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Circular 84

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Building Young Deciduous Fruit Trees

FRANCIS M. COE

SIX-MONTHS-OLD PEACH TREE TRAINED TO MODIFIED LEADER: Selected branches were left the first year.

UTAH AGRICULTURAL EXPERIMENT STATION

UTAH STATE AGRICULTURAL COLLEGE

Logan, Utah
INTRODUCTION

Importance of Early Training

THE MODERN FRUIT TREE in a commercial orchard, to survive in present-day competition, must bear heavy crops. The mechanical strength which determines whether it can hold its heavy load successfully or whether it will be broken down and become a liability to its owner is determined to a large extent by the training it has received the first two or three years after planting.

Similarly, size of the crops the tree can bear depends upon the size of the tree, its bearing surface, and its spur system, which are directly affected by early training. The cost of the tree's care is also determined partly by its shape; tall, upright trees are more expensive to prune, thin, spray, and harvest than low, spreading trees.

Quality in fruits, such as apples and peaches, which require direct sunlight to color well, is also affected by the tree's shape. Quality, therefore, as well as yields and costs, is partially determined by the early training the tree receives.

Profits, or net returns, represent the difference between price received and production costs. Since production costs are governed by yield as well as by management costs, and prices, dependent upon quality, are also affected by the shape and size of the trees, it follows that early training of the orchard is an important factor in determining profits.

Defects Remedied by Early Training

DESIRABILITY of proper early training lies not so much in what can be done with the shears as what can be prevented. As suggested, low quality and high unit-production costs are caused by certain defects in the orchard. Such defects as crowding due to improper spacing, poor adaptation of varieties or low dessert quality and price of a variety due to improper variety selection, and poor soil or frost damage due to faulty selection of site are mistakes made in establishing the orchard and cannot be remedied by training. (For further information see Utah Station Circular No. 83.)

Many Serious Defects are Preventable

Defects which can be remedied or at least improved by early training are: Crotch weakness and breakage, heart rot or wood decay, shape, i.e., spread in relation to height, density of head, lack of fruiting spurs, small-sized trees, and delayed bearing.

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1 Contribution from Department of Horticulture, Utah Agricultural Experiment Station.
2 Coe, F. M. "Planning, Planting, and Caring for the Young Orchard". Utah Agr. Exp. Sta. Cir. 83 (1930) Mimeograph Sheets, 37-42, inclusive, on varieties of fruit for Utah are available in limited numbers at the Utah Experiment Station. Publication authorized by Director, January 25, 1930.
Objectives in Pruning Young Trees

Young trees are pruned to accomplish the following objects:

1. To secure mechanical strength sufficient to enable the trees to carry heavy annual loads of fruit and to withstand weight of snow and ice as well as pressure of winds without breakage.

2. To secure low, wide-spreading trees with the maximum fruiting area exposed to sunlight.

3. To develop a well-distributed and nourished spur-fruiting system.

4. To secure such form and openness as to make orchard operations most convenient and efficient and consequently least expensive.

5. To secure the largest tree in the shortest time compatible with the foregoing important objects.

FUNDAMENTAL CONSIDERATIONS

Tree Nutrition in Relation to Pruning

Contrary to age-old traditions, **pruning of young, vigorously-growing trees is a dwarfing process**. The amount of this dwarfing effect is proportional to the severity of pruning. This fact has been incontrovertibly established by experiments in California, Oregon, Indiana, England, and elsewhere.

Trees

In the light of recent fundamental research results in plant nutrition, this effect is entirely reasonable. To explain why requires a brief discussion of fundamentals.

For the maintenance of life and growth, trees, like animals, require certain nutrients, or foods. For convenient understanding of their source and nature, these foods may be divided into two groups: (1) Inorganic chemical salts obtained from the soil. Of these substances **NITROGEN** is the one most commonly so limited as to restrict growth of the tree—in fact, it is the only one which has shown positive increases in growth and fruiting in widely-distributed fertilizer trials. Nitrogen, with moisture, therefore, constitutes the soil foods or inorganic foods of the tree most likely to limit growth.

(2) The organic or manufactured foods, on the other hand, are essentially **CARBOHYDRATES**, i.e., they are originally compounds of carbon, hydrogen, and oxygen, manufactured and used by the plant largely as a means of storing energy as well as to supply new tissue material.

These carbohydrate foods are manufactured in the leaves from carbon dioxide gas, which is always present in small quantities in the air, and from water from the soil. This process requires the services of the green coloring matter in the leaves, known as chlorophyll, and utilizes the sun's energy. When chlorophyll is absent, as in advanced stages of chlorosis or in the case of plants growing in the dark, the plant starves for want of the energizing carbohydrates.

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These carbohydrates are the bases of other important substances made and used by the plant. Originally they are starches, sugars, and pentosans, all of which are important in the nutrition and life processes of the tree. Later, they are changed into fatty substances; with nitrogen, phosphorus, sulfur, and other minerals added they become proteins, and are built up into protoplasm, the living cell substance.

The amount of these carbohydrate foods available to the tree for growth or for fruit production depends upon the rate of manufacture and upon rate of use. Since these substances are made in the leaves and require sunlight, it is evident that the amount manufactured is proportional to the total leaf area exposed to light. The leaf area, in turn, is determined by the supply of carbohydrates, nitrogen, and moisture available for new growth of shoots and leaves, the amount of nitrogen and moisture coming from the roots depending on the supply in the soil and the root area. Consequently, the more nitrogen and water available, the larger the leaf area and the supply of carbohydrates and the faster the tree increases in size.

Nitrogen and moisture are plentiful in young, vigorous, and well-cared-for trees, and the amount of growth is determined by the supply of carbohydrates available to provide the energy and the tissue-building material. Thus, under these conditions carbohydrates are the limiting factor of growth.

Relation of Pruning to Increase in Size of Trees

What is the effect of pruning on the supply of these carbohydrates which are limiting growth? In the dormant season pruning reduces the number of buds or growing points which will form leaves to begin the manufacture of these carbohydrates in the spring; it also reduces the amount of stored food in the parts of the tree removed. It is apparent, therefore, that pruning reduces the supply of carbohydrates available and so reduces growth itself.

Summer-pruning has an even greater dwarfing effect. In this case, not only the stored carbohydrates and the growing points on the pruned parts are removed, but the nitrogen and moisture invested in the new growth of leaves and shoots are lost without the return to the plant of carbohydrates which would normally have followed. While dormant pruning is often partly made up by increased new shoot growth resulting from fewer buds and hence a greater supply of nitrogen and moisture per bud, growth removed in summer is a net loss.

These considerations indicate the first rule of pruning young trees: Prune no heavier than necessary to secure strong, well-shaped trees. Small twigs and branches should not be pruned simply because they are not wanted in forming the permanent branching system. They will help supply the carbohydrates to feed the roots and increase the rate of growth. The ideal should be to get the largest tree possible in the shortest time, provided other considerations are satisfied. Do not anticipate the tree's development in pruning and cut away twigs and branches because in the future they will crowd each other. Of course, in rapidly-growing trees, such as peach, apricot, and Japanese plum which change entirely in a single season, it is necessary to anticipate to some extent.
Kinds of Pruning

TWO KINDS OF CUTS may be made in pruning: (1) "Heading-back" in which part of the shoot is cut off and (2) "thinning-out" in which whole shoots are removed. Another somewhat intermediate type of cut which is particularly useful in training trees is "cutting back to a lateral". Where a weaker branch is removed, this operation could properly be classed as "thinning-out", but where a strong leader is cut back to a lateral, as is often necessary to spread a tree or suppress a branch, the effect is similar to that of heading-back except that the effect in stimulating new vegetative growth is distributed along the remaining branch at the cut itself.

Effects of Pruning

The effects of pruning in stimulating new shoot growth are evident principally in the immediate vicinity of the cut. The bud closest to the cut in a headed-back branch will make the strongest growth.

Heading Increases Branching and Density

On the other hand, thinned-out trees increase faster in spread and height, are more open, and have much better development of spurs. This is the so-called "long system" of pruning and is the principal type of pruning advised in the building of young trees.
Fig. 2.—RESULTS OF THINNING-OUT AND HEADING-BACK. A, a 2-year-old prune branch which received a heading-back at the end of previous season. Note production of shoots and lack of fruit-spurs. B, a 2-year-old prune branch which was not headed-back at end of previous season. Note production of fruit-spurs, together with sufficient amount of new wood. (Courtesy, Calif. Agr. Exp. Sta.)
Building Strong Crotches

CROTCHES, i.e., the formations of tissue where one branch joins another, are mechanically the weakest points in the tree. Since most breakage takes place at these points, an analysis of crotch construction and reasons for certain crotches being weak and others strong should be profitable.

The strength of a tree or branch lies in its thick-walled wood fibers, which overlap in the woody cylinder forming the core of a branch, making a tough elastic structure. These layers of wood fibers are bound together laterally by cross-fibers called "medullary rays". However, when two branches grow together side by side, each growing from a separate source, as in a narrow crotch, there is no cross-tissue to hold them together and they split easily.

The first factor, therefore, in determining the strength of a crotch is the angle formed by the two branches forming it. A wide-angled crotch develops a normal "collar" or swelling surrounding the joint which strengthens it; therefore, a wide-angled crotch is strongest. On the other hand, a narrow-angled crotch grows together on the inside, often enclosing bits of bark which further weakens the crotch. When stress is applied, such a crotch splits easily. (Fig. 3.)

The second factor determining strength of a crotch is the relative size of the two branches forming it. Where branches are of equal size their tissues must develop side by side without a strengthening collar formation because neither branch can surround the other. Such crotches are relatively weak. Where one branch is much larger than the other, however, the new layers of woody tissue formed by the larger branch overgrow the smaller branch, binding it in with the hard tissue of which woody knots, are made, forming a heavy supporting collar. Such unequal crotches possess great strength and seldom break, provided they remain sound.

These considerations, therefore, lead to the second rule in training: Choose branches which are as wide-angled as possible and well subordinated to (smaller than) the leader branch. The strongest system of branching, therefore, is one in which every branch is progressively subordinated to a strong-
Subordinate Branches to Leaders

er leader branch; these are in turn subordinated to the primary leader forming the trunk. This is the ideal of the modified leader system of training.

Crotches become stronger with age. Breakage is usually worst in the young tree bearing its first crops. Later breakage is usually due to wood decay, resulting from infection of unprotected wounds. Prevention of wood decay will be discussed under "Wound Protection".

Controlling Height, Spread, and Density

THESE CHARACTERS are influenced more by inherent growth habits of the species and varieties than by pruning. For example, the Yellow Transparent Natural Habit apple tends to make a tall, narrow tree and is difficult to spread, while varieties like Rhode Island Greening are difficult to grow sufficiently upright. Pears and cherries tend to make strong leaders, or central upper branches, while peaches and Japanese plums are difficult to grow to leader form because the lower branches grow more strongly and girdle out the leaders.

SEVERAL METHODS are commonly advocated to spread young trees. Cutting to outside buds is one of these. Those trees whose buds continue to grow in the direction indicated by their location, such as sour cherry, adapt themselves readily to this method. Likewise, with species which normally branch freely, such as peaches and Japanese plums, this method is satisfactory, although here spreading by cutting to outward-spreading lateral branches and twigs is easy and more effective.
With those species or varieties which do not branch readily and whose habit is to send out but two or three branches in response to "heading-back", this method is not a success. The outside bud, left at the top, follows the original direction of the shoot, leaving the strongest side shoots on the inside, where they cannot be used to increase the number of branches because of crowding. In such cases, the third rule would apply: **Cut to the bud above an outside bud, or, if the shoot is a strong one likely to throw a number of good shoots, to two buds above the outside one desired to spread the tree.** This spreading lateral can then be retained as a side branch or can be made the leader by removing the branch above it, thus spreading the tree. The reason for leaving two buds on strong shoots is because of the undesirable narrow angle often made between the two uppermost shoots on a strong branch which has been headed back.

**The tendency to spread is increased with an increased number of branches.**

**Many-Branched Trees Spread More Than Those With Few Branches**

Trees with few strong leader branches tend to grow tall and lack spread. Branching may be increased in sweet cherries, pears, Domestica² plums and prunes, and certain varieties of apples by heading back the terminals to the point where branches are desired, although poorer crotches are formed as a result of heading back. Sour cherries, apricots, peaches, Japanese plums, and certain apple varieties branch freely without heading back. Where necessary, these should be pruned by thinning-out and heading-back to laterals which will spread the tree.

The tendency to grow tall may be controlled by heavier pruning back of the upper branches to suppress them and leave the lower branches relatively longer.

**How to Control Size of Branches**

This principle, the fourth rule of pruning young trees, is: **To suppress a branch in relation to the remaining branches, head it back or thin it out more severely than the other branches.** On the other hand, to encourage a branch, it should be left longer than the others. The rate of thickening is proportional to the length of the remaining branch (Fig. 5).

Use of this rule should not be expected to make a weak branch become larger than a strong branch. It applies to equal branches, but frequently must be followed more than one year to get results. Branches are difficult to suppress which are favorably located with regard to food-supply or have a size advantage to begin with, and should be removed if they cannot be used as leader branches.

**Early Fruiting Helps to Spread Trees**

Young trees should not be expected to have the same spread as older trees. No pruning, not even an undesirably heavy heading-back will spread upright-growing young trees to the extent desired as a permanent shape. **To get this major spread, it is important that early fruiting be encouraged, so the weight of fruit will pull the branches outward toward a horizontal position before they are too heavy and too stiff to bend.** Scaffold branches should be pruned to keep all the side branches toward the outside so as to pull the main branches outward and thus spread the tree.

A fairly dense head is not undesirable in a young tree. Such a tree grows rapidly and the shading causes the branches to spread well. Over-density is fairly well taken care of by the thinning-out necessary to space the branches far enough apart. **Later, as time of bearing approaches, some trees having dense tops**

²European type (Prunus domestica), such as Italian Prune or Green Gage.
Fig. 5.—(Left) Unequal cutting results in uneven development. Both shoots were the same size. The one on the left was cut back severely, the one on the right lightly. Both shoots were the same size when cut back. (Right) Equal cutting results in equal development producing weak, sharp-angled crotches. (Courtesy, "Blue Anchor", official publication of California Fruit Exchange).
will not form blossom buds well because of shading of the inside spurs. Summer-pruning is a remedy.

**Developing Fruit Spurs**

With the exception of peaches, all deciduous fruits bear a major portion, if not all, of their fruit on short twigs, or spurs. The development of an extensive spur system in the young tree is a necessary preliminary to early heavy bearing. In the peach, development of well-distributed new fruiting wood is the object in view.

Heading-back, or "short" pruning, encourages the multiplication of new shoots rather than the production of spurs. **Heavy annual heading-back, as was formerly customary, delays fruiting by causing excessive vegetative growth and decreasing spur formation.**

On the other hand, thinning-out, or "long-pruning" encourages the maximum formation of spurs by leaving the branches longer and increasing their light. (Fig. 2).

**Height of Head**

THE DISTANCE from the ground to the lowest branch is termed the "height of head". Formerly it was considered best to head trees high so that horses could walk close to the trees without difficulty. Later, particularly in the west, low heads of 6 to 12 inches became prevalent. At the present time medium heads of from 24 to 30 inches are recommended.

In order to have the same fruiting capacity, high-headed trees must have a large share of their fruiting area above 20 feet from the ground (for example, with apples, pears, and sweet cherries). Investigation has shown that costs of production rise and efficiency of spraying drops appreciably above this point with little chance for profit from fruit so borne. High-headed trees are seldom as vigorous as low-headed trees and are much more likely to be injured by sunscald, particularly in the arid west where intensity of the sun is high. Development and wide use of modern extension tillage tools make high heads unnecessary.

However, extremely low-headed trees are difficult to hoe, dig out borers, protect from rodents, etc. Such trees are by no means always low and spreading. Frequently in spite of their low branching, three or four strong upright leaders will make the tree tall and narrow.

Moderately low heads are certainly to be desired. The best plan is to have the lowest scaffold branch, in order to shade the tree, from 12 to 18 inches above the ground on the southwest side of the trunk. Other shoots arising low down may be pinched or clipped back, leaving a cluster of leaves at first and a weak fruiting branch later to shade the trunk.
Fig. 6.—A (Upper Left): NEWLY-PLANTED SWEET CHERRY WHIP: Before heading.

B (Upper Right): SAME TREE HEADED: Cut back to about 30 inches to establish height of lower scaffold branches and to balance top with roots.

C (Lower Left): TYPICAL YEARLING SWEET CHERRY: Distribution of branches rather poor; could have been improved by disbudding or pinching after growth started.

D (Lower Right): SAME TREE AFTER PRUNING: Two scaffold branches in addition to the temporary leader are all there is room for if they are to be well-spaced. Additional scaffold branches will be secured from the leader next season.
Where formerly the height of head was determined by the first heading-back of the newly-planted tree and all the branches allowed to grow at that point, this is no longer the case. The modern way is to take two or three years in developing a head, spreading it along a 2.5- to 3-foot trunk by use of the modified leader system, described under "Training Systems".

**Time and Amount of Early Fruiting**

WHEN should the orchard be expected and allowed to bear crops? From a financial standpoint, obviously, the sooner the better. Tufts4 answers this question as follows: "When a deciduous fruit tree has a spread of, say, five feet, it can with all safety be allowed to fruit, no matter what its age."

Light pruning, with intensive cultivation, irrigation, etc., brings this size and fruiting about at an early age under irrigation and favorable soil conditions in the intermountain region. Large vigorous peach and apricot trees may safely bear a light crop the third summer and a fairly good crop the fourth year.

Where these fruits, particularly, make only a moderate growth and are pruned lightly, however, they often bear a heavier crop than they are able to carry, with the result that they are frequently broken down or sadly bent out of shape. Such heavy production inhibits growth even further, keeping the tree too small to bear the large crops which would have followed strong growth at this stage of the tree's development. The principal business of the small young tree is to **grow and become as large as possible** in the shortest time. While moderate fruiting is beneficial in spreading the tree and in increasing the farm income, heavy fruiting which reduces growth is unwise and is made at the expense of delay in heavy production, possible only when the tree becomes large.

**Fruit-Bud Formation**

ALL BUDS begin as leaf buds, later differentiating into blossom buds if nutritional conditions are favorable. This differentiation takes place usually from July, to September of the year preceding blossoming. The **conditions necessary to setting of blossom buds are those which cause an accumulation of carbohydrate foods**, such as large leaf surface well exposed to sunlight and a moderate rate of vegetative growth. Rank vegetative growth uses up the supply of carbohydrates as it is formed; hence, such trees are seldom fruitful.

The natural increase in size and leaf area, with gradual limitation of the nitrogen and moisture supply available to the trees, usually serves to check excessive growth and bring the tree into fruiting without any special treatment.

Fruits such as peaches, apricots, sour cherries, and Japanese plums which normally bear all (in the case of peach) or an important part of their crop on new shoots, especially when young, seldom fail to bear at an early age. Fruits, such as apples, pears, and sweet cherries, and Domestica plums, which bear almost entirely on spurs, however, will sometimes need to have ex-
Fig. 7.—A (Upper Left): TWO-YEAR-OLD SWEET CHERRY BEFORE PRUNING: Has made a good growth. Note additional scaffold branches formed on leader, some of which are better formed and located than the first branches left.
B (Upper Right): SAME TREE PRUNED: The best located and spaced branches have been selected for permanent scaffolds. The upper ones at "A" are undesirably narrow-angled. The leader is rather high and will need more suppressing later. Note "heading-back to lateral" to spread tree at "B".
C (Lower Left): ANOTHER 2-YEAR-OLD SWEET CHERRY: This tree shows more nearly ideal spread, lower branches having nearly same length as upper, giving a round-topped tree.
D (Lower Right): SAME TREE PRUNED: Scaffold branches have now been selected. The heading-back to keep the branches from becoming "leggy" could have been avoided by clipping the strong growing branches in June. Note unequal cutting at "A" to subordinate lateral and removal of branch "B" to avoid bad crotch.
cessive growth checked by seeding-down to alfalfa or sweet clover. This should not be done until the trees are of good size and are capable of bearing 2 or 3 bushels of fruit. With most varieties this will not be necessary, but often is with Delicious, Arkansas Black, and Red Astrachan apples and Anjou pears, which if given plenty of moisture and fertility are often slow to bear. Heavy pruning intensifies this tendency to late bearing and should be particularly avoided as bearing size is approached. To bear satisfactory crops these fruits must have well-developed spur systems. Heavy heading-back is not conducive to the formation of such fruiting wood.

**Summer-Pruning**

As indicated in the discussion of tree nutrition, summer-pruning is much more devitalizing and dwarfing than is dormant pruning. There are two cases, however, in which its use seems justifiable.

Where long, unbranched growths are probable the first three or four years, as with sweet cherries, clipping the growing shoots in June, when they have reached 2 to 2.5 feet in length, will prevent this lack of branching and save heavy heading-back in winter, giving two years' branching in one season. Shoots which look as if they would not exceed 2 or 3 feet in length should not be headed-back in summer. This clipping should be done early, as the later it is done the more dwarfing is the effect, and the shorter the resulting branches.

A second use of summer-pruning is to thin out densely-topped young trees that should bear well but do not because of shading of the fruit spurs in the interior. Since fruit buds form in the spurs toward the end of June and since light must be admitted earlier if blossom-bud formation is to be increased, May is the proper time for this pruning.

**Fig. 8.—BREAKAGE FOLLOWS STARVING OF LEADER BY SIDE BRANCHES:** Note the stump (at arrow) of the dead or weak central branch. This non-growing region does not bind the branches together. In many cases wood-rot enters here and hastens the splitting of the tree. Grow the tree in a way to preserve the central branch (See Fig. 9). (Courtesy, Wis. Agr. Exp. Sta.)
Systems of Training

THREE SYSTEMS of training young trees in commercial orchards are recognized: (1) The "leader" or pyramid system, (2) the "open-center", and (3) the "modified-leader".

The LEADER or pyramid system has a dominant central branch continuing to the top of the tree with lateral branches along its entire length. Shade and ornamental trees are commonly trained to this form. Because of the dominance of their leader branches, pears, sweet cherries, and some apples normally assume this form if undisturbed. Its principal advantage is its mechanical strength. Its disadvantages include its height and the lessened bearing surface exposed to sunlight.

The "OPEN-CENTER" system has been almost universally used in western orchards. In this system the trees are headed low, the leader removed, and four to eight scaffold branches allowed to develop equally for the first year. Later the center space is kept completely open, no fruiting wood being allowed to develop in the center. The advantages of this system are (1) the economy and ease of handling the low-spreading trees and (2) the maximum exposure to sunlight with consequent high quality. The disadvantages are (1) the mechanical weakness of the primary crotch, where many branches arise near the same point, resulting in breakage; (2) difficulty of keeping branches equally vigorous; (3) sunscald injury and lowered production from extreme open center; and (4) extensive bracing necessary to prevent breakage.

The MODIFIED-LEADER system is of comparatively recent introduction. It is an attempt to secure the advantages of both systems without their disadvantages. This type of training utilizes a leader the first two years to space the scaffold branches well apart over a long trunk. Later, if necessary, the leader is suppressed to keep all the branches of equal strength and make a round-headed, low-spreading tree with strong crotches. The leader may be forced outward or may form the central fruiting branches, giving a "closed-center" tree with the maximum surface exposed to sunlight and a minimum of sunscald injury. Where the top is kept well-thinned to prevent shading out of the inside fruiting wood, this form should give maximum crops. The only disadvantage of this system is that it is somewhat difficult to apply to certain fruits, particularly peaches and Japanese plums, and requires rather heavy pruning at first to secure the desired spacing of scaffold branches. Its advantages are that it is capable of bearing maximum crops with a minimum of breakage or bracing.

This is the system which is described in the suggestions on training young trees.
The Ideal Tree

NEARLY EVERY TREE presents a different pruning problem. As a rule its solution represents a compromise between the ideal and the practical. Of course, the ideal is a practical one and is based on maximum utility and not upon beauty. However, pruning is a removal process in which one must take a branch where it Every Tree a is found and not where it should be and then decide Problem; Every whether it should be removed, headed-back severely, Solution a lightly, or to a lateral low-down or higher-up, thinned out, Compromise tipped, or left as it is. Seldom is a tree found with a branch of the right size and angle exactly where each branch is wanted. The pruner must decide whether each individual branch is an asset or a liability.

Not only must the pruner work toward an ideal form, but he must always keep in mind that in removing and heading-back branches he is reducing to the same extent net increase in size and size of early crops. He must balance future benefits against immediate returns.

In the solution of these problems, a clear-cut ideal of what a tree should be is most helpful. To assist growers in forming or reforming their ideals along lines shown to be the best by modern research and experience, A Clear-Cut Ideal Indispensable widely grown in the intermountain region will be given and illustrated as far as practical. Before describing these details of procedure, the following general ideals should be considered:

1. Trees should first of all be large for their age and making a vigorous growth. This requires careful attention to planting, cultivation, irrigation, and fertilization. Suggestions on these points are contained in Utah Station Circular 83. Growers cannot afford not to have their trees grow rapidly, as each year's delay means loss of crops and profits, with costs continuing to accumulate.

2. Trees should have five to eight scaffold branches well-distributed around the trunk and at least 6 inches apart—more, if on the same side. Each branch should form a wide angle with and be subordinate in size to the leader.

3. The form of the tree should be round-topped and spreading, the central leader branch only slightly taller than the lower branches, except during the first two years when additional scaffold branches are desired.

4. Secondary and tertiary branches should have wide angles and should be well subordinated to the main scaffold branches.

5. Main scaffold branches should all arise from the central trunk and not from another scaffold branch. The leader should be kept dominant so it can overgrow and strengthen the primary crotches.

6. Scaffold branches should have side branches well distributed along their length and branched within 18 to 24 inches of the trunk. Longer unbranched scaffolds give a "leggy" appearance and are weak. This is prevented by dormant or early summer-heading of vigorous growths.

TRAINING APPLES, PEARS, SWEET CHERRIES, DOMESTICA* PLUMS AND PRUNES

These trees are grouped together because they do not branch as readily as do peaches and other fruit trees included in the second group; they bear almost entirely on spurs; and they are somewhat slower in coming into bearing. Because of these European type (Prunus domestica), such as Italian Prune or Green Gage; Japanese type (P. salicina), such as Santa Rosa and Satsuma, are considered in next section.
characteristics, they require the same general treatment and for convenience are here grouped together. This does not mean they should be treated exactly alike. In fact different varieties of the same fruit often require different treatment because of differences in habits of growth and fruiting.

Training the First Season

PRUNING AFTER PLANTING.—These fruits usually are straight, unbranched whips where 1-year-old trees are planted, as is commonly the case in intermountain orchards. The whips require only heading—cutting back—to balance the top with the root and to establish the height of the lower scaffold branches, which will be formed the first year. The length of whip to leave depends upon its size, small trees having to be cut shorter than otherwise desired in order to balance the tops with the roots to secure good growth the first season.
Fig. 11.—A (Left): HEAD IS NOW WELL-ESTABLISHED: Apple tree after 3 years' growth from a whip. Leader will now have to be suppressed to keep the tree from becoming too tall. B shows same tree after pruning.

B (Right): SAME TREE AFTER PRUNING: Leader has been cut back more heavily than lower branches to strengthen the latter. Note spacing of scaffold branches and removal of crowding and of crossing branches.

With trees of the 4 - 6 or 5 - 7 foot sizes (9-16-and 11-16-inch minimum caliper,) heading at 30 inches is about right. With higher heading than this it may be difficult to get strong branches low enough, while with lower heading the heavier pruning may be more severe than necessary, resulting in poorer crotches and a shorter head with less space between scaffold branches.

**Head at 24 to 30 Inches**

Smaller-sized trees, 3 to 4 feet in length or 7-16-inch caliper, will need lower heading, 24 inches being an average figure. Small trees, 2 to 3 feet in length or 5-16-inch caliper, will need to be still lower, probably 18 to 20 inches. Trees of this size are not recommended for planting, if they come from blocks of nursery stock averaging much larger, as many of the trees may be slower growing and dwarfish in habit, due to naturally less vigorous seedling rootstocks or to lack of congeniality. Fewer side branches (not over one on the smaller trees, in addition to the leader or upper branch or two side branches on the medium-sized trees) should be left at the next pruning.

Two-year-old branched trees should be pruned as outlined under “First Dormant Pruning” which follows, except that the branches selected should be headed-back moderately.
Many varieties of those fruits do not produce enough side branches the first season after planting and usually the strongest branches grow in a cluster together at the top where the cut was made. When this is the case, only one or two side branches, in addition to the leader, can be left without crowding (Fig. 6C). If the extra branches could be spread out along the trunk from 18 inches above the ground to the 30-inch top, a distance of 12 inches, three or four side branches could be left at the first pruning, spaced 4 to 6 inches apart provided they were well-placed around the tree and those closest together up and down are on opposite sides of the trunk. This would mean a considerable gain in time in establishing the head, lower trees, and lighter pruning with its advantages of quicker gains in size and earlier bearing.

Several means are suggested for accomplishing this objective of distributing the first branches over a longer head the first season. How to Get Low Branches

These means are all relatively new and none have been universally tested and adopted as standard, yet all offer hope of improving upon natural habit. They are as follows:

1. While the trees are still dormant or buds just swelling, select four or five buds arranged around the tree so as to give a branch in each direction, from 4 to 6 inches apart beginning from the top leader bud just below the cut. Select buds showing a wide angle with the stem. Each bud should be at least 90 degrees in direction away from the bud directly above or below it. All other buds are removed, so as to insure these buds forming shoots. If later the top branch or two show promise of greatly outgrowing the lower shoots, pinching them back will assist in balancing them. A method similar to this has been favorably reported by Fagan and Anthony\(^7\) in Pennsylvania.

2. The second method is to accomplish the same result by removing the surplus shoots just after they have started growth and the first leaves have formed. This system reduces total growth somewhat, but this effect is offset by the lighter dormant pruning necessary.

3. The third method is to wait until the shoots are half an inch long, and then to pinch out the growing points of the top branches to force the lower buds to grow. This can be followed by later pinching-back of the undesirable shoots to cause greater development of the shoots wanted for scaffold branches.

No other summer-pruning will be advisable the first season.

The First Dormant Pruning

If the trees have made a good growth, they are ready for the selection of the scaffold branches. This operation should be greatly simplified if one of the treatments outlined just above has been followed to secure branching over a long head. If the trees have not started well and have merely “feathered out” or made a short growth, the pruning outlined at this point must be delayed until the next dormant pruning. While the age in years is used here to indicate the stage of development, the treatment outlined is for well-cared-for, vigorously growing trees. Comparison with the illustrations will place the particular trees to be dealt with in the corresponding age groups described.

Fig. 12.—A (Left): YEARLING APRICOT: Note long head and excellent distribution of branches. Several nursery branches were left and shortened-in when tree was planted.

B (Right): SAME TREE PRUNED: Three well-spaced branches in addition to the leader could be saved because of long head and good branch distribution.

Strong, wide-angled branches are selected at this time for the scaffold branches.

Choosing Leader and Scaffold Branches

At the top, a strong central branch is selected as a leader to be left longer than the branches below. From this leader additional scaffold branches will be taken next year to make up the five to eight main branches desired. The leader should be larger than the first side branch left below it at the point of union. This side branch can usually be selected close to the cut made in heading the tree. Below this branch the branches should be at least 4 to 6 inches apart—more, if possible, especially with apples and pears. They should be well-located around the tree, none directly above the other as described in selecting buds in the foregoing section.

Space Branches 6 Inches Apart

Three branches in addition to the leader is the maximum; usually two will be all that can be left with the desired spacing so important if strong crotches are to be had. The leader branch, or trunk, at each successive crotch should be enough larger than the side branch to make sure the latter will be overgrown, thus forming a strong crotch. Where the branch is nearly the same size as the leader the side branch should be removed if it can be spared. If not, it should be headed back very severely to suppress it. This will probably need to be followed by further heading later. Figures 3 and 4 show a case where heading-back one member of a bad crotch was not successful. Had the stress not come so soon, this split might have been avoided by later pruning.
No heading-back should be needed except to balance the branches, unless the shoots are over 2 feet long, except with cherries and varieties of other fruits which branch only at the tip. These should be tipped back to 18 to 24 inches.

![Fig. 13.—A (left): A 2-YEAR-OLD APRICOT WHICH HAS HAD LITTLE HEADING: Fairly good branch distribution. B (Right): SAME TREE AFTER PRUNING: Note spur development. A light thinning and heading has been the only pruning necessary.](image)

**Treatment the Second Summer**

All varieties of sweet cherries, and certain varieties of pears, apples, and Domestica plums do not branch well when growing. Where growth is vigorous, as it should be at this stage of the tree's development, and it appears the shoots will reach an excessive length (say 3 to 4 feet) which would require heavy heading-back at the next dormant season to avoid high "leggy" trees, these branches should be clipped back in June when they reach a length of 18 to 24 inches. This clipping will give two seasons' branching in one and will avoid undesirable heavy dormant pruning.

No thinning-out should be given. Sprouts from the base should be pulled or cut off close to the trunk. Others undesirably low may be clipped back and left to shade the trunk.

**The Second Dormant Pruning**

At the end of the second growing season, the tree should have the two or three scaffold branches left the previous year and a goodly number of new shoots Select Remainder of 5 to 8 Scaffold Branches on the leader from which to select the remainder. Two or three additional branches should be selected and the remainder removed.
At this point attention should be paid to the branches formed on the lower scaffolds left from the previous year. Usually there will be too many of these, which will crowd and make weak secondary crotches if left. Those which grow inward should be removed and one or two selected which spread the tree and fill in its periphery, broad-angled, well-spaced apart and subordinated to the leader of the branch. Each branch should be treated as a leader the same as the leader forming the trunk. The main crotches should next be examined. If a side branch approaches the leader in girth, it should be suppressed by severe heading and thinning. Where the branch leaders are undesirably upright, to spread the tree they are headed back to outside laterals.

The leader and scaffold branches are next examined for relative height. If the leader is considerably stronger and higher, as is frequently the case, it should be suppressed to strengthen the lower branches in relation to the upper branches and leader and to avoid a tall leader or 2-story tree, in which the lower branches will be shaded out. Where necessary, this can be done by heading the leader and upper branches strongly, preferably to lower side branches, and by additional thinning-out.

If the leader and upper branches are only high enough to give a well-rounded tree, heading-back depends on their length. Sweet cherries and varieties branching only at the ends, if over 24 inches long, should be headed back to 18 to 20 inches in length. Other kinds may be left longer and still fill in well. Heading-back unnecessarily is inadvisable as this causes new branches to form only near the cut.

Fig. 14.—A (Upper): SHORT-OR STUB-PRUNED APRICOT IN CALIFORNIA: Note upright form with little spread. Top is dense from heading-back. Compare size with “long-pruned” tree in B.

B (Lower): LONG-PRUNED APRICOT IN CALIFORNIA: Note open head and larger size from lighter pruning. Tree will spread from weight of fruit on ends of branches. This tree is comparable with that in Figure A. (Courtesy, Utah Agr. Ext. Serv.)
PRUNING THE THIRD YEAR TO BEARING

Summer-clipping may be used profitably as long as it appears to be needed. Light Dormant pruning should be confined to the thinning-out of branches necessary to prevent crowding and weak crotches. Heading-back should be done only to maintain proper balance between branches. Small branches which will never compete as large branches should be left to increase in size and to produce early fruit. Horizontal or drooping branches are less vigorous and usually first to fruit.

Spur formation should be encouraged by enough thinning-out to provide sunlight for each branch. Spurs should be retained down the entire length of branches and leaders. Crossing and narrow-angled branches, obviously, should be removed. Water sprouts should be pulled off in early summer.

Preserve Spurs and Weak Shoots

As bearing size is reached, densely-topped trees may need summer thinning-out, as outlined under "Summer-Pruning".

Heavy pruning at this stage is to be avoided as bearing may be delayed several years by heavy cutting.

Fig. 15.—(A) (Left): PEACH TREE AFTER ONE SEASON'S GROWTH: This is reasonably good growth for the first year. Branch distribution is fair. Lower branches at base of tree are undesirable for permanent branches because they will interfere with hoening and in control of borers.

(B) (Right): SAME TREE AFTER PRUNING: Modified-leader training has been followed. Two long side branches and one short one have been left. The remaining scaffolds will be selected from shoots coming from the leader the next season. Compare with Figure 12-A.
Training Peaches, Apricots, Sour Cherries, and Japanese Plums

These fruits differ from the first group described (1) in that they branch more freely, (2) in having a tendency for the lower branches to grow more strongly than the upper and weaken the latter, (3) in growing with greater vigor, (4) in bearing earlier, and (5) in bearing an important part of their crop while young on shoots rather than spurs. Only those points wherein treatment differs from the first group will be discussed.

PRUNING NEWLY-PLANTED TREES

These fruits are usually branched as they come from the nursery, even as 1-year-old trees. Where these branches are located as desired and are uninjured, they may be used at once to form the lower branches. In this case the trees are pruned as described under "First Dormant Pruning", with the exception that the leader must be left relatively longer in these fruits because of the tendency of the lower branches to grow stronger than the upper branches; likewise, all the branches including the leader must be shortened-in to balance the root system.

It is particularly important with these fruits that lower branches be spaced well apart and be well subordinated and not too numerous. Cases of starving

Fig. 16.—A (Left): PEACH TREE AFTER TWO SEASONS' GROWTH: Shows desirably vigorous growth during the past season. Beginners are often puzzled to know what to do with so many shoots. Note the leader and scaffold branches left at the last training. Only one should have been left at "A".

B (Right): SAME TREE PRUNED: The well-developed leader and spacing of branches due to previous training makes it easy to complete the selection of scaffold branches and final formation of head. Secondary branches have formed on lower scaffold. Note heading to laterals to spread top of tree. A light crop should be borne next season.
of the leader, with later heart rot and almost certain ruin, are common results of failure to observe this rule.

Likewise, sharp angles are even more apt to cause breakage because of the softer nature of the wood of these fruits and on account of more rapid growth. Because of this rapid growth and early bearing subjecting the whole structure to greater stresses before crotches have been strengthened by additional layers of wood tissue, more "pruning in advance of the need" must be done with these fruits. These trees "fill-in" more rapidly and also are more apt to be damaged sooner by shading and crowding of branches; hence, more thinning-out pruning is necessary.

SOUR CHERRIES do not form adventitious buds freely as do peaches and other fruits of this group. Hence, heading-back must always be to a live bud—never to a stub. Since the buds swell early and are often rubbed off in handling, this is an important consideration. New branches of this fruit also grow out sharply in the direction in which the bud is pointed. To avoid crossing inside branches, cutting to inside buds should be guarded against. Removing inside buds often helps.

Where nursery branches are not suitable they may be removed, forming a whip of the tree. In this case a good plan is to stub the branches on the part of

Fig. 17.—A (Left): TWO-YEAR-OLD SOUR CHERRY: This tree made only a short growth the first season: hence, selection of scaffolds has been delayed until after second season's growth. Part of branches were pruned back to good buds at planting.

B (Right): SAME TREE AFTER PRUNING: Six scaffold branches and a leader branch have been left. Note heading back of branch at "A" which was competing with leader to avoid weak equal crotch. Secondary crotch angles at "BB" are wider than camera shows.
Trees May be Whipped

The trunk to be retained, thus insuring plenty of buds to form branches. The whips may then be treated as outlined under “Pruning After Planting” for the first group.

For securing good distribution of shoots by removing surplus shoots after growth is started, the second method suggested is used successfully on peaches in the Shenandoah-Cumberland Valley region and is reported as most promising by Auchter and Knapp.

PRUNING THE FIRST WINTER

Summer-pruning the first season is not usually advisable with these fruits.

At the dormant pruning, following the first season’s growth, the trees are handled similarly to those of the first group the first year or second year, depending upon their beginning and upon their subsequent development.

In general, to prevent crowding of scaffold branches, they require a heavy thinning-out with particular attention to crotches and subordination. Branches close up to the trunk should always come from the trunk and not from a side branch.

The opportunity to spread the tree by cutting back to laterals can be taken advantage of to a greater extent with these fruits. Heavy heading should be avoided as much as possible.

TRAINING THE SECOND SEASON

At the end of the second season the tree should have all of its scaffold branches selected and its head formed. Peach, apricot, and Japanese plum trees which have received good care and have made a vigorous growth may be safely allowed to fruit lightly the following season. Pruning by thinning-out and some heading to laterals is usually all that is needed.

TRAINING THE THIRD SEASON TO FULL BEARING

Vigorous trees pruned by this system should bear a good crop the fourth summer. To this end, moderate thinning-out and necessary corrective pruning is all that is needed. From this time on the trees may be treated as full-bearing trees, except that more vigorous growth, from 30 to 36 inches, should be maintained on these young trees until the space allowed is well occupied. As crops become heavier and trees older, to maintain vigor pruning should be speeded up and more heading-back used. Heavier pruning gives less fruit, more growth, and more fruiting wood for the following year.

THE SOUR CHERRY will need less pruning than the other fruits in this group. When the vigor becomes low, however, experience in Wisconsin shows that heavier pruning is profitable.

THE JAPANESE PLUM will require heading-back and renewal pruning to maintain size of fruit rather early in life. If highest returns are to be realized, hand-thinning, as with apricots and peaches, must supplement pruning.

APRICOTS are best “long-pruned” (thinning-out only) until their terminal growth falls below 12 to 18 inches, when annual renewal pruning to stimulate vegetative growth and to renew the fruit-spur system may be necessary.

PEACHES require heavier pruning than do other kinds of fruits to prevent overbearing and to maintain vigor. Thinning-out at first, then heading-in to lower laterals with increasing severity is usually necessary to maintain vigor. Thirty to 36 inches of new growth while young and 18 to 24 inches after full size is reached indicates the desired vigor in the peach.


PRUNING TOOLS

That "GOOD TOOLS MAKE A GOOD FARMER BETTER" is a true slogan. Every fruit-grower has his favorite pruning tools. They should be light, sharp, clean-cutting, and strong. The necessary tools are as follows:

**Hand Shears.**—For shaping young trees and light trimming hand shears are useful. A 9-inch, light-weight, roller-spring shear is preferred by many.

**Loppers.**—Long-handled lopping shears are most useful after the trees are two or more years of age. A steel-handled shear with curved guard to hold branches from slipping out is a particularly good type.

**Saws.**—Saws come in curved, straight, and meat-saw types. Of the curved saws, the type with teeth set pointing back toward the handle to cut on the draw stroke for light work, and the straight "New York Pruner" type for heavier work are preferred.

**Pole Pruner.**—A light-weight, "pump-gun" action type pole pruner is a great convenience in work with bearing trees—6-foot size for peaches, 8-foot for apples, and 10-foot for tall trees are convenient sizes.

WOULD PROTECTION

So the cuts will heal over rapidly, shear cuts should always be made smooth and close to the branch that is left. NO STUBS should be left. Saw cuts should be made within the collar and parallel with the flow of sap in the remaining branch.

All wounds larger than 1 inch in diameter—whether caused by pruning, mechanical or winter injury, or breakage—should be covered with a good wound dressing. Such a dressing should be waterproof, elastic, lasting, non-injurious, and should have strong fungicidal properties.

Bordeaux paint, made by mixing dry-powdered Bordeaux mixture with raw linseed oil to the consistency of a thick paint, is considered an excellent dressing. Several good proprietary materials are also available.

The purpose of wound protection is to prevent entry of the fungous organisms causing "wood decay" or "heart rot". These fungi are the common ones which rot off fence posts, barn sills, etc. They enter any exposed wood not protected by bark and digest the woody tissue upon which the tree depends for mechanical strength, leaving it "punky" and worthless for strength. Most breakage in old trees is due to wood decay. Breakage in old peach trees which have been dehorned is particularly common.
1. Early training of the young fruit tree affects later profits by influencing yields, quality, earliness of fruiting, costs of production, breakage, and longevity.

2. Young trees are trained to secure mechanical strength, low wide-spreading form, and to develop well-distributed spur-fruiting systems. Rate of increase in size is, likewise, an important consideration.

3. Pruning of vigorous, well-cared-for young trees is a dwarfing process. Heavy pruning has a greater dwarfing effect than has light pruning. Summer-pruning retards increase in size more than does dormant pruning.

4. Nitrogen, moisture, and carbohydrates are the most important foods upon which tree growth depends. Carbohydrates are usually the limiting growth factor in the young tree. Pruning decreases the supply of carbohydrates and so decreases net growth.

5. "Heading-back" pruning increases shoot formation, makes denser heads, and lessens spur formation. "Thinning-out" gives more open heads, better distribution of branches, greater spread, maximum spur formation, and earlier fruiting. "Cutting to a lateral" is intermediate in effect and is useful in spreading trees.

6. Weak crotches that split easily are the result of narrow angles and equal size of branches. Branches with wide angles should be chosen and subordinated to the leader branch.

7. Spread the trees by cutting to outside laterals, by keeping the head moderately dense, by keeping the leader relatively low, and by encouraging moderate early fruiting to pull the branches down.

8. Medium heading, from 24 to 33 inches, is recommended. Branches should be developed over a long head by use of the modified-leader system of training. Five to eight scaffold branches should be developed at least 6 inches apart and should be well arranged about the tree.

9. Apples, Pears, Sweet Cherries, Domestica Plums and Prunes are trained by heading the whips the first year, disbudding or pinching to secure well-distributed branching in the spring, selecting scaffold branches the first and second dormant prunings, and light thinning-out and corrective pruning until bearing. To cause branching, sweet cherries and certain varieties of other fruits which do not branch may require summer-tipping.

10. Peaches, Apricots, Sour Cherries, and Japanese Plums are trained by selection and heading-back of a leader and one to three lateral branches at planting or the trees may be whipped. Selection may be made of several more lateral branches with rather heavy thinning-out and moderate cutting-back to spreading laterals the first dormant pruning. Moderate thinning and light heading to laterals are necessary at the second pruning. A moderate crop may be borne the following year if trees are large enough.

11. Certain types of hand shears, lopping shears, saws, and pole pruners are recommended.

12. Wood decay, caused by wood-rotting fungi which gain entrance to the trees through neglected wounds, causes breakage in older trees. It may be prevented by careful pruning and treatment of wounds with Bordeaux paint.

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Division of Publications,
Utah Experiment Station,
Logan, Utah, U. S. A.