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Orchard Management *in Colorado*

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*Work reported on by this bulletin -was carried for the most part on the fruit substation, Austin, Colo., which is operated cooperatively by the Colorado Experiment Station and the office of the State Horticulturist. Division of Agriculture.

†Respectively : Director and horticulturist, retired; deputy state horticulturist; and associate horticulturist.

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Orchard Management in Colorado*

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While the general aim in orchard management is to produce a maximum crop at the least expense from a good orchard, the problems upon which success or failure depends vary with the conditions under which the grower is operating. Factors such as varieties, soil, altitude, drainage, irrigation, labor, transportation, and markets must be studied from the local standpoint. The aim of this bulletin is to give general principles so far as they have been developed.

Nothing on the farm deteriorates so quickly as a neglected orchard. After 2 or 3 years of neglect, it will take several years to restore an orchard to full production. In many cases, complete restoration is impossible. A neglected orchard is, under all conditions, unprofitable, even during a period of high prices. It is far better to remove the trees and utilize the land for other crops. It is true that many existing orchards should never have been planted, for the soil is unsuited for fruit trees and climatic conditions are unfavorable. The sooner these misfit orchards are removed, the better it will be for the owner and the community.

Attention should be called to economic conditions affecting fruit growers. There has been an overproduction of orchard products, especially apples, the past few years. This has made selling difficult, and prices in general have been low. Although there has been a large decrease in the number of apple trees in commercial orchards, annual production is still high. Planting of peaches along the Eastern Seaboard, in the Middle West, and in the Northwest has been heavy. These factors can be interpreted but one way: The commercial production of fruit will be economically difficult, especially in the West, and fruit growing will be more than ever a specialist's job. Economic conditions will tend to force the adoption of a definite system of orchard management that will maintain the trees in a healthy condition and produce a maximum tonnage of marketable fruit on a given acreage in order to reduce the production cost per bushel. There will be no place for the man who will not base his growing and marketing practices on scientific information and current economic trends. Some growers will be able to produce at a profit, but many will not be able to survive.

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Marketing, especially, must be given continuous serious thought. Local and nearby markets should be developed to the fullest possible extent, and the product should be adapted to the demands of these markets. In some instances, this will, no doubt, mean a shift in the type of handling used. There still will be a place for the progressive grower on a desirable location who grows, packs, and markets his fruit as the times demand.

Orchard Location

Size and Purpose of Plantings

Several factors must be considered in the location of an orchard. Probably the first is the use for the fruit which will be produced. This will definitely affect the size of the planting. If the fruit is grown for home use, the requirements will vary according to the individual family. The home orchard should be planned and planted with this in mind. The greatest trouble with the average home orchard has been its size. Too often it has required so much time that it did not receive the necessary care. Such a planting is always a liability.

If fruit is to be grown for local markets, attention should be given to the possible length of the marketing season. Probably small fruits and truck crops may be grown as supplemental crops. For the best sales possibilities, the grower should have a continuous supply of produce on sale over a long season. Consequently, a rather wide selection of varieties will be desirable.

In strictly commercial plantings, where fruit is raised in large quantities, the number of types and varieties should be restricted. A few carefully selected varieties of good market qualities should be sufficient. Probably no early apples should be included, since they will not ship or store well. Early apples should be planted only after a thorough study shows possibilities for marketing them.

The ability of a variety to stand the handling incidental to commercial grading and packing, and its storage quality, are important. Market preferences should be considered carefully. Experience has shown that it is much easier to market an accepted variety than it is to introduce new ones. The demand the country over is for red apples. Also, since unit costs decline as yields increase, varieties which will produce good annual yields are essential.

It is not possible to, give a definite number of acres as an economic unit for a commercial orchard under the management of one individual, since this would depend upon the location, the kind of

fruit to be grown, and whether other types of farming are carried on in conjunction with the orchard. With peaches, the acreage will be limited by the number of varieties and the number of days over which the fruit will ripen, together with the probable supply of labor available for harvesting and packing. With apples, the size of the orchard will depend upon the spray equipment since, for certain sprays, the orchard must be covered in not more than 3 or 4 days during the growing season. In most cases, this will be approximately 20 acres where only fruit is grown. A larger acreage can be handled by one individual if two or more kinds of fruit are grown and the spraying and harvesting requirements do not overlap too closely. Where cherries, peaches, pears, and apples can be grown in the same locality, labor can be spread more evenly over the season. Income also will be distributed more uniformly over the year. In the final analysis, the most profitable acreage will be that which can be handled with the smallest amount of seasonal help. Many growers suffer severe losses where overhead and cash outlay is large. This is particularly true during years of crop failures.

Site

The particular piece of ground on which the trees are planted likewise may control success or failure. It should be remembered that any planting of tree fruits will be on the ground for many years and that mistakes made in location cannot be remedied as easily as with an annual crop.

A satisfactory orchard site will be one in which the land is situated at a level somewhat higher than the surrounding country where satisfactory soil drainage and air drainage may be found. Generally a north slope will delay, and a south slope will hasten, blooming and maturity. With stone fruits, a north slope may prove advantageous. However, local conditions such as nearby topography or large bodies of water may influence air currents, thus affecting or even altering slope effects. Low-lying spots are subject to winter-killing and frost damage unless they are protected by air currents from adjoining canyons. Orchards in the Palisade district in Mesa County are protected by such air currents.

Soil

Although many tree fruits can be grown on a wide range of soils, different types of fruits are better adapted to certain types of soils. Apples and pears, for example, do best on a deep, silty or clay-loam soil. The peach is at its best on a soil of a lighter type. It is well adapted to a sandy or gravelly loam which is deep and well drained. It will not succeed where the soil drainage is poor. For

sour cherries, a fairly deep soil of moderate fertility should be selected. The sweet cherry is probably the most difficult type of fruit so far as soil adaptation is concerned. Ordinarily it does best on a light, well-drained, sandy or gravelly loam.

The depth of the soil should be 5 feet or more. As a rule, the higher mesa lands are freer from frost but may be underlaid by excess lime deposits. Bottom lands generally have deeper soils, but damage from seepage and low temperatures may be greater in these locations. The site should combine, as nearly as possible, soil of good depth and fertility with good drainage. The site may be on new land, old crop land, or on old or abandoned land which has previously proved satisfactory for the growing of fruit. If an old orchard site is to be used, it is desirable to crop the land for several seasons or to grow a green manure crop the year following removal of the old trees. The crop should be turned under in the fall and the new trees planted the following spring. Trees usually grow to a better advantage if a different kind is set than previously was grown on the site. For example, peaches will grow better following apples than will apples, and vice versa. It is also better not to plant in the same holes.

DRAINAGE AND WATER-HOLDING CAPACITY OF SOIL. — Good soil drainage is necessary. Fruit plants will not thrive in a wet soil. A wet soil is always cold and poorly aerated. Such soil decreases bacterial action. The water-holding capacity of a soil should be considered because of its effect on the amount of rain or irrigation water that will be needed. Sandy soils are much less retentive of moisture and require water at more frequent intervals than do loam or clay soils. They also may be much more difficult to irrigate than the heavier types of soils. Layers of hardpan, tight clay, rock, sand, or gravel close to the surface are undesirable in any orchard location. They tend to limit the penetration of both roots and moisture. Fruit trees feed over wide areas and often make satisfactory growth on soils of moderate fertility. A deep, well-drained soil fertile enough to produce good yields of small grains should produce satisfactory orchard trees. A relatively high content of organic matter is desirable, and the soil management program should be such that it will be maintained at a reasonable level.

Under irrigation, the slope of the land is important. It controls the ease and success with which irrigation water may be applied. A gentle, even slope is desirable.

Air Drainage

Most successful orchard locations in Colorado are at an elevation above the surrounding country. Cool or cold air functions in

much the same manner as does water. It tends to flow from higher to lower levels. Thus elevations adjacent to lower land to which the cold air may drain are desirable. Since this type of air movement or "air drainage" is a definite protection against damage from late spring frosts, all orchard locations should be selected with this factor in mind.

Southern and western slopes, because of their exposures to the sun, are warmer than northern or eastern slopes. Trees growing on such slopes will bloom earlier in the spring and thus may be more susceptible to spring frost injury.

Orchard Arrangement

Planting Distances

Most orchards are crowded. When the trees are first set, they appear thin on the ground. The crowding of trees in the orchard has many disadvantages. It prevents proper top development. It increases competition for both plant, nutrients and moisture. It interferes with necessary orchard operations because of lack of space. The ultimate results of such crowding are decreased yields, lowered quality, and increased costs of production.

In spacing trees in an orchard, soil types and available moisture should be considered. Trees planted on "dry land" with limited rainfall and no irrigation should be spaced much farther apart, than on more desirable locations. There is always the question, however, of the desirability of attempting to grow fruit, on such land. Suggested planting distances for several types of fruit are given in table 1.

TABLE 1.—*Planting distances for fruit trees on desirable locations.*

| Fruit | Distance | Fruit | Distance |
|---------|----------|------------------|----------|
| | Feet | | Feet |
| Apples | 30-40 | Cherries (sweet) | 25-30 |
| Pears | 25-30 | Cherries (sour) | 18-25 |
| Peaches | 20-25 | Plums and prunes | 20-25 |

The ultimate size the trees will reach should determine the planting distances. Definite differences in size of trees are found in the sour cherry. The English Morello cherry tree is much smaller than the Montmorency cherry tree. Similar differences are found in apple varieties. Wealthy and Yellow Transparent trees tend to be rather small, Jonathan trees are of medium size, and Gano and Northwestern Greening trees grow to large size.

System of Tree Arrangement

There are two main systems of orchard tree arrangement, in use, the hexagonal and the square. The hexagonal system will allow for about 15 percent more trees on a given piece of ground, but it is more difficult to handle. In commercial plantings on fairly level land, the square system is most commonly used. It is simple and easy to lay out, and it makes all subsequent orchard operations easier to perform. There are two modifications of the square system which are sometimes used. One is the oblong or rectangular method where the trees are set at the corners of a rectangle. The other is known as the quincunx. Here a tree is set in the center of the square. This arrangement is not particularly desirable since, after the trees reach fair size, all orchard operations must be performed on the diagonal. On very hilly ground, the "contour" system of planting may be used. In this system the contour of the hill is followed.

Filler Trees

Filler trees have been used to provide greater yields while the trees are young. In some cases they have been fruits of other types, such as peaches among apples. This combination has been unsatisfactory from the standpoint of spraying. In other cases, where apples have been used as fillers among apples, it has been done by planting trees closer in the rows. This is objectionable since many growers have failed to remove the fillers before serious damage from crowding has occurred to the permanent trees. There is no reason why fillers should not be used with late-bearing fruits such as apples if they are planted in the center of the squares and are pulled out before crowding occurs. Only early bearing varieties such as the Rome Beauty or Jonathan should be used. Heavy early bearing of filler trees can be induced by girdling when the trees are of sufficient size to bear a bushel or more of apples each. This undoubtedly would shorten the life of the trees. It might encourage early removal and thus prevent damage to the permanent trees from crowding.

Nursery Stock

Nursery stock should be ordered well in advance of planting time from a reliable nursery in order to obtain the stock desired. Fall planting has often been recommended as the most desirable. Probably this is true from the standpoint of allowing the root system a longer time in which to establish itself before top-growth begins. It is possible that in years of heavy snowfall and mild temperatures the trees would suffer little winter injury. However, experience in-

dicates that these conditions cannot be predicted, and more often the roots will be loosened by heaving and the tops desiccated by cold winds. Heavy losses may occur. Fall planting would seem desirable only in milder climates. Under Colorado conditions, trees planted between March 1 and April 15, depending upon weather conditions, have generally made the best growth, and fewer trees have been lost. If the nursery stock arrives before preparations for planting have been completed or during adverse planting weather, the bundles should be opened and the trees "heeled in" in a trench. Soil should be carefully packed in and around the roots and, if they are dry, the soil should be soaked to keep the trees from drying out. If the trees arrive during freezing weather, they should be stored in a cool place protected from freezing. *Do not unpack nursery stock if it is in a frozen condition.* If the package is not frozen, the outer paper or burlap covering should be loosened, and the packing around the roots kept moistened but not wet. If the trees are packed in a box, the cover should be removed and the packing moistened. The stock should be inspected by the county nursery inspector prior to "healing in", and any diseased or insect-infested trees should be destroyed.

The tendency is to purchase, the lower-priced smaller sizes of trees on the assumption that they will soon equal the larger trees in growth. In many cases these trees are smaller in size because of inferior root systems. Since the cost, of the trees is only a small part of an orchard investment, it will pay to buy the better grades. Trees of 7/16- to 11/16-inch caliper should be satisfactory. Most nurseries now grade their stock by caliper instead of by tree height. Caliper is the diameter of the trunk at a given height, above the crown. The 1-year tree or "whip" usually is preferred. Apple, pear, sweet, cherry, and some plum trees can be obtained in desired sizes when they are propagated by budding or grafting on whole roots. The 1-year peach tree usually will be branched. In some sections, trees of satisfactory size cannot be produced in one season. In such cases, 2-year trees must be purchased. These will prove satisfactory, but the head cannot, be formed as easily as when whips are planted, because the 2-year-old tree will be branched. One-year whips of a larger caliper than suggested will tend to be spongy and immature. During transplanting they will suffer more from drying out of the tops, and greater losses may occur.

Soil Preparation

Soil preparation before planting should be thorough. The land should be fall-plowed if at all possible. Deep plowing is desirable since it materially decreases the labor of digging the holes. Previous to planting, the soil should be worked to a fine and friable condition.

Laying Out the Orchard

For the square system of tree arrangement, the simplest method of locating the trees is plowing furrows parallel to and at the proper distance from each other. This is the distance apart the trees are to be set. A similar set of furrows, properly spaced, is run at right angles to the first, and the trees are planted where the furrows cross each other.

A more desirable method which will insure straighter rows and more even spacing consists in the following procedure. A base line is staked out parallel to a boundary line. This line of stakes should not be closer than 20 feet to the boundary line, since at least this much space is needed for turning with spraying and cultivating machinery. Corner and intermediate stakes are set where trees are to be planted, establishing the location of the first tree in each row. Then two lines of stakes are run at right angles to the base line, one at the side of the field, the other through the center, with the stakes set at the distance it is desired to space the trees. In order to obtain a true right angle, the corner stake on the first line is used as a pivot and a distance of 30 feet is measured off along this line. A temporary stake is placed at this point. From the pivot stake, a distance of 40 feet is measured off approximately at right angles to the first line. This point is shifted as needed until the diagonal distance between the 30-foot point and the 40-foot point measures exactly 50 feet. Then the stake is set and this line continued by sighting the other stakes in line with the pivot, and second temporary stake. Then a third line is sighted through at the lower end of the field, parallel to the first line run and at right angles to the two perpendiculars. The stakes in this fourth line are set in the positions the trees are to be planted. These stakes will represent the end trees in each row. The balance of the field is then staked out by two men sighting across the field at right angles to each other, with a third man setting the stakes in position. This method will insure straight lines of trees, although the spacing may vary slightly in hollows and high points in the field.

Planting

In setting the trees, every precaution should be taken to keep the roots or the soil from drying during planting operations. It is not desirable to plant trees when the soil is excessively wet. The best time is when the soil "breaks" freely from the shovel.

Digging the Holes

The holes should be dug large enough, both in depth and diameter, to accommodate the root system of the trees being planted.

The roots should receive only such pruning as may be required to remove diseased or broken roots and freshen the tip cuts. In digging the hole, it is well to keep the topsoil separate from the subsoil. This topsoil should be placed around the roots.

Planting the Trees

The trees and holes may be more accurately aligned if a planting board is used in setting. The planting board is made from a piece of 1-inch by 6-inch lumber about 5 feet long with three V-shaped notches, one at each end and the third in the exact middle of the board (fig. 1). To prevent variations in alignment, in case the position of the board is changed from tree to tree, the points of the three notches should be exactly in line.

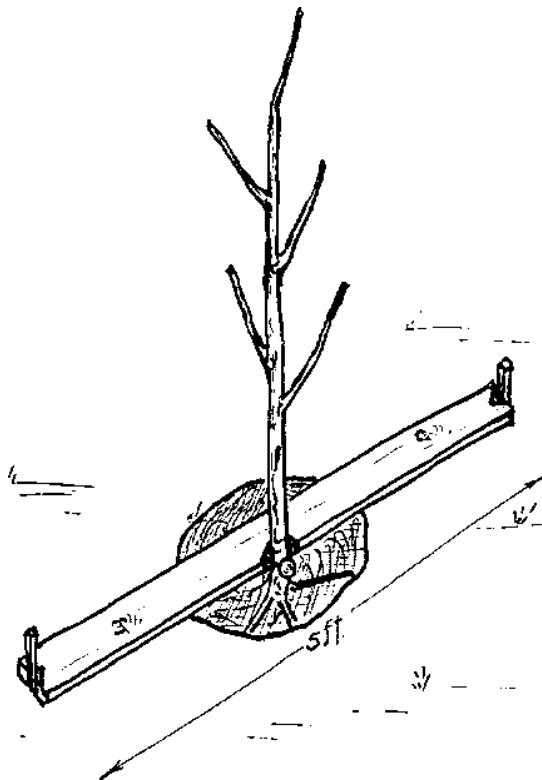


Figure 1.—Planting board. Always be sure the notch in the middle of the planting board faces in the same direction.

The board is placed with the center notch snugly against the stake marking the location of the tree. Extra stakes are then driven into the ground in each of the end notches in the board. Then it is removed while the hole is dug. The board is replaced over the hole with the two end notches in position over the end stakes, and the tree is set upright in the hole with the trunk resting in the center notch in the same position as the original stake. Then the planter shovels in the dirt, taking pains to pack the soil well between the roots with his hands, then tamping it firmly with his feet. The hole is filled to within 2 or 3 inches of the surface of the ground, and one or two buckets of water are poured into the basin formed around the tree. After the water has settled, dry dirt is added to fill the basin. If irrigation water is available at this

time, the trees can be watered with less labor by running the water down a furrow plowed along the side of each row of trees. While the general opinion is that newly planted trees do not require much moisture, this preliminary wetting is very important since, until new root hairs are formed, the soil around the roots must contain more moisture to keep the tree from wilting than is necessary for young trees already established.

In planting young trees, especially in sections where winter conditions are severe and sunscald is common, it is desirable to set the trees so that the lowest branch will be on the southwest side of the tree. This will provide shade on the part of the trunk which is most frequently damaged.

After planting, the trees should be pruned. If they are 1-year whips, it is necessary merely to cut the top off at the desired height. For sweet cherries, apples, and pears, a height of 30 inches from the ground is most satisfactory. In the case of 2-year-old apple trees that are already branched, one to three of the best spaced side branches are saved, and the rest are cut off close to the trunk. Unless the tree is more than 5 feet in height, the top need not be cut back. The lowest branch saved should be 18 to 24 inches from the ground. The side branches that are left should not be cut back unless they are more than 18 inches long or are longer than the top itself. With branched peach trees it is best to cut the main stem back to about 24 inches and cut all side shoots back to one or two buds.

Varieties

In selecting varieties for a commercial orchard, it is well to be cautious about planting new and untried varieties. Only those should be planted that have an established place on the market and are known to be heavy bearers. Experimenting with new varieties on a large scale is expensive for the grower. It is best to let the experiment stations do this. On the other hand, there are some of the older varieties of fruits that have serious faults. These should be dropped. Quality of fruit should always be considered. However, orchards are planted for the profit that may be obtained from them, and some varieties which produce fruits of high quality are not sufficiently productive to be profitable. It is also undesirable to plant too many varieties of a given fruit in any one orchard or district. Preference should be given to those which will grow best in the district. It is possible that some of the newer varieties may prove superior to some of the older ones.

Apples

Three or four varieties ripening at different periods should be sufficient for most orchards. For the Colorado districts in which they are adapted, the Jonathan, Rome Beauty, Delicious, and Wine-sap can still be considered standard commercial sorts. Recently red sports of these varieties have been developed. Since, for all practical purposes, they are identical with the original varieties in all characteristics except color, they should be given preference wherever difficulty is encountered in coloring of the fruit. The Starking, a

red sport of the Delicious, may tend to bear heavier crops at an earlier age than the Delicious itself. Turley, a Winesap seedling similar in appearance to the Stayman, may prove worthwhile as a replacement for both the Winesap and the Stayman. It appears to be free from the storage troubles to which the Stayman is subject, and it produces fruit which is larger-sized than the Winesap and is as well colored.

For northeastern Colorado, where winter hardiness is an important factor, hardier sorts must be considered. These would include varieties such as Yellow Transparent, Duchess, Wealthy, McIntosh, Northwestern Greening, and Red Sheriff. Varieties such as Jonathan and Delicious may do well after they have become established, although they are subject to injury when first set.

In districts at high altitudes, where trees of standard commercial varieties grow well but where the growing season is too short to mature the fruit, short-season varieties should be planted. Yellow Transparent, Duchess, Red June, Wealthy, and McIntosh are of this type.

It is possible that some of the newer hardy varieties developed for Plains conditions may prove satisfactory for these sections.

Pears

The Bartlett and the Anjou are still considered the best market pears. However, the Bartlett is very susceptible to fire blight, and the Anjou is frequently affected with cork. The Gorham, a comparatively new variety, shows promise as a replacement for the Bartlett. It ripens about 10 days later but is fairly resistant to blight. It equals Bartlett in quality, both for canning and for eating out-of-hand, and can be grown wherever the Bartlett succeeds.

Peaches

Although many new varieties of peaches have been placed on the market in the last few years, there does not yet appear to be any which will prove as profitable for Colorado peach sections as the standard Elberta. Some of these show promise, but they have not yet been sufficiently tested. Most of the older, early maturing peaches leave much to be desired in both eating and shipping qualities. The fruit of the J. H. Hale is of good quality, but the trees have not proved to be as hardy or as heavy producers as the Elberta. Several different strains have been distributed under the name "Hale." Some of these have been rather unstable in fruit characteristics. In mixed plantings, it might be desirable to include a few Hale trees, since most nurseries have succeeded in weeding out the poorer strains in the

last few years. The Canadian Queen shows promise as a replacement for the Elberta. The fruit ripens at the same time or a few days earlier and is superior in quality. It is a good shipper and canner, lacks the tartness of the Elberta, and is quite free from red coloring at the pit.

Apricots

Apricots can be grown only in more protected places free from spring frosts, since they are among the earliest blooming trees. The Moorpark has been most generally planted, although now there is a tendency to displace it with other varieties. Apricot varieties have become badly mixed. Frequently the same variety has been sold under several different names. Where they can be grown, the Moorpark, Wenatchee, Chinese or Colorado, and Riland should constitute a satisfactory list. The Wenatchee tends to develop certain minor weaknesses in ripening but can be considered an improvement over the Moorpark. The Chinese and Colorado are considered the same variety. The fruit ripens somewhat earlier than the Moorpark. The Riland is a new variety which is promising. The fruit is large and well colored and ripens about a week ahead of the Moorpark. Unless it should develop weaknesses not now apparent, it can be considered as one of the best varieties to plant. There is little difference in bud hardiness in the varieties listed, except in the Chinese which often matures a few fruits even after killing frosts.

Plums and Prunes

The Japanese and Japanese hybrid plums bloom so early they frequently suffer losses from frost. However, where adapted, the Santa Rosa and Duarte will probably prove the most satisfactory. A new variety, the Flaming Delicious, is promising in both tree and fruit characteristics. The fruit ripens about a week later than the Santa Rosa.

The European plums bloom later and are more consistent in bearing. The more desirable varieties are classed as prunes rather than plums. Of these, the Italian prune would head the list, followed by the French or Improved French, German, and Tragedy prunes. The trees of the last-named variety are not very vigorous and are subject to winter injury. The fruit is of good quality and ripens slightly later than the Moorpark apricot. The Sugar prune fails in tree characteristics, and it is doubtful if it should be planted. The Stanley is a new variety worthy of trial.

Sweet Cherries

The varieties most commonly grown are the Bing, Lambert, and Napoleon or Royal Ann. However, the last variety is in demand

mainly for canning, its price being little more than that paid for sour cherries. Under these conditions the advisability of planting the Napoleon would seem questionable. Sweet cherries require a uniform soil of good depth with a uniform moisture content throughout the season. They are more susceptible to atmospheric conditions than most other fruits. They do best under a relatively high humidity and a relatively low mean seasonal temperature. The fruit is subject to cracking of the skin during wet weather at harvest time.

Sour Cherries

The list of desirable varieties of sour cherries is not extensive. The Montmorency and English Morello are the most productive and are generally used. The Early Richmond will grow where these other two varieties will succeed, but canners object to it. The sour cherry is more resistant to winter temperatures than many of the other tree fruits, and the bloom is late enough to escape many spring frosts. Sour cherries also are more adaptable to soils if grown on Mahaleb root stocks and will do well on the shallower, more calcareous soils upon which apples and peaches grow poorly.

Pollination

It has long been known that many kinds and varieties of fruits cannot set fruit with their own pollen. Consequently, pollen from some other variety must, be provided if the flowers are to be satisfactorily pollinated so that fruit will set and develop to maturity. This is known as "cross-pollination." Practically all apples and pears must be cross-pollinated. Most sour cherries, apricots, and peaches will set fruit when the flowers are fertilized with their own pollen. Notable exceptions in peaches are the J. H. Hale, Early Elberta, and Candoka varieties which cannot set fruit with their own pollen. Conditions are further complicated in sweet cherries. In addition to requiring cross-pollination from another variety, some sweet cherry varieties are intersterile. This is the case with Bing, Lambert, and Napoleon. While the pollen of each of these three varieties is viable and will function on many other varieties, none of these will fertilize their own flowers or those of the other two varieties. Consequently, it is necessary to provide another variety such as Deacon, Governor Wood, Republican, or Black Tartarian which will pollinate any of the three intersterile varieties mentioned. Also, pollen of any one of the three intersterile varieties will pollinate the other varieties listed.

Many varieties of plums are self-unfruitful. This is true with most Japanese sorts. Practically none of the American plum species

can set fruit with their own pollen. While some European plums will set some fruit with their own pollen, much better crops can be obtained by providing pollen from other varieties. Within the European sorts, satisfactory yields should result from the interplanting of any two or more varieties *if they bloom at the same time*. Plums of the American and Japanese species cross-pollinate readily. However, they will not pollinate European plums satisfactorily.

Number of Pollinator Trees Needed

All fruit plantings of varieties which need cross-pollination should be so arranged that the greatest distance between the pollinating variety and the ones to be pollinated will not be over 50 to 90 feet. This can be arranged by planting at least one tree in nine of the pollinating variety. When commercial varieties are planted, solid rows of one variety may be used to advantage.

In the selection of varieties to be used as pollinators, several factors should be considered. First, the varieties must be able to pollinate each other. They must, bloom at the same time, or their bloom periods must overlap. Since any one variety may not bloom every year, it is desirable to provide more than one pollinating variety. *If you are in doubt as to the value of any varieties of fruits as pollinators, write the Colorado Experiment Station, Fort Collins, Colo., for specific varietal information.*

Where solid blocks of one variety have been planted, a temporary expedient, in supplying proper pollination would be the placing of bundles of blooming branches in buckets of water near the tops of the trees. However, to function properly, these must be replaced frequently. A permanent remedy would be to graft, in pollinating varieties on scattered trees through the orchard, using a definite spacing arrangement. This would not prove as satisfactory as entire rows and would tend to complicate harvesting. Also, where only a limb or two is grafted on a tree, there is danger of pruning them off in the course of time.

Honey Bees in Pollination

Even where varieties are mixed, it is desirable to provide bees as pollinators where insects are known to be scarce. One hive to 2 or 3 acres should be sufficient. The hives should be in the orchard only during the blooming period. Owing to the difficulty in some sections in obtaining bees, there has developed a demand for "package bees," and many beekeepers are now making a business of supplying them to fruit growers. Package bees are supplied in wire cages containing from 3 to 5 pounds of bees with a queen. The grower merely

needs to wrap the cages in heavy paper, place them in the desired location, and pull the corks from the openings. Under adverse weather conditions, package bees have been observed to continue working the blossoms when the bees in weak hives have stayed at home. The cost of these packages is approximately the same as for the rental of hives.

Training and Pruning

Definite rules for training and pruning cannot be laid down. Each tree is an individual and is a problem in itself. Trees of the same variety develop differently, and different varieties exhibit still greater differences in growth habits. Thus individual and varietal variations in growth habits must be considered, often at the sacrifice of the ideas or ideals the grower has in mind.

Reasons for Pruning

The primary reason for pruning is the establishing of trees which are able to produce heavy crops of fruit over long periods of time. The trees must be strong mechanically. This strength is largely the result of pruning or training the tree the first few years in the orchard. Since any orchard is a liability until it has come into production, the grower wants to get as large a tree as he can in as short a time as possible. Production costs are also dependent on pruning and its results. For ease in handling, a low tree is desirable. For volume of production, a large bearing area is necessary. For quality fruit, an open tree which will permit penetration of light and economical spraying and harvesting is needed.

How does pruning affect these needs? First, pruning is a dwarfing process. It reduces the total amount of growth made, mainly because it reduces the leaf-bearing area of the tree. Heavy pruning will delay bearing and will produce a small tree. Consequently, pruning at any time should be no more severe than is needed to obtain the desired type of tree. On the other hand, pruning will greatly stimulate growth in local areas. Removing a branch will cause the branch or branches near it to grow more rapidly and to greater size, but the increased growth will be limited to the vicinity in which the cut is made.

Pruning can play a large part in the strength of the tree by controlling the angles of the crotches formed. A wide crotch angle is mechanically strong; a narrow one is weak. Figure 2 shows why a narrow angle is weak, and figure 3 shows why a wide angle provides a stronger mechanical structure.



Figure 2.—A narrow crotch is weak. It will split at the crease, "a", under heavy load.

Time to Prune

Most of the pruning of fruit trees should be done during the dormant season, that is, when the foliage is off the trees. The ideal time is in the spring shortly before growth starts. At this time wounds will heal more rapidly. Fall and winter pruning, while possible under some conditions, may cause some dying back of cut areas before growth starts.

There are distinct advantages to pruning during the dormant season. Probably most important is the fact that it is much easier to see just where branches should be removed, since the tree has no foliage to interfere with the vision of the operator. In large orchards, dormant pruning will also provide for better utilization of "year-'round" labor.

Where winters are severe, it is desirable to wait until the worst of the cold weather is past. This is true in those parts of Colorado where winter weather is similar to that found in the north central section of the State. In milder sections this

is of less importance.

Making Pruning Cuts

Wherever a branch is removed from a fruit tree, do not leave a stub. See that all cuts are made close to the trunk or branch. Leave them smooth and clean so they will heal over rapidly. Stubs heal slowly, if at all.

In removing a branch or a part of one from a fruit tree, be sure to cut back to a lateral branch. If attention is paid to this one point, the formation of water sprouts can be reduced radically.

Making the cuts in this manner is also a direct means of spreading the top of the tree and keeping it low and open.

Types of Training

Several distinct types of training fruit trees have been developed. Of these, two are usually found in commercial orchards. These are (1) the "vase-type" or "open-center" and (2) the "modified-central-leader" or "delayed-open-center" types. Excellent orchard trees have been developed from both.

OPEN-CENTER TYPE.—This is the type found in most western fruit plantings (fig. 4). Properly handled, it has been reasonably satisfactory. It

provides a low, open, spreading tree. It is an easy type to establish and maintain. However, it does have one

serious defect. Since all the main branches come out from the trunk at practically the same point, within a space of 6 to 12 inches, it is often structurally weak.

Three to five main branches should form the main framework of the vase-shape tree. One-year-old trees from 4 to 6 feet in height usually are used. After the trees have been planted, they should be cut back to a height of 16 to 24 inches from the ground. The buds below the cut will then develop into strong branches which will form the support of the crown. Generally five or six buds start to form branches. All of them should be left growing the first year. At the beginning of the second season in the orchard, the number should be reduced to not over five, evenly distributed around the trunk. The branches left should be cut back lightly to cause secondary branching and strengthen the crotches. If they are not cut back, they will continue to grow, forming long, slender branches which cannot support heavy crops of fruit.

This shortening up of the main branches, as well as the thinning out of superfluous secondary branches, should be continued. The tree will develop into a vase form without a central column or trunk.



Figure 3.—A wide-angled crotch. The creasing shown at "a" in figure 2 is missing. A strengthening shoulder is developing at "b."

The absence of a central trunk will distribute not only the wood growth, but also the fruit production, over the entire tree. If the pruning is carefully done during the first 4 or 5 years, there should be little occasion for heavy pruning after that time. Subsequent pruning should consist in thinning out superfluous shoots and in shortening lateral growth where too abundant.

MODIFIED-CENTRAL-LEADER TYPE.—This is a combination of the old "central-leader" tree, where the main trunk or leader was permitted to develop without



Figure 4.—An open-center tree. Note that all the main scaffold branches come out at practically the same point.

checking its height, and the vase-type tree. It is a planned attempt to secure the mechanical strength of the first and the desirable open head of the second. It differs from the central-leader type in that the leader has been removed *after* the main or scaffold branches have been selected. It differs from the open-center or vase-type *only* in the placing of the main branches. Instead of coming out from the trunk in a short space, the main or scaffold branches are spaced at intervals ranging from a few inches to 12 inches up and down the trunk. When the desired number of main branches, usually four or five, have been selected, the leader is cut out above the highest main branch. The resulting tree is low-headed, open, and spreading. Because of the better placing of the main branches along the short trunk, this type does have the distinct advantage of greater mechanical strength.

This type of tree is somewhat more difficult to obtain than the vase-type previously outlined. When 1-year "whips" are used, a heading back or cutting back of the top of the tree to compensate for the loss of roots incidental to transplanting is all that is needed when the trees are planted. If the young tree is from 4 to 7 feet tall, cut it back to 24 or 30 inches from the ground. Higher heading

makes it difficult to obtain branches low on the tree. If the tree makes good growth the first year in the orchard, the grower may be able to select several of the branches at the beginning of the second year (fig. 5).

The first step in this pruning is to select the terminal branch which is to continue the development of the trunk. This should be a vigorous shoot and the one most centrally located. Then select as many suitably placed side shoots for main branches as are available, taking care to space them up and down the trunk not less than 6 to 9 inches apart. A little more distance is desirable. They should be located around the trunk in such a manner that no branch is directly above another. These side branches should be kept shorter than the terminal. In certain sections where sunscald is serious, it is desirable to place the lowest branch on the south-west side of the tree.

When 2-year-old nursery trees are set, they should be pruned as described for 1-year whips which have been in the orchard a year.

At the beginning of the third year in the orchard, the scaffold branches selected the previous years should be maintained. Others desirably placed are chosen. If the total number desired, about four or five, are now available in the proper positions, the terminal or leader should be cut off just above the last branch selected.

A tree that is headed from 18 inches to 3 feet from the ground will usually produce a greater trunk diameter within a given number



Figure 5. — Young tree pruned to the modified-central-leader form. The vertical-spacing between branches shown plainly. The point at which the central leader was removed is indicated by "a."

of years than one headed higher. The modified-leader form will often produce a lower tree than the vase-type because the branches tend to grow out at a broader angle. Consequently, although the branches might be rather long, the tree itself will be lower. This effect is obtained by retaining the central leader over several years, merely cutting it back each season sufficiently to prevent it outgrowing the side branches.

The number of main branches left may vary from three to seven. A happy medium would be four or five, since in trees where only three are left the loss of one would seriously cripple the tree. With too many, the tree will eventually become a mass of long bare poles with a tuft of smaller branches at the outer ends. The vertical spacing will also vary with the number of limbs. With a smaller number, the spacing would be greater, up to a foot apart where only four are left. The entire number of main branches may not be obtained in the first or even second year of growth. However, by the third year the head should be well established, and the central leader can be removed later.

Pruning during the Intermediate Period

The intermediate period is the time after the head is established until the tree begins to bear regularly. During this time, pruning should be confined to removing excess branches, maintaining the framework already established, and maintaining the balance between the main branches. It is well to remember that branches which if left will require large saw cuts for removal in later years may be removed at this time with shears. On the other hand, the tree should not be pruned too heavily, and many small branches that must eventually be removed may be left for a year or 2 longer and then cut off. The main branches need not be shortened until they have reached approximately the height at which it is desired to head the mature tree, except to maintain a balance with neighboring branches. The tops of trees at this age may be left rather dense because the weight of the first crops of fruit will spread the main leaders and open the top.

Pruning the Bearing Tree

After the tree has begun to bear, the pruning should continue the original form and keep it at a convenient height. The main consideration now should be to encourage and maintain the fruit-bearing structures which, in the case of apples and pears, are the fruit spurs. There are two methods of pruning used at this time: (1) Heading back and (2) thinning out. Heading back is the annual cutting back from one-third to two-thirds of the yearly growth. Sometimes this

cutting is clone into 2- and 3-year-old wood. In such cases, stubs are left which do not heal readily. This type of pruning often results in the production of a large number of new shoots in a small area of the tree and few fruit spurs. With any kind of fruit tree, this will result in a dense top with the growth concentrated at the outer ends of the branches. It can be seen that heading back such varieties as the Jonathan, Ben Davis, and Winesap, which tend to produce fruit from axillary buds on the new growth, will result in the removal of part of the crop. Thinning out consists in cutting out from less than one-third to two-thirds of the lateral growth along the main or secondary branches. This results in the production of many new shoots, spread all over the tree, which will develop into fruit spurs in their second and third years. This will tend toward annual bearing and larger crops. Pruning for fruit production should consist of thinning out rather than heading back, except where it is necessary to subordinate excessively rank-growing 1-year-old wood. Then the cuts should be made at lateral branches which are in a position to assume the lead in place of the one removed. Such cuts may be made in 2- and 3-year wood or older, and the severity or amount of pruning will vary with the vitality of the tree and amount of growth it is making. Old, devitalized trees respond more readily to thinning out, and the wounds heal more rapidly.

APPLE, PEAR, AND SWEET CHERRY.—These three fruits bear the bulk of their crops on spurs. In most cases, any one spur will bear fruit only in alternate years. As they grow older they become more irregular. Consequently, the aim should be to keep the existing spurs in a healthy condition and to encourage the production of new ones annually. With some varieties, where the spurs have become old and considerably branched, it might be well to thin them out and remove some of the small branches. The pruning should not be severe; enough to force them into shoot growth unless branches are needed to fill, out the top of the tree. Older trees should be thinned out in the tops to facilitate spraying and to permit sunlight, to penetrate to all parts of the tree. While sunlight is essential to the coloring of the fruit, it should be remembered that fruit exposed directly to the sun may scorch or scald. It is the sunshine available to the foliage surrounding the fruit that is most important. All weak and diseased wood should be removed. Recently a system of pruning has been advocated that, consists in removing all of the smaller, weaker growth in the inside parts of the tree on the assumption that such wood produces inferior fruit. There is a question as to whether such wood need always be weak or whether this condition is not due to improper pruning. Past experience indicates that, where the top is kept, sufficiently open the lower interior growth will remain in a

healthy condition and will bear fruit of good quality. Pruning out the inside of the tree year after year can result only in forcing the bearing wood outward. This will eventually produce a globe-shaped canopy of bearing wood with many long, bare branches inside. This would seem opposed to the desired objective, and it would tend to complicate spraying and harvesting operations. It is evident that pruning should be as light as possible to produce the desired results. This is possible only where it is an annual operation.

SOUR CHERRY, PEACH, AND OTHER STONE FRUITS.—These fruits can be classed together as to their pruning requirements. The sour cherry, apricot, and plums are intermediate between the apple and the peach in that they bear fruit on axillary buds on the new wood as well as on the spurs.

The sour cherry should not be pruned as open as the other types of stone fruits. The top should be thinned out only enough to keep the smaller inside wood from being shaded out. The sour cherry also suffers more than other fruits from heading back of the shoots and branches.

The peach bears its fruits on axillary buds on the new growth only. Therefore it requires heavier pruning to force the production of sufficient amounts of new wood each year. Since the fruiting wood tends to develop farther out on the tree each year, pruning should consist in thinning out the shoots and secondary branches according to the amount of growth the tree is making. The cuts are made in 1-, 2-, and 3-year-old wood to the lowest lateral branches or shoots which are in a thrifty condition. Some growers head back all the new growth. Although the peach will stand this severe type of pruning better than most tree fruits, it is not a desirable practice. Pruning should not be severe enough to force out long shoots, since those over 2 feet long rarely, if ever, develop fruit buds under Colorado conditions. Those less than 6 inches in length produce fruit of small size and cannot carry as many fruits to the shoot. A desirable condition for maximum yields is the production of shoots from 12 to 18 inches long on young trees and 8 to 12 inches long on old trees which are in full bearing. New shoots appearing along the lower part on the upper side of the main limbs should be saved and trained to replace the main leaders as these bend down and become so low they interfere with orchard operations. Unpruned peach trees tend to lose all the lower and interior wood. They set no fruit buds except those on the ends of small, weak shoots on the outer part of the tree. Therefore it is important that peaches be pruned regularly each year. As with other fruit trees the tops should be kept well thinned out.

Remedial Pruning

Through neglect, improper pruning, or other conditions, trees may become too thick, too tall, or develop too many scaffold limbs. Sometimes all of the branches may be bent to one side by wind. In such cases, judicious pruning will often remedy the difficulty. Trees that have become weakened by neglect in pruning and maintaining soil fertility can be invigorated by a severe pruning. This will reduce the growing points to a number the root system can support. However, this is only a temporary expedient in most cases and should be used only for 1 or 2 years until the soil fertility can be built up. In some cases, the soil is of such character that, its fertility cannot be increased. Then heavy pruning would have to be continued for the balance of the life of the trees. This would result in smaller trees and lowered production. The real remedy in such a case would be the removal of the trees.

Where trees have become too dense and tall, the remedy is to cut out a considerable amount of the wood by thinning. This should be done mainly in the top. The tall leaders can be cut back to lower laterals that may be located near the desired height, growing in the same general direction as the part cut off. Caution must be used in doing this type of pruning because frequently most of the lower and inner growth will be dead. Here again too severe pruning in 1 year will remove the greater portion of any crop that may be present. Excess scaffold limbs should be cut out, but this also should be done gradually to allow new shoot growth to fill the vacant space. Otherwise the bark of the remaining limbs may suffer severely from sun- scald. If the top of the tree is bent over to one side, the branches toward the wind should be pruned only lightly. What cuts are made should be to branches growing out into the wind at a rather flat angle. The side away from the wind is then pruned more severely to dwarf it. Where a windbreak is not planted, this process will of necessity be a continual one. Leaving a greater weight of low- hanging branches on the side toward the wind will tend to offset the effect, of the wind and will spread the top more when the branches are loaded with fruit. Steady breezes have a greater effect in bending trees than do strong winds blowing intermittently.

Dehorning

In years past it has been the practice to cut the main or secondary limbs back to short stubs for the purpose of renewing the top. This practice is known as "dehorning." It has been found that this type of pruning is too drastic. In some cases it results in the death of the tree. Usually it causes the tree to remain in a non-bearing state for several years. With the peach, the new growth is

long and rank, and no fruit buds are set until this growth slows down. With the apple, it takes several years before fruit spurs are formed, and bearing does not begin much sooner than would be the case with a newly planted tree. In all cases, unhealed stubs remain, and the new growth is bunched on each stub near the cut. Dehorning cannot be recommended as a general practice, except possibly in the case of the transplanting of fairly large trees.

Soil Management

Because orchard fruits are grown on the same land for many years, probably no single factor is of more consequence in the success or failure of a fruit-growing enterprise than proper soil management. The soil should be kept in good physical condition, well aerated, and with a uniform soil moisture content throughout the year. Organic matter must be supplied to replace that destroyed. Neglecting the soil in an orchard eventually will have disastrous results. In many cases symptoms of malnutrition such as die-back, rosette, and chlorosis can be remedied by proper soil management.

Systems of Orchard Soil Management

Five methods of soil management are now used by Colorado fruit growers. These are (1) sod or sod mulch; (2) clean cultivation; (3) clean cultivation with cover crops; (4) permanent cover crops; (5) intercrops.

SOD CULTURE.—It has been argued that natural conditions under which wild forms of fruit grow are the logical ones to follow. Although sod or sod mulch orchards cannot be recommended for general use under Colorado conditions, they are both desirable and necessary in some locations. If the orchard is located on steep, stony, or hilly land which is subject to erosion, it is desirable to keep the orchard in sod permanently. Under such conditions, the grass grown in the orchard either should be allowed to remain in the orchard uncut from year to year, or it should be cut and used as mulch around the trees.

There are advantages in the use of such a system. Even when commercial fertilizers are used as a supplement, the cost of maintenance is low. Both sod and sod mulch methods permit the use of land otherwise not adapted to fruit to be utilized for fruit production. In addition, sod in orchards conserves organic matter in the soil.

There are disadvantages to the use of sod in an orchard. Trees grown in sod tend to develop shallow root systems and are more subject to drought. Since the root systems are shallow, the feeding area of the roots is curtailed and the fruit produced may be inferior

in both size and yield. Irrigation is more difficult. Where mulch is used around the trees, injury from rodents usually increases unless the trees are protected by wire screens or other types of preventives. Mulch in any orchard also introduces a serious fire hazard.

CLEAN CULTIVATION.—With the development of fruit growing in the Northwest, clean cultivation in orchards came into vogue. Clean cultivation is beneficial to young trees because it stimulates wood growth, and better trees can be produced. On virgin soil naturally rich in plant food, it will give satisfactory results for a considerable period of time. However, this system has its defects. Depletion of organic material in the soil is more rapid and as the organic content decreases, the soil becomes quite impervious to water. Plant food becomes either exhausted or unavailable to the trees. Injury from excess nitrates and alkali salts in the soil is aggravated under this system. Continuous clean cultivation is the most expensive method, and it permits the greatest loss of topsoil from an orchard through sheet erosion.

Some of these difficulties can be overcome somewhat by incorporation of manure, hay, or straw into the soil. Applications of commercial fertilizers also may be used to advantage. However, these all increase production costs.

It is apparent that clean cultivation should be restricted. It *is* a means of conserving water, so it may be desirable in years of water shortage, and it may be an acceptable method of controlling noxious weeds. In new plantings, it is desirable for the first few years.

COVER CROPS.—Under most orchard conditions, a system of clean cultivation in which the use of a cover crop is included appears to be the most practical and effective method of soil management. It gives satisfactory results at relatively low cost. It requires more water than does clean cultivation but less than do sod or sod mulch systems. The use of cover crops has distinct advantages. It is a means of offsetting the detrimental effects of excess irrigations. It will check late growth and insure maturity of wood before winter without depriving the trees of the plant foods necessary to produce a crop of fruit. When incorporated into the soil, the plant residues add organic matter to the soil. This increases the friability of the soil and makes it easier to work, it increases the water-holding capacity of the soil, it aids in making plant food in the soil available to the trees, and it tends to offset the harmful effects of excessive amounts of alkaline salts and nitrates in the soil. The part of the organic matter which exists in a more decomposed state in the soil is known as "humus." Humates may have a great effect, in the pre-

vention and control of "yellowing" or chlorosis which results from unfavorable soil conditions such as excessive amounts of calcium carbonate.

Two general methods of handling cover crops are used. In the first, annual or biennial plants are sown in the late summer or early fall, then are turned under in late fall or early spring. The orchard is again cultivated until late summer, when a cover crop is planted again.

In the second method, biennial or perennial crops are sown in the orchard either in the spring or fall and are allowed to remain from two to four seasons. An interval of one or two seasons of clean cultivation is then followed by reseeding. This system is often spoken of as the use of "perennial cover crops." In addition to the interval of clean cultivation, the crops should be disked lightly each fall or spring after the first season's growth. This will destroy some weeds and insects. Disking in the fall is more effective and should be less harmful to the cover crop than spring cultivation. In hot, dry sections, the cover crop may serve also as a shade crop.

Sometimes the fruit grower is confronted by conditions under which it is impossible to produce a crop of fruit and a cover crop. There is always a question as to the advisability of attempting to grow fruit under such conditions. However, this condition exists in many of the sour cherry orchards in the State.

CHARACTERISTICS OF VARIOUS COVER CROPS.—In general the various sweet clovers have deep root systems and produce a heavy top growth. Some are annuals, such as the Hubam, and others are biennials, such as the common white and yellow blossom. The Hubam and the white biennial are both tall growing, while the yellow blossom generally produces a shorter and more recumbent growth. Some yellow blossom strains, however, have been noted growing fully as tall as the white blossom. The earlier blooming of the yellow blossom may prove a disadvantage in districts where bees are numerous and spraying is continuous, for the assertion is made that bees are attracted to the bloom and killed by the spray poison. Sweet clover is more difficult to start under adverse moisture conditions because of its small seed. Planting must be shallow and the surface soil must be maintained in a moist condition until the roots have become well established. When sweet clover is seeded in the orchard late in the season, these requirements tend to cause overirrigation of the trees.

Hairy vetch is an annual and is among the best cover crops for stone-fruit orchards, particularly when combined with winter rye. It is satisfactory for pears and for apples where only a one-season cover crop is desired. It competes well with weeds and produces a

heavy top growth with a fairly deep root system. In new plantings, inoculation is necessary, and vetch may have to be grown several seasons before maximum growth is obtained. The seed is large and germinates rather readily, even under adverse conditions. This crop has the same ability as other legumes to fix nitrogen from the air in nodules formed on the roots.

The Austrian winter field pea has made only fair growth when seeded in late spring or early summer. It has been more hardy to winter temperatures than the hairy vetch at Austin and might prove satisfactory as an overwintering cover crop. The Canada and the San Luis Valley field peas are similar in nature but are not as winter hardy as the Austrian.

Soybeans and cowpeas are better adapted to row culture than to broadcasting and in general have not produced sufficient growth under average orchard conditions to prove satisfactory. Cowpeas in particular are subject to a leaf spotting disease that materially reduces the stand in the seedling stage.

Other legumes such as *Sesbania*, purple vetch, common vetch, and ladino clover have not proved adaptable to orchard conditions in Colorado. Red clover is a very satisfactory cover crop where a stand can be obtained and maintained.

Grains in general make satisfactory cover crops under certain conditions. They add bulk material to the soil, but as a class they have the disadvantage of shallow root systems. Also, when allowed to head out and form seed, they tend to reduce the vitality of the trees.

COVER. CROP REQUIREMENTS FOR SPECIFIC FRUITS.—Cover crop requirements vary, not only for different types of fruits, but also at different periods in the life of a fruit planting. Stone fruits, grapes, and young fruit plantings of all types require more cultivation than do mature apple or pear trees. On this basis, annual cover crops are best suited to their needs. These usually are sown in the early summer and are plowed or disked under in the late fall or early spring. If cover crops are planted in late summer, harvest operations may destroy the stand of young plants. Where soil nitrates are abundant, excellent results have been obtained with winter rye alone, or with a mixture of winter rye and hairy vetch. In locations where they are adapted, some varieties of field peas may be substituted for the hairy vetch. If inoculated legumes are used, some nitrogen is supplied by the plants in addition to that obtained from the soil. Legumes, especially alfalfa, also help overcome the harmful effects of excessive soil nitrates and other salts in the soil. Oats may be used as a cover crop but will seed if sown much before the first of August.

When this occurs, tree growth may be definitely checked. There have been instances where crops such as alfalfa or clover have produced conditions unfavorable to stone fruits. This has been evident where they have competed for both moisture and plant foods during the spring.

Under Colorado conditions, apples have fared better with biennial or perennial cover crops, and the most satisfactory crops for this purpose have been white and yellow sweet clover. Hubam clover has shown some promise, but it is an annual and the seed is high in price. It is better adapted to 1-year rotations, although, under favorable conditions, advantage may be taken of natural reseeding in maintaining a stand over longer periods. This is true of hairy vetch to some extent, but natural reseeding is not as effective with the latter crop. Sweet clover may be sown either in the spring or fall. However, when fall seeding is practiced, the plants grow through one full season only. When sweet clover is sown in the spring, two full seasons' growth is obtained, and a greater amount of material can be turned under. Seeding should be at the rate of 20 pounds to the acre. When sweet clover is seeded in the spring, the surface soil must be kept in a moist condition until the seedlings have become well established. In order to make orchard operations less difficult, the growth should be cut and left on the ground, or it may be mashed down with a plank drag. During the first season, one cutting or dragging should be sufficient, but two may be required during the second season. When a mower is used, the cutter bar should be raised to leave stubs from which new sprouts will grow. When sweet clover is dragged, new sprouts grow from lateral buds just below the bend. In the case of spring planting, sweet clover may be disked lightly the following spring and then marked out for irrigation.

Alfalfa is not as desirable as sweet clover because it tends to check tree growth to a greater extent during the first season. Young trees planted in cultivated strips in an alfalfa field generally have not attained the size of trees where the entire field has been cultivated for the first few years. Alfalfa is also more difficult to eliminate from an orchard once it is established. It can be used with fair success when properly handled but should be given a thorough disking each fall. The crop should not be cut for hay and removed from the orchard but should be allowed to remain as a mulch. Stands of alfalfa should not be maintained over too long a period. Often it will thin out and allow weeds to obtain a foothold.

Pears are intermediate between stone fruits and apples in their response to different cover crops. They decline in vigor somewhat earlier under perennial cover crops than do apples. Either cover crops with cultivation or perennial cover crops may be used. When

sweet clover or alfalfa is sown, it is best not to allow more than two growing seasons before turning it under. The biennial sweet clover does not live more than two seasons, but with heavy stands there is some natural reseeding which, in practice, establishes a perennial cover. With varieties of pears that are susceptible to fire blight, the perennial cover might be desirable in spite of the reduction in tree growth. Even then, care must be exercised not to carry this practice to an extreme, and disking the cover crop each fall would be advisable.

SOWING COVER CROPS.—The time to sow cover crops depends upon the type of crop and the weather, even under irrigated conditions. Where the growing season is long and high summer temperatures prevail, early seedlings may not do well. Late plantings are also objectionable because they do not provide much top growth to turn under. When seeding is done too close to harvest, the young plants may be killed by trampling. In some sections of the State, vetch will make more growth when seeded early. Later seedlings may be advisable for field peas. Rye as a cover crop may have some disadvantages since, when it is sown alone over a period of years, it tends to form a "plow sole" unless deep plowing is employed. Under irrigated conditions, cover-crop seed may be sown either before or after an application of water. Planting before irrigation is usually preferable since the furrows are marked out before the cover crop comes up and better stands result.

With some of the legumes, inoculation with the specific nitrifying bacteria for the crop used is desirable the first year or 2 the crop is planted. Unless this practice is followed, it may be difficult to obtain satisfactory stands with plants such as vetch. Rates of seeding vary with the plant or plants used. Table 2 gives seeding rates which have proved satisfactory at the fruit substation at Austin.

TABLE 2.—*Fates of seeding of cover crops.*

| Crops | Rate of seeding in pounds per acre |
|--------------------------|-------------------------------------|
| Rye alone | 60 to 70 pounds |
| Rye and vetch | Rye 30 pounds, vetch 30 pounds |
| Rye and field peas | Rye 30 pounds, field peas 40 pounds |

INTERCROPS.—Intercrops are cultivated crops which are grown between the rows of trees in young, non-bearing orchards. Corn, tomatoes, potatoes, strawberries, and nursery stock all are used. Filler trees might also be classed as intercrops. Truck crops are usually fertilized and cultivated, thus maintaining desirable growing conditions for the young trees. Crop rows always should be kept several

feet away from the tree rows and this distance should be increased as the trees increase in size. Where possible, a cover crop should be planted at the last cultivation.

Not all types of crops are adapted to intercropping. Raspberries and blackberries cannot be recommended as intercrops for young apple or pear trees, although they are often used. They are especially subject to the disease, crown gall, and to some insect pests which should be kept out of the orchard. The use of grain or hay crops usually is not desirable because they draw on the soil for moisture and plant nutrients at the time tree demands are greatest.

Cultivation

The main objectives in orchard cultivation are (1) turning under plant growth, (2) elimination or destruction of weeds and insects, (3) breaking up hardpan layers, and (4) improving movement of both air and moisture through the soil. Deep rooting plants such as alfalfa, sweet clover, and hairy vetch are effective in opening up the subsoil. Experience has shown that deep working of orchard soils should be restricted to the time that top growth is at its lowest, that is, during the dormant season. This is especially true with old trees and with trees planted close together, because any method of working the soil to depths of more than 4 or 6 inches during the growing season destroys many feeder roots at the time they are most needed. Consequently, operations such as plowing, deep disking, chiseling, or subsoiling should be confined to a period from late fall (after leaves have dropped) to not later than the delayed dormant stage of flower development in the spring. During this time, destruction of roots is not as serious as in the growing season.

ORCHARD CULTIVATION TOOLS.—Until recently, few implements used in orchard cultivation were designed primarily for orchard use. Ordinary plows and disks tend to ridge the soil between the rows or form knolls around the trees. The use of horse drawn tools has decreased to a great extent until the present tendency is toward the use of tractors and heavy, tractor-drawn tools. With the heavy types of disks now available, cover crops can be turned under satisfactorily, and the plow as an orchard tool is being discarded. Cultivation during the growing season can be done with disks, spring-tooth harrows, or chisel-tooth cultivators. Deep subsoiling, from 16 to 22 inches, is sometimes advisable, but it should be confined to the middles of the spaces between the rows of trees. It should be done across the direction the orchard rows run, as well as with the rows. It can be done where perennial cover crops are growing as well as on ground under clean cultivation. Deep tilling of this type often serves to open up

tight soils and hardpan and to increase the penetration of water and tree roots. To prevent excessive packing, it should be done during the dormant season when the soil is somewhat dry.

Fertilizers and Soil Amendments

For many years, barnyard manure was practically the only type of fertilizer used in orchards. However, fruit growers are experiencing increasing difficulty in obtaining it in sufficient quantities. Consequently, they are looking for other means of maintaining or increasing orchard soil fertility.

When manure was available, the organic matter in the soil was usually maintained by its use. Now that its use is no longer a matter of common practice, other means of maintaining the organic matter in the soil must be used. This is particularly essential where some of the commercial fertilizers, especially those containing nitrogen, are used. If there is not a sufficient amount of organic matter in the soil, applications of commercial fertilizers may be neither effective nor profitable.

It is not economically possible or necessary in Colorado soils to maintain the amount of organic matter at the levels often found under humid conditions, but it is important for all orchard soil management programs to include provision to maintain organic content at a reasonable level. Where manure in sufficient quantities is not available, the use of cover crops is the logical procedure to follow. If legumes are used, soil nitrogen may be increased when they are incorporated into the soil, and this may be an economical method of soil management. In any case, the systematic use of cover crops should provide the soil conditions necessary to permit commercial fertilizers to function satisfactorily.

WHEN TO APPLY COMMERCIAL FERTILIZER.—In orchard fertilizer practice, three times of application have been used: (1) In the spring about 2 weeks before bloom; (2) the so-called "split" application where half the amount is applied prior to the time of bloom and the balance when the petals are off; and (3) fall application about the first of October to the first of November, some time before growth is stopped completely by cold weather. Satisfactory results have been obtained in Colorado from application at the first time—about 2 weeks before bloom. No local data on the other times of application are available.

WHAT TO USE.—Fruit growers in Colorado are working primarily with alkaline soils. Consequently, it would seem desirable to use non-alkaline fertilizers. As a nitrogen carrier, ammonium sulphate is recommended rather than nitrate of soda or cyanamide. The nitrate

of soda contains about 20 percent, sodium, and the cyanamide carries approximately 40 percent lime or calcium. As a phosphorus carrier, treble superphosphate is satisfactory. For potassium, either muriate of potash or potassium sulphate may be used.

Mixed fertilizers are sometimes recommended for orchard use. They should not be purchased on the ton basis but on the unit cost of the plant food they contain. A mixed fertilizer of a 4-12-4 analysis carries 20 pounds of plant food per 100 pounds, while an 8-24-8 analysis fertilizer carries 40 pounds. The cost per ton is greater for the higher analysis fertilizer but the unit cost per pound of actual plant food is usually less. For example, if a 4-12-4 analysis fertilizer sold for \$60 per ton, the cost per pound of actual plant food would be 15 cents. If the 8-24-8 analysis product sold for \$75 per ton, the unit cost per pound of plant food would be a little less than 9½ cents. The use of the higher analysis product also means that the grower need not handle as much material to obtain similar results. Today some manufacturers are producing granulated fertilizers. They are more pleasant to handle than those which are finely powdered or those which contain particles ranging in size from fine powder to coarse sand. In some cases they may also prove more effective.

HOW TO DETERMINE NEED FOR FERTILIZERS.—There is only one sound criterion for determining an orchard's need for fertilizer. That is on the basis of tree growth and fruit production. For this reason, a grower should make trial fertilizer applications on small areas in his orchard and develop his fertilizer program on the results he obtains. It is true that fertilizer trials at experiment stations are valuable aids in determining what fertilizers may be needed, but it should be emphasized that no two soils are alike and that they cannot be expected to react to applications of fertilizers in exactly the same way.

It is also true that reactions from fertilizers vary in different parts of Colorado. This variation is especially pronounced between the Eastern and Western Slopes.

In north central Colorado near Fort Collins, excellent increases followed applications of 7 to 10 pounds of ammonium sulphate per tree on old apple trees growing in sod. However, since maturity was delayed 10 to 14 days, the application probably should be decreased if applied annually.

In this same part of the State, definite increases in yield were obtained on mature sour cherry trees with small amounts of ammonium sulphate applied annually. The increases were greater than where liberal applications of manure had been used. The increases from either ammonium sulphate alone or from manure were signifi

cantly greater than from a complete fertilizer carrying nitrogen, phosphorus, and potassium; from nitrogen and phosphorus; or from phosphorus and potassium. No increases followed the use of either potassium or phosphorus alone.

At the fruit substation at Austin, treble superphosphate applied with manure proved beneficial. Light applications of ammonium sulphate were believed advisable with varieties such as Rome Beauty where annual growth was less than desired.

With peaches, mixed fertilizers containing nitrogen, phosphorus, and potassium produced the largest tonnage. These were used at the rate of 250 pounds per acre. Both 4-8-4 and 4-12-4 analysis fertilizers have been used, depending upon the need for phosphorus.

Applications of ammonium sulphate and treble superphosphate at the rate of 2 pounds of each per tree also gave good yields of peaches.

There was some evidence that nitrogen alone decreased size and delayed maturity of peaches. Similarly, the use of phosphorus alone seemed not only to decrease size of fruit, but also to hasten and shorten the ripening period.

MINOR ELEMENTS IN THE SOIL. — Recently much attention has been given to the minor elements in the soil which plants need in only very small amounts. Usually there is enough of each in the soil, but if any of them should be deficient they should be added sparingly and with great care. Minute amounts are necessary for plant growth. Large amounts may be extremely toxic.

One of these elements is iron. Iron probably is not deficient in any Colorado soil so far as total amounts in the soil are concerned. However, it may be rendered unavailable to the trees under some adverse soil conditions, and chlorosis or yellowing of the foliage results. This seems to be the case in soils which are high in lime content, and low in organic matter. The application of soluble iron compounds to the soil is seldom the remedy for this trouble, since this soluble iron is soon changed to an unavailable form. The incorporation of more organic matter into the soil is a better treatment.

Manganese occasionally may be deficient, causing a chlorotic foliage condition somewhat similar to that, caused by a lack of available iron. In such cases, light application of manganese sulphate would be desirable.

Boron and zinc deficiencies have been reported from other western states, but no known cases have been found in Colorado up to the present time. In cases where there is reason to believe either of these elements to be deficient, specific advice from the Colorado Experi-

ment Station at Fort Collins should be obtained before applying them. They are very toxic to plants if used in more than very small amounts.

In Colorado, sulphur usually is considered a soil amendment since it tends to overcome the effects of excessive alkalinity and helps to make heavy soils more friable. It should not be applied continually since constant applications tend to dwarf fruit trees.

Weed Control

Weeds are not often a serious problem in an orchard. Often some of the less harmful annuals may serve as cover crops. However, there are a few, such as wild morning glory or bindweed, white top, and wild licorice, which definitely check tree growth when they become well established. Spraying with chlorates will eradicate these weeds. However, these chemicals will also injure the trees. Young trees are easily killed by them. Consequently, the advisability of their use in orchards is questionable.

Where cover crops are used, light infestations of these weeds can be checked by heavy seeding of the areas where the weeds are growing. "Blading" frequently enough to prevent their reestablishment is probably the only successful method of eradicating them from orchards. This method has the same objectionable effects as constant clean cultivation, and the trees may suffer during the process. However, it will probably damage an orchard less than will the use of chemicals.

Irrigation

The question of irrigation is one that can be discussed only in general terms. Water requirements in an orchard will vary from season to season. During any growing- season they will vary according to weather conditions, the water demand of cover crops, and the type of soil. Consequently, it is impossible to give exact directions as to the number of irrigations needed or the times when they should be applied.

The need for irrigation can be determined by actual examination of the soil to a depth of 3 or 4 feet. This can be done either with a soil auger or a shovel. Fruit trees apparently need about 6 to 10 percent available moisture in the soil. An experienced grower can tell quite closely when this amount is present. A fairly accurate estimation of this amount can be determined by the following method: Weigh out 6 pounds 4 ounces (100 ounces) of soil and dry it by direct exposure to the sun for about a day. Then reweigh the sample. The loss in weight in ounces will give the percentage of available or free

water. If the loss is not more than 6 or 8 ounces, water is needed and should be applied. Water should be applied when the need is apparent, regardless of the time of year. The only exception to this is the time of full bloom. Frequently irrigation is necessary immediately after bloom to insure early growth of the fruit, particularly with peaches.

In years of normal moisture, irrigation of young, nonbearing trees should stop the latter part of July or the first of August. With bearing peaches, the last application of water before harvest, should be put on not later than 10 days to 2 weeks before harvest. On bearing apples, it is desirable not to apply water after the last of August. At higher elevations, irrigations should stop even earlier. These dates are only approximate, of course, and they will vary according to climatic and crop conditions.

Care should always be taken in irrigating fruit trees. Late or heavy irrigation of young trees may delay maturity and cause winter injury to unripened wood. Wide fluctuations in soil moisture are always objectionable. During the growing season, dying back of young top growth may follow such fluctuations. With the fruit, such troubles as water-core, bitter pit, or Jonathan spot may be aggravated. Heavy irrigation near harvest may cause cracking of the fruit of some varieties of apples and will impair the quality of peaches. It should be remembered that, excessive soil moisture will cause poor keeping quality and will reduce the storage life of fruit-

Later in the fall or in early winter, after the trees have become dormant, a "winter" irrigation should be applied if water is available. Ordinarily this would be done in the latter part of October or in early November. This irrigation will supply the trees with winter moisture. In many cases of winter-killing in Colorado, the damage is not due to low temperature but to the dry, cold air which draws moisture out of the trees when they are unable to replace the loss from dry soil.

In irrigation, the soil should be wet down 4 or 5 feet. The time required will vary with individual orchards and soils. Depth of wetting should be checked. This can be done with a soil auger or with a small steel rod 4½ to 5½ feet long. The rod can be pushed into most soils quite easily as deep as the moisture has penetrated.

A relatively small head of water in each furrow will prove more effective than a large head since a greater part of the water will penetrate the soil and less will be wasted. Experience has shown that, even in heavy soils, more uniform wetting can be obtained with short runs of from 200 to 400 feet.

Fairly deep furrows are often used in clean cultivated orchards. These may be 6 to 8 inches deep and as far apart, as 4 or 5 feet. The use of deeper furrows has advantages. Excessive soaking of the topsoil will be eliminated, water penetration through heavy soils will be faster, and evaporation will be reduced. In lighter soils, and with those having low water-holding capacities, closer spacing of the furrows may be necessary where cover crops are growing, but, the same depth of furrows can be used. However, when the crop is seeded, shallow furrows between the deeper ones may be needed. After the cover crop is established, they may be abandoned.

Frequently the furrows next to the tree rows in bearing orchards are placed close to the trees. If the water subs across sufficiently from the furrows, this will not be necessary. In soils where water subs slowly, deep tilling or subsoiling to improve water penetration and movement has been found practical and effective. Subsoiling at right angles to the direction of the water flow, keeping 3 or 4 feet from the tree row, will greatly facilitate water movement, especially in soils which tend to form a plowpan or hardpan. Such deep working of the soil should be done only *in the dormant season*, and care must be taken to cause as little root damage as possible.

In many cases, chlorosis or yellowing of fruit trees is caused by poor drainage or overirrigation. When yellowing is noticed in an orchard, the grower should examine the subsoil with an auger or spade to see that drainage is good and that the underlying water table is not high enough so that the tree roots are standing in water. This condition cannot be detected from the surface, and many orchardists have literally drowned their trees without knowing it. If water is accumulating in the subsoil, then irrigation should be lighter and less frequent so that new feeder roots will develop at lower depths as the water goes down.

In extreme cases, drainage systems may be necessary to lower the water table enough to allow the roots a good feeding area of comparatively dry soil. In the young orchard, both cultivation and irrigation should cease the latter part of August to permit the trees to harden their wood and enter the winter in good condition. If cultivation is continued and water applied, tree growth will continue into autumn and the trees will enter the winter in a soft condition. As a result, winter-killing or injury is very likely to occur.

Fruit Thinning

Fruit thinning has become an established orchard practice wherever the grower has difficulty in producing first-quality fruit. Properly done, it will definitely increase the quality of the crop. It

helps to produce fruit of larger size and better quality. It aids in increasing the amount of color. It eliminates much low-grade fruit and aids in the control of certain insects.

Time of Thinning

It is usually recommended that all fruits be thinned shortly after the "June drop." With care, it is possible to thin immediately after fruit setting. If thinning is done at this time, some dropping of fruit may be eliminated and, in off-year bearing, the tendency may be directed toward regular, annual cropping. It is doubtful whether this is a practical procedure and, at present, it cannot, be recommended as a general practice. With peaches, late thinning has increased the size of the remaining fruit. It permits the removal of blemished fruit that may develop after the usual period of thinning. However, the beneficial results as shown by tree growth and increase in fruit size are not as marked as when thinning is done earlier.

Severity of Thinning

The amount of fruit removed in thinning should be adjusted to the size of the crop and to the vigor of the individual tree and the particular branch on which the fruit is growing. Frequently the crop on a tree as a whole will not be large enough to justify thinning although one or more branches may have set more fruit than can be matured properly. Such branches should be thinned if a uniform crop is to be produced.

In all fruit thinning, the first, step should be to remove all blemished fruits. With apples, all wormy fruit is taken off. Terminal fruits on the ends of long, weak branches also should be removed. After this is finished, enough additional fruit, should be taken off to leave the remaining fruit spaced at more or less regular intervals of 3 to 8 inches, the spacing being dependent upon the vigor of the tree growth. Only the largest and best, shaped fruits should be left. With apples, only one fruit should be left on every third or fourth spur. All others should be removed.

There is a definite ratio between the number of leaves on a branch and the number of fruits that should be left. This ratio affects size and quality of fruits produced. With the apple, the number of leaves needed to produce one good-sized fruit will range between 40 and 80. Using this as a basis, good judgment and experience are worth more than any "rule of thumb" that might be suggested. Too heavy thinning is not profitable. The higher unit, price which may be obtained for larger and better quality fruit may not be sufficient to offset the usual decrease in tonnage. After all, there is a limit to the stimulation which may be expected from thinning.

Fruit Insects and Their Control

It will not be possible to consider in this bulletin all the insects and diseases found on tree fruits in Colorado. Only the more common ones will be discussed. If information on specific insects or diseases is desired, it may be obtained from the Colorado Experiment Station at Fort Collins upon request.

Codling Moth

The codling moth is the most destructive insect pest of apples and pears in Colorado. Fruit attacked by codling moth larvae have holes eaten in from the blossom end, or in from the side to the core. The seeds and core are tunneled and eaten by the pinkish-white, brown-headed worms.

The adult is a dark grayish or brownish moth with a wing spread of one-half to three-fourths inch. The moths usually remain on the branches or trunks of the trees during the day. They become active at dusk when temperatures are above 60° F. Depending on the location in the State and on seasonal conditions, there may be from one to three broods or generations of moths per year. The moths do not all hatch out at once, so there is often an overlapping of broods.

The use of poison sprays is the primary means of codling moth control. Arsenate of lead sprays have long been the standard control. Recently fluorine sprays have been used successfully for second-brood moths. Within the past 2 or 3 years, some fixed nicotine sprays have been developed which show definite promise as substitutes for lead arsenate and fluorine. They are used with or without the addition of small amounts of mineral oil. They are most effective when used with the mineral oil. These do not leave a residue of lead, arsenic, or fluorine on the fruit which, according to law, must be removed before the fruit can be offered for sale. Although the removal of the residue from these fixed nicotine sprays is not legally necessary, the appearance and sale value of the fruit is greatly improved by cleaning.

To secure the best control, codling moth sprays should be applied on a schedule based on moth emergence. This is best determined by the use of moth traps. The traps may be made from 2-quart glass or enameled containers filled with a mixture of molasses, yeast, and water. They should be hung in the upper third of the trees. The molasses should be diluted at the rate of 1 part of molasses to 10 to 15 parts of water. A small amount of yeast is added to start fermentation.

The first and most important spray in any codling moth control program for apples is the "calyx" spray. This is applied when at least 90 percent of the petals have fallen but before the calyx lobes have closed. Careful filling of the calyx cups with poison at this time will kill all larvae trying to enter the apple through the calyx. With pears, this spray is sometimes omitted if moth infestation is light.

The next spray, the "first cover" spray, should be applied within 5 clays after the time the moths begin to fly regularly. This spray should be completed within 10 clays after the calyx spray. The other first-brood sprays should be applied at 10-day intervals, a heavy coating being kept on the fruit when the worms are emerging.

The first cover spray for the second-brood worms should be completed within 5 or 6 days after a definite increase occurs in the number of moths caught after the first of July. Later sprays are applied at 14- to 16-day intervals, depending on the severity of infestation and weather conditions. Likewise, the number of sprays needed to provide satisfactory codling moth control will vary with local conditions. The spray program for apples and pears given in the spray supplement is for the control of a heavy infestation of codling moth. It should be varied to meet local conditions. Contact the county agent for local information.

While sprays are the main codling moth control, some orchard sanitation measures should also be followed. All possible hibernating quarters should be destroyed. Rough bark should be scraped from tree trunks and all worms found should be destroyed. Where infestations are heavy, banding the trees with chemically treated bands is advisable. These bands are usually made of corrugated cardboard treated with beta naphthol. They will kill all larvae pupating in them. The bands should be in place before the first worms emerge, usually about the first of June. Bands are not effective on trees which have not had the rough bark removed. Treated bands should not be used on young, smooth-barked trees because the chemicals used in treating the bands may damage the trees severely. On such trees, untreated bands may be used. These should be examined at intervals of about 10 clays, and all worms found should be destroyed. All bands should be removed during the winter and burned.

Aphids

Aphids, or plant lice, are some of the most troublesome insect pests in orchards. Most aphids attack the foliage, twigs, branches, and fruit. When they are present in large numbers, they cause the leaves to curl. On twigs, they may stunt growth definitely. If the

fruit is injured, it will either remain small, hard, and misshapen or it will develop abnormally. The green apple aphid, the rosy aphid, and the woolly aphid are frequently found on apples and often on pears. On the peach, the peach aphid is a common pest. Unlike the other aphids mentioned, the woolly aphid does not attack the fruit. It is found as a cottony mass covering purplish aphids either around wounds on trunk or branches of apple and pear trees or on the roots. On the latter, the aphids cause knots.

Most forms overwinter in the egg stage on twigs, at the base of buds, or in cracks or crevices in the bark. They hatch out in the early spring, and the young begin to feed at once, sucking the sap from the young leaves, flowers, and twigs. It is at this time that control measures are most effective. After the foliage has begun to curl and protect the insects, it is impossible to secure control. Two types of spray materials are commonly used for aphid control. These are oil sprays and nicotine sulphate. Oils used as delayed dormant sprays, applied after the aphid eggs have hatched but before the buds have opened, may give satisfactory control. Oil sprays must be applied while the buds are dormant. When the leaves are opening, they would be injured by the oil. The oil spray should contain about 4 percent actual oil. After the leaves have begun to open, nicotine sulphate should be used at the rate of 1 pint of nicotine sulphate to 100 gallons of water. It should be applied with a driving spray when the air is still and the temperature is above 60° F. Nicotine sulphate should always be used with a spreader. The entire tree must be covered thoroughly with the spray. Aphids are not affected by stomach poisons since they do not eat plant tissue. The control measures are dependent, on the sprays coming into *actual and complete* contact, with the insects.

Control of aphids is important. They not only do direct damage to the leaves, twigs, and fruit, but they also spread plant diseases such as fire blight.

Woolly aphids, when present, above ground, can be controlled by nicotine, lime-sulphur, or oil sprays applied thoroughly under high pressure. The spray must be forced through the "woolly" covering. If woolly aphids are on the tree roots, they are practically impossible to control.

Mites and Red Spiders

The tiny mites and red spiders cause much greater damage to fruit trees than most growers realize. Nearly all types of fruit trees may be attacked by at least one species. They are especially serious during hot, dry seasons. They are found primarily on the foliage. Light infestations show only as a light flecking or speckling of the

foliage. Heavy infestations cause the foliage to become a sickly yellow color. The leaves have the appearance of being covered with dust. Severe foliage injury is reflected in reduction in fruit size. There are at least two types in Colorado, the blister mite and the red spider.

Lime-sulphur, wettable sulphur, and oil sprays are all recommended controls. The spray schedules accompanying this bulletin give recommended times of application and materials.

Peach Tree Borer

The peach tree borer is especially serious in Colorado on peach and cherry trees. The larval stage is the injurious one. The larvae feed on the inner bark at the base of the tree, usually in an area from about 2 or 3 inches below the ground level to 10 or 12 inches above. Injury is usually shown by the mass of gum and frass or sawdust exuded from the base of the trees.

Two control measures are suggested. Use of paradichlorobenzene, or PDB, in the fall as a fumigant has given control. The PDB crystals are placed in a continuous ring around each tree, 1 or 2 inches from the trunk. Then soil is mounded up over the crystals and around the trunk to a height of 4 to 6 inches. The mound of soil is used to confine the gas given off by the crystals to the area around the trunk. It should be leveled off by July of the following year. Soil temperatures must be above 60° F. if the treatment is to be effective.

The following dosages of PDB are suggested:

| | |
|--------------------------------|---------------|
| Three-year-old trees | ½ ounce |
| Four- or 5-year-old trees..... | ¾ ounce |
| Mature trees | 1 to 1½ ounce |

A more recent control method which has not been used extensively in Colorado is an ethylene dichloride emulsion. It seems to be a promising material for borer control. It has the advantage of being effective at lower soil temperatures. The emulsion is applied either by pouring or spraying the desired dosage on the ground. For directions for using this method of peach borer control, write the Colorado Experiment Station.

Peach Twig Borer

The peach twig borer is a small, brown worm found working inside twigs and new growth. Sometimes it is found on the fruit. When it is present and not controlled, it may cause "gummy" fruit. A liquid lime-sulphur spray applied between the time the buds begin

to swell and the time of opening of the blossoms will control these borers. Arsenate of lead sprays applied during the time indicated will give fair control.

Pear or Cherry Slug

The pear or cherry slug is a small, soft-bodied larva often found feeding on pear and cherry foliage. It skeletonizes the leaves, leaving only the veins. It is easily controlled by nearly any stomach or contact spray or dust. Applications should be made as soon as the slugs appear. Poison sprays, such as arsenate of lead, should not be applied to cherries near the time of harvest, since the residue may be difficult to remove.

Fruit Diseases and Their Control

Fire Blight

The bacterial disease, fire blight, is the most serious and destructive disease found in Colorado on apples and pears. No spray which will control it is known. It may be spread by insects, rain, or wind carrying the bacteria to uninfected parts.

Fire blight may attack any part of the tree. When it attacks the blossoms, they turn brown soon after opening. Diseased leaves become brown or even black in color, and often they have a water-soaked appearance. They usually hang on the tree for a long time. On large limbs and on the trunks, the disease is found as cankers, or slightly sunken, darkened areas in the bark. Names descriptive of the locations, such as blossom blight, twig blight, or blight cankers, are often applied.

Sprays controlling insects such as aphids, which spread the disease, will decrease its spread. A weak Bordeaux spray applied during bloom is sometimes recommended. The weak lime-sulphur or wettable sulphur sprays often used in the pre-calyx sprays may also reduce infection at blossom time. Proper cultural practices will prevent extremely rapid, succulent wood growth which is more subject to fire blight.

Pruning and surgery have their place in any control program. All diseased shoots and branches should be cut off at least 8 inches below apparently diseased wood. The cut end of the branches and the pruning shears should be disinfected after every cut to prevent further spread of the disease. A solution of bichloride of mercury or corrosive sublimate is a satisfactory disinfectant.

Where fire blight cankers are found on larger branches or on tree trunks, two methods of treatment are available. One is surgical,

cutting the diseased wood and bark back to healthy tissue. The wound area is then disinfected with the bichloride of mercury solution. All tools used should also be disinfected. This treatment is effective but laborious.

The second method, the use of zinc chloride solutions, is easier. It involves no cutting, only the painting of cankered areas with zinc chloride. Treatment must be given before the disease has penetrated very deeply into the wood if it is to be effective. It involves the use of solutions of different strengths for branches and trunks of different ages. In Colorado, this method has been very successful on pears, but it has not been satisfactory on apples.

Powdery Mildew

In some seasons, powdery mildew has caused rather severe losses in apples and pears and sometimes in cherries. It may attack blossoms, foliage, young shoots, or fruits. The disease appears as grayish or whitish felt-like areas of fungus growth. It may cause the blossoms to shrivel and stop development. Foliage and young shoots may be covered with the white powdery coating and severely injured. On the fruit, the fungus causes a russetting which injures storage quality. The disease is carried over from year to year on "mildewed" twigs and buds.

Control measures consist of fungicidal sprays, either weak or summer strength, lime-sulphur or wettable sulphur sprays. These are applied early in the growing season before the disease has had opportunity to spread.

Coryneum Blight

Coryneum blight is a peach disease also known as "California Peach Blight" or "Brown Spot." It should not be confused with "Brown Rot" which has not been found in Colorado. It attacks all types of stone fruits but is most, serious on peaches and apricots. It is carried over the winter as small cankers on new shoots. Dormant buds may be affected. When this occurs, the buds may be killed.

The disease appears in early spring on the leaves as small, purplish spots with yellow centers. They increase in size, turn brown, and the diseased tissue drops out. This causes a "shot-hole" appearance of the leaves common to the disease.

On the fruit, the lesions are similar to those on leaves, as small reddish-purple spots. As they develop, they darken and become depressed, and the fruit becomes rough in appearance. Both the quality and the grade of the fruit is reduced.

Control measures are based on the use of two sprays. A dormant lime-sulphur spray applied in the spring, and a 4-4-50 Bordeaux spray put on soon after the fruit is harvested should give commercial control.

Virus Diseases

With the exception of the peach, tree fruits have been remarkably free from injury by virus diseases. A number of virus diseases of the peach have been reported, at least one dating back well past 100 years. In Colorado, peach mosaic is the only one which has been found. Growers in peach-producing areas realize how destructive such a disease can be. Where virus diseases are present, systematic tree-by-tree inspections are necessary to locate diseased trees early. Whenever diseased trees are found *they should be pulled out and burned immediately*. Growers who make a practice of removing all sickly trees that fail to respond to good cultural practices are less likely to suffer severe losses from virus diseases.

Bacterial Gummosis

While gumming of stone-fruit trees may be caused by a number of factors not in any way connected with disease organisms, there is at least one bacterial disease which shows these symptoms of "gumming." This is "bacterial gummosis" or "bacterial canker." It is particularly a disease of sweet cherries. The "gummy" cankers develop on the trunks of young trees and on young wood on older trees. The disease destroys the cambium and the inner bark, and a gum pocket develops where the tissue has been destroyed. Often a thin layer of outer bark may cover the gum pocket like a drum head. Apparently the disease is spread by cherry aphids.

Preventive measures should include the control of aphids. The top working of sweet cherry varieties on mazzard trunks has been suggested, since the mazzard is resistant to the disease. Where cankers are already developed, all diseased tissue and all gum should be cut away. The exposed wood should then be disinfected with a mercury solution and painted over with Bordeaux-linseed oil paint.

Bark Rots and Wound Parasites

Very few wood-rotting fungi are important in Colorado. However, there is at least one type found on fruit trees in the State. This is a disease (caused by an organism known as a *Cytospora*) which may enter through minor bark wounds. It sometimes becomes established, gradually extending through the bark until the tree is killed. There are also some other wood-rotting organisms which may enter through pruning wounds. Treatment of existing infection is based on removing all diseased tissue, cutting well back into healthy

wood and bark. The exposed bark and cambium should be protected with grafting wax. Exposed wood should be disinfected with a mercury solution and then protected with Bordeaux-linseed oil paint.

Spray Materials

The grower has a wide range of spray materials from which he must select the ones he uses. Many are effective for one purpose but without value for another. Others will control a particular pest but will have too high a cost. Others, while effective as control measures for specific pests, will seriously injure the trees.

The spray materials discussed are all effective for certain purposes and their use should be limited as recommended.

Oil Sprays

Oil sprays are used primarily as insecticides or insect controls. There are two types on the market at the present time, the dormant and summer oils. *These should be mixed and applied according to manufacturers' directions.* Dormant oil sprays should be used only when the trees are dormant. They must not be applied when temperatures will drop below 40° F. within, a few hours of the time of application. Summer oils are designed for use on trees in leaf. They will cause burning of foliage at temperatures of 100° F. and above. Most oil sprays are not compatible with lime-sulphur sprays. If both are used in a spray program, they should not be applied within 3 to 5 weeks of each other. Where oils are to be used in the summer cover sprays, it is suggested that the lime-sulphur or the lime-sulphur-wet-table sulphur combination be used in the early sprays. Oil sprays should not be included before the "second cover" spray. If this recommendation is followed, possible injury from the lime-sulphur-oil combination will be avoided. Most wettable sulphurs are compatible with oils.

Lime-Sulphur

All recommendations regarding the use of lime-sulphur solution are based on the concentration of the material. This is measured on a scale known as the "Baume" scale. Thirty-two degrees Baume is the standard for lime-sulphur solution. The liquid lime-sulphur dilution table, table 3, gives the amounts which are used if the concentration varies from the 32° Baume standard.

TABLE 3.—*Dilution table for liquid, lime-sulphur.*

| Amounts of liquid lime-sulphur solution to be used in making up 100 gallons of diluted spray | | | | |
|--|---------------|-----------------------------------|----------------|---------------|
| Degrees Baumé | Dormant spray | Blister mite and twig miner spray | Summer Sprays | |
| | | | 2½ gal. to 100 | 2 gal. to 100 |
| 34-33 | 11 gallons | 7½ gallons | 2¼ gallons | 1¼ gallons |
| 32-31 | 12 gallons | 8 gallons | 2½ gallons | 2 gallons |
| 30-29 | 12¾ gallons | 8½ gallons | 2½ gallons | 2 gallons |
| 28-27 | 14 gallons | 9¼ gallons | 2¾ gallons | 2¼ gallons |
| 26-25 | 15 gallons | 10 gallons | 3 gallons | 2½ gallons |
| 24-23 | 16¾ gallons | 11 gallons | 3¼ gallons | 2¾ gallons |
| 22-21 | 18¾ gallons | 12¾ gallons | 3¾ gallons | 3 gallons |
| 20-19 | 20¾ gallons | 13¾ gallons | 4½ gallons | 3½ gallons |

If dry lime-sulphur is used in place of liquid lime-sulphur, it should be at the rate of 4 pounds of dry lime-sulphur for every gallon of liquid lime-sulphur recommended.

Wettable Sulphurs

Wettable sulphurs are pure sulphurs which have been made wet-table either by the addition of "wetting agents" or by special manufacturing processes. The newer "micro-sulphurs" are extremely fine in particle size. These smaller-sized materials have given better control than larger-sized material. For spray purposes, sulphurs should be 300 mesh or smaller. In making up sprays, 4 pounds of wettable sulphur should be used for every gallon of liquid lime-sulphur recommended.

There are a number of ways to make "home-made" wettable sulphurs. A satisfactory formula is as follows:

Superfine dry dusting sulphur 95 pounds

Soybean meal or soybean flour 5 pounds

Mix thoroughly in a barrel mixer, a seed treating machine, or a concrete mixer that is clean and free from sand or other grit. This mixture can be stored for a considerable time in dry, air-tight containers. It has excellent adhesive properties and does not cause a heavy "run-off" of material. It is compatible with practically all other spray materials which can be combined with pure sulphur. This is not true when lime has been added. In purchasing dusting sulphur, specify a sulphur of 300 mesh fineness to which no distender or carrying agent has been added.

Wettable sulphur sprays, when made up as recommended, are practically non-caustic. Injury will seldom occur except at high temperatures or with plants which are extremely susceptible to sulphur injury. When wettable sulphurs are combined with arsenate

of lead in apple sprays, add 1 pound of hydrated lime for each pound of arsenate of lead used. For stone fruits, increase the amount of lime used to 4 pounds for each pound of lead arsenate.

Lead Arsenate

Lead arsenate is the most widely used spray material for the control of chewing insects. When used with spreaders or stickers as recommended, it is still a standard control for codling moth. It will combine with practically any other spray material. It adheres well to foliage, thus giving protection over a longer period of time. It is less injurious to plants than many other materials. However, there is one serious objection to lead arsenate. It leaves residues of both lead and arsenic on the fruit which must be removed before the fruit is sold.

Natural Cryolite

Natural cryolite, a fluorine compound, is used to some extent, as a substitute for arsenical sprays. It is used in the same manner. It is subject, to residue tolerances similar to those for lead and arsenicals, so where it is used, the grower must, be prepared to wash the fruit. It is suggested primarily for second-brood codling moth control. Where not more than three cryolite sprays have been applied, no difficulties in removal have been encountered when equipment and solutions designed to remove arsenate of lead residues have been used.

There are several points to consider in the use of natural cryolite. *It must not be combined with liquid lime-sulphur or any form of lime.* Proper selection of spreaders is essential. Soaps tend to decrease its toxicity. Fish oil, used at the rate of from one-half to 1 pint of oil to 100 gallons of spray, has given satisfactory coverage. When cryolite is used in second-brood sprays, the amount of any one poison required is reduced. Consequently, residue removal is simplified. Although there are only small decreases in the number of "stings" when cryolite is compared with arsenate of lead, the size of the stings is decreased. It does not decrease coloring of the fruit to as great an extent as does lead arsenate.

Bordeaux Mixture

Bordeaux mixture is primarily a fungicide or disease control. Where only very small amounts are used, commercially prepared material is satisfactory. For most purposes, tank-mix Bordeaux is preferable. Formulas for the preparation of Bordeaux sprays are expressed by three figures. The first figure represents the amount of copper sulphate used in pounds, the second the number of pounds

of lime, and the last the number of gallons of water used. Copper sulphate is available in several forms. "Snow", or granulated, and the powdered forms which dissolve readily should be used. Only high grade hydrated lime of the type made especially for spraying- should be used. Coarser grades tend to clog spray nozzles and increase wear on spray machines.

Colorado fruit growers will probably need only two formulas for Bordeaux mixture. These are the 4-4-50 mixture, used primarily on stone fruits, and the 1-3-50 mixture, sometimes used on apples in full bloom as a fire blight control.

To make 200 gallons of a 4-4-50 formula Bordeaux mixture in a spray machine with a 200 gallon tank, first fill the tank about one- fourth full of water. Then wash 16 pounds of finely powdered or "snow" grade of copper sulphate through the strainer with water. This should be done with the agitator running. Continue adding water until the tank is three-fourths full. Then wash 16 pounds of spray grade of hydrated lime through the screen. Continue adding water until the tank is filled. Agitate for 1 minute after the tank is filled and the spray is ready to use. Keep the agitator running while spraying.

Satisfactory Bordeaux mixture should have a rich blue color. A chalky cast indicates too much lime while a greenish cast indicates too much copper sulphate.

Spreaders and Stickers

The efficiency of some sprays may be increased by adding certain materials to the spray mixtures to increase the wetting ability of the spray materials used or to increase the deposits of spray on foliage and fruit. Some of these are not compatible with all spray materials. Many have not been sufficiently effective.

Calcium casenate, which has been used for a number of years, is not always satisfactory. With arsenate of lead, it tends to cause a heavy run-off, decreasing the spray deposit. It is incompatible with fluorine sprays and should not be used with them. In Colorado its use apparently should be confined to lime-sulphur sprays, either with or without arsenate of lead, and to aphid control sprays where nicotine sulphate is used alone. With lime-sulphur and arsenate of lead sprays, 1 pound of calcium casenate to 100 gallons of spray should be used. With nicotine sulphate, one-fourth pound to 100 gallons of spray should be sufficient.

Where arsenate of lead or natural cryolite is used alone, other adhesives or stickers must be used. Fish oil at the rate of from one-half to 1 pint of oil to 100 gallons of spray will give good adherence.

A spreader-sticker for arsenate of lead now widely used is a kerosene-soap mixture. It has the definite advantage of not seriously complicating residue removal. It is mixed as follows: Fill the spray tank to the agitator with water. Start the agitator. Then, for each 100 gallons of spray to be mixed, add one-fourth pound of neutral soap dissolved in warm water. Next add one-half gallon of kerosene for every 100 gallons of spray and mix until completely emulsified. Then fill the tank, adding the arsenate of lead as the tank is filling. Keep the agitator running until all the spray in the tank has been applied.

Soybean meal is a wetting and sticking agent which is compatible with nearly all classes of spray materials. Although it will not build up as heavy deposits of arsenate of lead as will the kerosene-soap mixture, it is useful in first-brood codling moth sprays. It is used at the rate of one-fourth pound of meal to 100 gallons of dilute spray.

Disinfectants and Wound Paints

Mercury-glycerine Solution

Mercury-glycerine solution is used as a disinfectant for pruning tools, pruning wounds, and cankers in treating fire blight infections.

Mercury-glycerine solution contains the following ingredients:

| | |
|-----------------------------|---------|
| Bichloride of mercury | ½ gram |
| Cyanide of mercury | ½ gram |
| Warm water | 1 pint |
| Commercial glycerine | 3 pints |

Dissolve the chemicals in the water and glycerine. Since it is corrosive, it should be mixed and stored in glass containers only. In use, the solution is daubed on tools and wounds with a swab. Cotton waste or cloth wrapped on a stick will serve for this purpose.

This solution is extremely poisonous and should be so labeled. It should be kept where children and livestock cannot reach it.

Wound Paint

A very satisfactory wound dressing consists of a mixture of Bordeaux powder and raw linseed oil mixed to the consistency of ordinary house paint. Boiled linseed should not be used. This paint should be mixed in small amounts because it tends to thin out on standing. It is applied to wounds with a small paint, brush. More rapid healing and callus formation will take place when the paint is not applied to the cambium layer. This layer can be covered by a small band of grafting wax.

Rodent Control

Young fruit trees are often severely injured or even killed by mice and rabbits. Trees under sod, cover crops, or clean cultivation may be injured. Mouse injury is more frequent where grass, weeds, or cover crops remain around the base of the trees during the fall and winter. Several methods of protection may be used. These are the cleaning of sod, cover crops, or weeds away from the tree trunks in early fall, the use of poison baits, and the coating- of branches and trunks with repellents.

Mechanical Protectors

The most practical mechanical protector is one made of hardware cloth or wire screen having 3 or 4 meshes to the inch. The hardware cloth is cut into strips about 20 inches by 18 inches or 20 inches by 16 inches and placed around the trunk and fastened to keep it from unrolling. It should be opened and spread out as the tree grows. Where mice are present, the protector should be shoved below the surface of the ground.

Cylindrical tree protectors of fiber, heavy cardboard, or wood veneer can be purchased. Heavy wrapping paper and cornstalks tied around the trees will do. Tar paper is not desirable because it may injure young trees. The wire protectors may be left, on for several years, but the fiber, veneer, or paper wraps should be removed each spring. The use of these mechanical protectors is not feasible where the trees are headed close to the ground. They will not protect low branches from rabbits where there is a deep snow cover.

Poison Baits

Poison baits for mice are made of poisoned grain. A teaspoonful of poison bait is placed in a glass jar, tin can, or other waterproof container which has an opening small enough to permit the mice to enter but too small to allow birds to get in and feed. The open ends of tin cans may be crushed in to decrease the size of the opening. Bait should be in place in the late fall before snowfall. Mouse bait can be obtained from the United States Bureau of Biological Survey or through the county extension agent.

Repellent Coatings

Many types of washes or repellent coatings to protect trees against rodent injury have been suggested. Some are quite effective, some have little value, and some are definitely injurious to the trees. Liquid lime-sulphur diluted, one part of the lime-sulphur solution to

8 gallons of water, is a practical repellent. It should be painted on the trunks and lower branches before snow falls. A casein or soy bean meal spreader may prolong the time the solution is effective. It may be necessary to repeat the application before spring.

Other repellent mixtures are given in the spray schedule supplement.

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