mate on the leaves. After fertilization the females travel downward on the trunks and deposit from 15 to 20 eggs in small crevices in the bark.

The aphids feed on the undersides of the leaves by sucking the sap and soon after they start feeding bright yellow blotches develop around the punctures and grow until they may be one-fourth of an inch across, or larger. If a large number of the aphids feed on a tree the yellow blotches on the leaves make the tree quite conspicuous. In a short time the yellow blotches turn brown and the leaflets drop off if the blotches are numerous, thus causing defoliation of the tree.

Control. The black pecan aphid is controlled by spraying with a solution of nicotine sulphate-summer oil emulsion. The summer oil emulsion contains ¾ of one percent summer oil in water and the nicotine sulphate is added at the rate of one part to 4,000 parts of the emulsion. The spray applications should be made at the time the aphids first appear in considerable numbers. The leaves should be examined closely at intervals in summer and early fall at which time the aphids may be found on the undersides of the leaves. The aphids multiply rapidly during the summer and fall and only a short time is required for them to become numerous enough to do serious damage.

The Phylloxera

The phylloxera is a small insect closely related to the aphids. The insect feeds on the buds in the spring and later attacks the young leaves and shoots. The insect selects a place on an unfolding leaf or rapidly growing shoot and feeds by sucking out the sap. This stimulates abnormal growth activity in the leaf or shoot which results in the formation of a gall. The young growth of the tree may be attacked at any time during the season but most of the galls are found in the spring. Some varieties are more susceptible to this insect than others. The Texas Prolific seems to be the most susceptible of the western varieties. The phylloxera usually does little harm because natural enemies tend to hold it in check. However, there are some cases where the damage is serious.

Control. A thorough spraying with nicotine sulphate (Blackleaf 40) and liquid lime sulphur will control the phylloxera. The formula for the spray is:

Nicotine sulphate ..... **1 pint**
Liquid lime sulphur **2½ gallons**
Water ..... **97½ gallons**

The spray should be applied in early spring just as the first buds begin to unfold.

SOME PECAN DISEASES AND THEIR CONTROL

Like most other horticultural crops the pecan is affected by parasitic and nutritional diseases which seem to develop more or less simultaneously with the development of the industry. Such diseases have already increased in the state to the extent that they often cause enormous damage to pecan crops. Fortunately, however, agricultural research workers have perfected control measures for most of the important diseases.

Pecan Scab

Until recent years pecan scab was not considered of economic importance in Texas except in the more eastern and coastal regions. However, as more orchards of susceptible varieties are developed the disease is more prevalent and is causing increased losses in orchards from the central part of the state eastward.

Scab is usually first noticeable as brown or black elongated or circular spots on the veins on the underside of the leaflets or on the nuts. Somewhat later, circular spots of the same color appear on the leaflets, shoots, and nuts, and increase to about one-eighth to one-quarter of an inch in diameter. In severe cases of infection these spots coalesce and form large, irregular, black blotches which may sometimes cover the entire surface of the nuts and leaflets. The nuts may drop from the trees or may die and remain on the trees indefinitely. Heavily infected leaves usually drop prematurely and poor filling of the nuts results. The first spots on the leaves and nuts usually are noticed about May 1 to 15 but may occur later.

The scab fungus is carried over winter on old leaves, shucks, and lesions on the shoots and spreads from these in the spring. Periods of rainy weather or heavy dews in the spring facilitate the spread of the spores. All old shucks and

leaves should be destroyed in an orchard before spring growth starts. The old shucks may be knocked from the trees when they are wet by slight jarring, and these together with the old leaves should be plowed under, provided a winter cover crop is not grown in the orchard.

Pecan scab may be controlled by proper spraying with Bordeaux mixture. The first application should be applied when the leaves are one-fourth to one-half grown and before pollination takes place. This mixture should contain 4 pounds of bluestone (copper sulphate) and 1 pound of hydrated lime, in 100 gallons of water. Care must be exercised in making this early application of spray since the foliage may be injured if the temperature is as low as 50 to 55 degrees Fahrenheit when the spraying is done.

A second spray of 6-2-100 Bordeaux mixture should be applied soon after pollination is complete, or as soon as the ends of the small nuts have turned brown.

A third and fourth spray of 6-2-100 Bordeaux mixture should be applied at three or four-week intervals after the second spray in cases where the scab infection is severe. In some areas of the state where the rainfall is moderate the first two or three spray applications should give commercial control of scab, especially when supplemented by good orchard sanitation.

Bordeaux mixture is made of bluestone (copper sulphate), hydrated lime, and water. It is recommended that powdered bluestone be used because it dissolves very readily in water thus saving time in preparation of the spray, and a good grade of hydrated lime containing at least 70 percent calcium oxide should be used.

Bordeaux mixture may be made as follows: Assume that a 300 gallon tank of 6-2-100 Bordeaux mixture is to be prepared. Weigh out 18 pounds of powdered bluestone (copper sulphate) and 6 pounds of hydrated lime. Start filling the spray tank with water. Place the bluestone in the strainer of the tank and let the water run over it to dissolve it. The lime is dissolved in enough water to make a milky paste. When the tank is three-fourths full the engine should be started to operate the agitator. When all the bluestone is dissolved the milk of lime should be added slowly. Water is then added until the tank is full when the spray is ready for use. Bordeaux mixture should be applied soon after it is prepared.

Foliage Diseases

In addition to pecan scab there are other fungus diseases that occur on pecan foliage but do not infect the nuts, and therefore are referred to as foliage diseases. Some of the more important of these diseases in Texas are downy spot, vein spot, liver spot, and brown leaf spot. These diseases make their appearance in the late spring or early summer and occur as circular spots on the under surface of the leaflets. The spots are white changing to yellowish-brown or brown in downy spot, liver color in liver spot, and reddish brown in brown leaf spot. Vein spot occurs as black or brown lesions on the veins of the leaflets or on

the petioles. It is somewhat difficult for the layman to differentiate between some of these diseases and in most cases more than one is present in the same orchard. In many sections of the state the foliage diseases do more harm than scab, since with severe infections trees may be partially or completely defoliated by them. These diseases also occur further west than does scab.

Foliage diseases may be controlled by spraying with Bordeaux mixture. If a scab spray schedule is being followed it will control the foliage diseases, otherwise the first and second spray applications as recommended for scab control should be used for the control of the foliage diseases.

The foliage diseases are carried over from one season to another in the spots on the leaves. Therefore, it is important as a control measure to destroy the leaves and other debris in the orchard in the fall or early spring. This is usually done by cultivation.

There is a close correlation between the damage done by foliage diseases and the vigor of the tree. Therefore, efforts should be made to keep the trees vigorous at all times by proper spacing, cultivation, cover cropping and fertilization. To produce regular crops of well filled nuts a pecan tree requires its foliage to be vigorous and healthy and to remain on the tree until late in the fall.

Rosette

Pecan rosette is a nutritional disease and occurs throughout the pecan territory on all varieties and seedlings although some are more resistant than others. The disease is characterized by yellow mottling, or chlorosis, and crinkling of the leaves and as it progresses shows dwarfing of the leaves, shortening of the internodes, and finally the leaves and shoots die. The disease usually starts in the top of the tree and gradually spreads to the lower branches. Rosette itself causes few if any of the trees to die, but it so weakens trees that many of them succumb to attacks of borers or diseases.

Rosette is successfully controlled by two or three spray applications of a solution of 2 pounds of zinc sulphate in 100 gallons of water. The first application should be made about the first to 15th of May, followed by additional applications at three—or four-week intervals. If the rosette is not severe, two spray applications will usually control it. If a foliage disease spray schedule or nut casebearer spray schedule is being followed, the zinc sulphate may be added to the Bordeaux or arsenic sprays. In such cases 4 pounds of zinc sulphate are added to each 100 gallons of spray material.

If the soil in the orchard is acid in reaction (free from lime or alkali) applications of zinc sulphate to the soil will control the rosette. The zinc sulphate should be applied at the rate of 1 to 2 pounds for each inch of diameter of the tree trunk. It should be broadcast evenly beneath the tree, covering a circular area from near the tree trunk to beyond the limb spread, and should be plowed or disked into the soil. Where the trees respond to soil applications of zinc sulphate one treatment usually is

effective for several years. However, if a spray program is being followed the zinc sulphate may be added to the spray and thus reduce the cost of rosette control.

In considering whether control measures for pecan diseases are economical the fact should not be overlooked that benefits from proper cultivation, fertilization, or other good orchard management may be voided if diseases are not controlled.

HARVESTING, CURING, AND STORING PECAN NUTS

Harvesting

Pecan nuts are usually harvested when the nuts are fully ripe and will come out of the shucks with little beating of the branches. However, it is not always desirable to delay the harvesting of a valuable crop this long because the trees may be exposed to depredators, it may be desirable to market the nuts early, and nuts of some varieties may sprout on the trees if harvesting is delayed. Under such conditions it is best to thresh the nuts from the trees as soon as they are mature, which can be determined by observation of the nuts. If the shucks crack or open from gentle pressure, or if they sound hollow when thumped with the finger, the nuts may be considered mature enough to harvest. Two weeks after the first nuts are ripe all nuts on the tree will be ready to harvest except faulty nuts that never mature properly. If the nuts are inclined to sprout on the tree, it is advisable to harvest them as soon as they are fairly mature in order to prevent the sprouting. If the nuts are not inclined to sprout on the tree, they may be harvested at this time but the threshing will be much easier if harvesting is delayed. By the time a nut is fairly mature the shuck is relatively loose and the shell is normally colored, even though the shuck has not opened. Cane poles are most frequently used for threshing. The small ends should be wrapped with adhesive tape for a distance of two feet to prevent the poles from splitting.

The harvesting of the nut crop may be facilitated by the use of sheets spread on the ground under the tree and outward past the spread of the branches for the nuts to fall on when they are threshed. If the ground under the trees is not clean, the saving in time will soon pay for the cost of the sheets and fewer nuts will be lost in harvesting. Sheets for this purpose are usually made from new 8-ounce duck cloth in rectangular pieces about 5 x 10 yards in area. Two of these will cover an area under a tree approximately 10 yards square, which will be large enough for average trees up to 10 to 12 inches in trunk diameter. For larger trees more than two sheets may be needed. The sheets should be stored between seasons in rat-proof containers such as lard cans.

Curing

Pecans stored in bags or bins will rot if they have not been sufficiently cured. Therefore, provisions must be made for curing the nuts when they are harvested with good weather and a small crop of nuts the curing is usually accomplished with little difficulty but may be a different problem when a large crop of nuts is harvested. Nuts may be

cured in trays made of 1 x 4 inch boards with ¼ or ½ inch hardware cloth bottoms. The trays should be placed across supports so that the air can circulate among the nuts freely. Nuts may also be cured in small burlap or cloth bags provided the bags are arranged so the air circulates freely around them. It is well to turn the bags upside down occasionally so that the nuts may cure uniformly. Nuts cure slowly in bags but with precautions to insure good air circulation they will cure satisfactorily in dry weather. Much of the work of curing can be eliminated if the nuts are allowed to cure in the shuck before harvesting.

Storing

The size of the pecan crop varies widely from year to year and in years when the crop is large and the price is low it is often an advantage to the grower to hold his pecans and market them later; or he may desire to hold them for other reasons. The nuts may be kept for two years without appreciable deterioration when stored at a temperature of 32° to 38° F. They should be stored as soon as curing is completed since their quality is impaired at ordinary temperatures long before rancidity is perceptible. Most commercial cold storage plants have suitable facilities for storage of pecans, and the cost of storage is relatively low. Pecan nuts should not be stored where free ammonia comes into contact with them since very small amounts of ammonia cause the kernels to turn dark and this impairs the quality. Furthermore, the storage rooms should be free from all odors since the oil in the kernels readily absorb them causing the nuts to have objectionable flavors.

PROTECTING TREES FROM SQUIRRELS AND CROWS

Squirrels may destroy large quantities of pecan nuts during the season since they start feeding on them while the nuts are immature and continue until the nuts are harvested. Squirrels also cause considerable damage to trees that are being topworked by gnawing the bark off of the new shoots so that they die.

The most effective method of controlling squirrels is by installing squirrel guards on the trees, as shown in Figure 18. This guard will furnish positive protection except in cases where the squirrels can jump or climb from other trees that are not protected. To make this guard draw a circle the size of the circumference of the tree on a piece of sheet metal and make radial cuts about one inch long as shown in Figure 18, A. Round off the square corners and cut the metal so the guard can be placed around the tree trunk. Turn up the radial flanges and nail to the tree as shown in Figure 18, B, allowing the edges of the guard to overlap. The metal should extend out from the tree about 6 to 8 inches. The guard may be adjusted to the tree as it grows by making the radial cuts longer and turning up the flanges to fit the circumference of the tree.

For information on control of crows see **Farmers' Bulletin No. 1102, United States Department of Agriculture, Washington, D. C.**

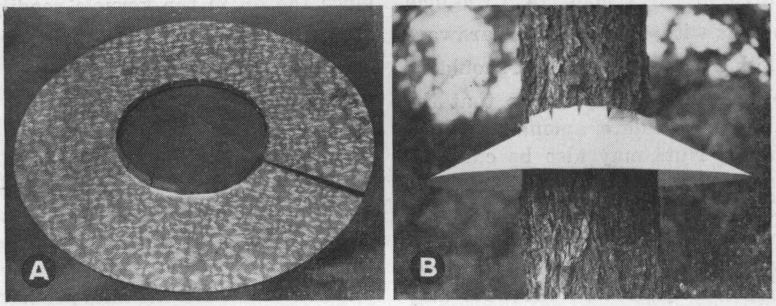

Figure 18. Squirrel guard: A, Sheet metal cut ready to put on tree; B, shows guard in place on tree.

AGENCIES IN TEXAS FROM WHICH INFORMATION ON PECAN PRODUCTION MAY BE SECURED

Agricultural Extension Service, A. & M. College, College Station, Texas.

U. S. Pecan Field Station, Brownwood, Texas.

U. S. Pecan Insect Laboratory, Brownwood, Texas.

Texas A. & M. College, College Station, Texas.

Texas Agricultural Experiment Station, College Station, Texas.

Texas State Department of Agriculture, Austin, Texas.

Cooperative Extension Work in Agriculture and Home Economics, Agricultural and Mechanical College of Texas and United States Department of Agriculture Cooperating.
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