FEBRUARY, 1931 BULLETIN 254

AGRICULTURAL EXPERIMENT STATION

KANSAS STATE AGRICULTURAL COLLEGE
MANHATTAN, KANSAS

GROWING AN ORCHARD IN KANSAS

PRINTED BY KANSAS STATE PRINTING PLANT
B. P. WALKER, STATE PRINTER
TOPEKA 1931
13-6942

SUMMARY

Growing a commercial orchard which will prove a source of income over a long period of years is an intensive and highly technical process. It requires a large investment of capital and, on the part of the grower, an understanding of both the theory and practice of fruit growing. Growing a home orchard differs only in the money invested.

Profitable orchards can be grown in many parts of Kansas, but a careful selection of the site on the basis of the fertility and depth of the soil, air drainage to lessen frost hazard and exposure to prevailing winds is necessary. It is both difficult and expensive to grow a good orchard on worn-out farm land. By the time an orchard comes into profitable bearing the owner will have made an investment of more than $200 an acre, exclusive of the original cost of the land.

Apple and sour cherry are the most valuable kinds of tree fruits for Kansas. The most profitable of the early apple varieties are Yellow Transparent, Early Cooper, and Wealthy; and of the late varieties, Winesap, Jonathan, Grimes, York, and others of the Winesap group. No block of one apple variety should be more than six rows wide or cross pollination will be inadequate some years. Early Richmond and Montmorency are the leading sour cherry varieties of Kansas.

Trees for planting an orchard should be first grade and should be purchased from a near-by, reliable nursery. They should be planted on well-prepared soil in the early spring. Planting distances, on the square, are, apples, 35 to 40 feet; sour cherry, 25 feet; and other fruits, 20 feet. Sloping land should be terraced before the trees are planted.

Protection of the young orchard from pests is based on daily observation by the owner or his trained agent. Insects, diseases, rodents, and farm animals must be kept under control or they will quickly ruin an otherwise good orchard.

Orchard soil management is the most important and the most complicated problem of Kansas orchardists. Maintenance of fertility and moisture content and prevention of erosion are the specific points in this problem. Sod in the orchard solves the last of these but not the first two; clean cultivation, long continued, exhausts fertility and increases erosion; straw mulch ranks high in all these major points but has many minor defects; so it appears that clean cultivation to promote nitrification and the absorption and retention of moisture during the growing period combined with cover cropping to maintain fertility and to reduce erosion during August to May, would be the ideal soil management, especially on terraced land, for young Kansas orchards.

Ten years' experimental work in the station orchard at Manhattan failed to show profitable results from the application of nitrates, phosphates, or potash to young apple trees.

Experiments extending over nine years have proved winter vetch and rye to be the most valuable cover-crop plants for young orchards in Kansas. They both yield heavily and maintain the fertility of the soil.

On almost all Kansas lands a cover crop system of soil management should supplant intercropping in the young orchard even where corn or other cultivated crops are grown as the intercrop.

TABLE OF CONTENTS

GROWING AN ORCHARD IN KANSAS[1]

R. J. BARNETT

INTRODUCTION

For 60 years Kansas has been known to be a fruit-producing state. In 1871 Kansas-grown apples won the highest award at the exhibition of the New Jersey Horticultural Society. In 1876 the Centennial Exposition in Philadelphia awarded the Kansas entry, an exhibit of 96 varieties of apples, a medal inscribed as follows: "For an exceedingly fine exhibit of apples esteemed the more value from the general absence of merely local showy and worthless sorts." Kansas-grown grapes won heavily among the fruit entries at the World's Fair in Chicago, and whenever shown well-grown Kansas fruits have attracted attention to their size, color, and quality.

This early or general farm phase of Kansas orcharding came to a definite end about 1915. The old trees were destroyed by drouth and diseases and young ones had not been planted on the farms of the state to replace them. However, commercial orcharding had by that time developed in several sections of the state so the net loss of trees through the decay of the farm orchards was not so great as might have been expected. To a student of the subject these changes in type of Kansas orchards emphasize the very close relation between fruit growing and the man in charge. Of two adjacent orchards one may prove successful and the other bring only failure. The man who understands the science of fruit growing and practices the art efficiently is the one who succeeds. He is competent to select a proper location and site, to choose adapted varieties, to plant them carefully on well-prepared soil, and then to give them years of good culture and protection from their enemies. Orchards so started and so cared for will succeed in most sections of the state.

Much of this bulletin was written with the beginning commercial fruit grower in mind, but with certain modifications it will apply equally well to the needs of the home orchardist. The main difference between the practices of these two types of fruit growers is one of extent rather than kind. Both require intensive work and the use of good judgment.

Experienced orchardists have all found that there is no *best* method, applicable to all parts of the state, for many of the orchard

1. Contribution No. 96 from the Department of Horticulture.

operations. Differences in location, in soil, in weather, in varieties, in surrounding orchards, in pest incidence, and in many other variable factors require corresponding variations in the method of caring for the orchard. The principles remain the same but the practices must be varied to fit the conditions in each individual orchard. Soils respond differently to the same culture; Jonathan apples need no protection against blotch and Winesap none against fire blight; young orchards may or may not need to be sprayed; intercrops are profitable in some orchards and actually harmful in others; thinning should be done some years but may be unnecessary others. It is in deciding these and a hundred similar questions that the judgment of the grower is so important. Correct decisions lead to success. This care and the exercise of intelligence which it requires is difficult and expensive to buy, so, in general, good orchards are grown only through the actual labor of the owner or under his daily supervision. The old saying attributed to a classic Greek writer, "The best fertilizer is the footprints of the owner," is certainly applicable to growing an orchard.

TREE FRUIT GEOGRAPHY OF KANSAS

At the present time Kansas has only two well-developed orchard regions: The eastern counties from Wyandotte north to the state line, but largely concentrated in Doniphan county, and the valley of the Arkansas river from Hutchinson to Arkansas City, but especially the sections about Belle Plaine and Oxford. The location of these regions is shown in figure 1. Fruit growing could be greatly extended in the first of these regions, especially on the loess soils of Atchison and Leavenworth counties, and there are many unplanted but well-adapted sites in the Arkansas valley. Well-cared-for orchards in these locations will produce medium to large yields of high-quality apples, sour cherries, peaches, and other tree fruits.

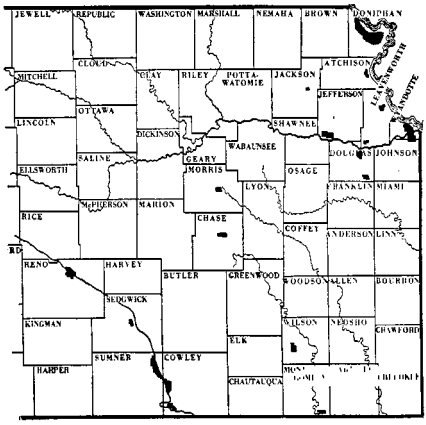

FIG. 1.—Black areas are locations in the eastern half of Kansas where commercial orcharding has been developed.

Commercial fruit-growing centers could be developed in other

sections of the state though, probably, none of them would equal in acre production those now developed. They might, however, surpass the old locations in facilities for transporting and marketing the fruit. Minor centers of production now exist about Kansas City, Atchison, Grantville, Council Grove, Baldwin, Lawrence, Fredonia, Strong City, and other points. Qualified growers could extend the plantings in any of these localities with profit.

Productive home orchards are no longer common in Kansas but could be again established on most farms in the eastern third of the state and on many farther west. The time is past, however, when fruit of any value can be expected from neglected home orchards. They must be given good care if they are to add, as they may, to the wealth, pleasure, and health of the farm family.

LOCATING THE ORCHARD

Choosing the Location.— When a person plans to become a commercial grower of fruit the first decision he must make is that relative to location, the geographical place where he will establish his orchard. This choice is important because a poor location is a lasting handicap while a good one makes success easier and more certain of attainment. Specific comparisons of Kansas locations, such as the Arkansas river valley and the Doniphan county section, will not be attempted here, but the prospective grower must carefully weigh the advantages and disadvantages of all commercial districts with which he is acquainted and choose the one which promises to be best.

The principal facts which a grower should have before him to aid in choosing a location for fruit production are shown in outline form below. They do not apply to the home orchard as its location is determined when the farm is purchased.

Factors Affecting the Choice of an Orchard Location

1. CLIMATIC RELATIONS.
   a. Temperature.
   b. Moisture.
   c. Light.
2. TRANSPORTATION.
   a. Common carriers.
   b. Highways and wagon roads.
   c. Distances to market.
3. ORCHARD PESTS.
   a. Prevalence.
   b. Community control.
4. GROWERS' ORGANIZATIONS.
   a. Number.
   b. Strength.

5. ORCHARD COSTS.
   a. Original cost of land.
   b. Cost of development.
   c. Labor supply.
   d. Costs related to probable yield.
6. SOCIAL RELATIONS.
   a. Home making.
   b. General social life of the community.
      (1) School, church, amusements, sanitation, etc.

Choosing the Site.—The orchard site is the particular piece of land on which the orchard is grown. First in importance among site characteristics is soil. An orchard soil must be fertile, of good texture, well drained, and deep; fertile, because orchard trees exhaust fertility as rapidly as grain crops, short rotations are not possible, and only fertile soils give large yields of fruit over long periods; of good texture, preferably a sandy loam for most fruits, because such soils are usually productive, are easy to work, warm up early in the spring, and respond more readily to cultural treatments including fertilization; well drained at all seasons of the year, because all of the fruit trees are quickly injured by free water on the surface or about their roots in the soil; and deep, because fruit trees require a large body of soil for the distribution of their roots to the end that an adequate supply of water and mineral nutrients may be gathered and the trees may be securely anchored in place against high winds. Six feet of soil through which the roots of the tree can readily penetrate should be the minimum for all orchard sites.

The orchard site must have good air drainage that the hazard of frost injury may be lessened. The United States Department of Agriculture is authority for the estimate that frosts and freezes are responsible for the destruction of 14.6 per cent of the apple crop annually. Insects and diseases together destroy only 7.3 per cent. Peach losses from low temperatures are higher than apple losses, but sour cherries are a somewhat more certain crop.

Air drainage depends on the difference in weight between warm and cool air. Cool air, being heavier, settles to the surface of the earth and frost forms during windless nights when the dewpoint is below 32° F. On a slope the air continues in motion downward and the probability of frost formation is lessened. A fairly level area lying several feet above an unobstructed drainage system is nearly as safe as a steeper slope. Doniphan county hillsides have about the same frost hazard as Missouri river bottom sites provided the latter have some slope to the river channel and the flow of air is not obstructed.

Fertile soil and good air drainage are the principal requisites of a good orchard site, but the direction of the slope and natural barriers against prevailing winds are also important. In general, Kansas growers consider an east or north slope more desirable for an orchard than one facing west or south. However, this difference is not great and commercial orchards seem almost equally valuable on all slopes, although the trees on the east and north sometimes live longer than those exposed to the summer winds and the more direct sunlight.

FIG. 2.—A windbreak of pine and arbor vitae trees south of an apple orchard. The windbreak is younger than the orchard whereas it should be of equal age or older.

Windbreaks on the west and south sides of the orchard are valuable if started early and composed of good tree species. Scotch or Austrian pine, arbor vitae, Russian olive, and hackberry are among the best tree species to use. Figure 2 illustrates a windbreak composed of arbor vitae and pine trees. Red cedar, cottonwood, box-elder, elm and Osage orange are not recommended for this use. The first serves as host for cedar-apple rust and the others require too wide areas for their shallow root systems. Osage orange is also a favorite host of the San José scale.

Hail storms seem to follow somewhat definite tracks and such areas should be avoided when choosing the site for an orchard.

An orchard on a carefully chosen site has much greater value than

one located without reference to the items just discussed. Many sites are so poor in one or more of these requirements that even the best subsequent orcharding will fail to produce a property of value.

ORCHARD COSTS AND YIELDS

Anyone who contemplates growing an orchard must consider costs of development and care and income from the enterprise. A discussion of these subjects is difficult because no two orchards ever cost the same or return the same profits, and averages are of doubtful value because the group of poorly managed and inadequately financed orchards is much larger than that of first-class orchards. It is evident that the financing of a 30-acre orchard is a much more complex and longer task than financing a 30-acre grain or even potato field.

In Kansas apple trees bear their first profitable crop at 6 to 10 years of age. This means that the whole cost of planting and caring for the trees for about eight years must be met from some other source than returns from the orchard. The source of this income is a problem for each individual grower, but its amount can be somewhat closely approximated.

Investment Costs. — Acre cost of land adapted to apple or cherry culture will vary from $65 to $250 in Kansas. These variations are based on the items previously given to aid in selecting an orchard location and an orchard site and, although the amount paid for the land constitutes a permanent future charge against the orchard, the high-priced land is frequently the more profitable. Profitable orchards have been grown on land costing $1,000 or more an acre.

Preparation of the land for planting may be very cheap or very expensive. If it needs only plowing and surface working $4 an acre is adequate, but if leveling or terracing must be done this expense may amount to $50 an acre, Apple trees to plant an acre can often be purchased for $10 and sour cherries for about twice that amount. Staking, setting, and pruning will add about $5 an acre and the year's cultivation about $8 more. In the fall $5 will be spent for wire cloth trunk guards and about the same amount for each acre of winter vetch cover crop. So the cost for the first year will vary from about $40 to $90 or more an acre. During subsequent years the care will vary in cost, depending largely on the basis of how many spray applications are required, but will average about $25 an acre. Omitting the original cost of the land, each acre of really good orchard will represent an investment of $200 or more by the time it reaches profitable bearing age.

Yields and Profits. — Under the same natural conditions a few growers of fruit, will achieve wealth, many will be moderately prosperous, and some will become bankrupt. In general, however, profits from fruits are closely related to yields because it costs as much to bring an acre yielding 200 bushels of apples or one ton of sour cherries to harvest time as though the trees were bearing several times that amount of fruit. Heavy expenditures coupled with heavy yields of high-grade fruit are more likely to prove profitable than cheap care coupled with irregular and small crops of inferior fruit. Commercial apple orchards in Kansas vary in production between 200 and 800 bushels an acre and, one year with another, it is the high producers which show the high profits. Sour cherries will begin to bear about the fourth year and will be in full bearing by the eighth. Yields of 4 tons to the acre have been recorded, but in these days of cherry shortage half that amount would give a good income.

Orchard economies and profits are also closely related to the size of the orchard. Too small an orchard will not provide sufficient income for a family and undertaking the development of too large an orchard may overtax either the physical and mental capacity of the owner or his financial resources. Thirty or forty acres of non-irrigated orchard is probably the best one-family unit. It will provide economical use of modern orchard machinery and nearly year-round employment for the owner and his family. Orchards of 75 to 100 acres are also of good economic size for abler or more ambitious growers, but oversize orchards are often neglected as to details of management and are consequently short lived.

TREE FRUIT VARIETIES

One of the most perplexing problems for many fruit growers is that of choosing the varieties to plant. This difficulty is caused by the activities of tree agents in pushing sales of new and untried varieties, the great multiplicity of varieties of most kinds of fruit from which the choice must be made, and the common lack of any well-thought-out guide or score card to govern in making the choice. But an answer must be given to this question as soon as the location and site for the orchard are selected, and on its correct answer depends the future value of the property; for "No orchard is better than its varieties."

Rule for New Varieties. — No other development in American fruit growing has proved of so great benefit to the industry as the discovery or production and testing of new, better adapted and higher quality varieties of the apple, peach, and plum. The prin-

cipal debt which this generation of fruit growers owes to the preceding one is for their accomplishments in this line. And the work is not finished. Vast improvements are yet possible and generous support of all well-planned attempts to produce valuable new fruit varieties is needed.

However, the production and testing of a new fruit variety is a long and tedious process. The testing alone is not complete until the first generation of trees is mature and giving sure indications of long life. At any time before this stage is reached the most promising variety may develop faults which bar it from a place in the commercial orchard. The fruit may be large on young trees but too small on mature ones; it may wilt, scald, or spot in storage, or its color may so handicap it as to lessen greatly its market value. Bad tree characters frequently ruin new and promising varieties. Low or uncertain yields, poor shape, weak and brittle wood, late bearing, or susceptibility to diseases, any or all, may appear as the tree approaches maturity and destroy or greatly lessen its value. "Go slow on new varieties" is the only sensible rule for the commercial fruit grower. A wrong choice is disastrous. The author has known commercial orchards which have had the varieties changed twice by topworking, an expensive substitute for original straight thinking. Trees of untested varieties may be tried out in small numbers but should not constitute any large part of the orchard.

Score Card for Selecting Orchard Varieties.— The fruit dealer and the consumer are interested only in the fruit of a variety. In contrast, the grower must give as great weight to the tree as to the fruit itself. Poor tree characteristics make the growing of some of the varieties which bear the best fruit unprofitable. A score card indicating the points about a variety which should be studied and their relative values is given below.

Score Card for Choice of Tree Fruit Varieties

THE TREE		50 points
Productiveness	20	
Pest resistance	13	
Strength and vigor	10	
Precocity	7	
THE FRUIT		50 points
Color	15	
Size	10	
Quality (as related to use)	10	
Handling value	15	
Total		100 points

No variety of any of the deciduous tree fruits scores high in all of these characters. A high valuation for any of them would be 90 points and the score card is deceptive here, as elsewhere, because one fault may be so serious as to bar the culture of an otherwise highly desirable variety. Thus, among apples, unproductiveness of Esopus, susceptibility to blister canker of Ben Davis, blotch on Maiden Blush, and lack of beauty and tendency to crack of Ralls, prevent their planting in present-day orchards.

Number of Varieties.— The first generation of Kansas apple orchards contained many varieties. This large number made favorable conditions for cross pollination but was otherwise unprofitable as there are rarely more than five apple varieties which are well adapted to a locality. Later, commercial orchards of only one or two varieties were planted and proved unproductive because nearly all apple trees are self-sterile. It is now known that apple varieties should be planted in blocks not more than six rows wide, preferably four rows, then two or more rows of a good pollenizer variety with repetition or variation of the varieties throughout the orchard. Three to five fall and winter varieties may well constitute the whole orchard but, where they sell well, a few acres of summer apples are profitable. The Winesap group (Winesap, Black Twig, Arkansas Black, Stayman, and Delicious) are said not to cross pollinate well though all of them except Stayman are potent for other varieties.

A good distribution of varieties for a 30-acre orchard in eastern Kansas would be: Jonathan, 350; Winesap, 175; Grimes (double worked), 70, and Stayman or York, 70 trees. This would leave room for about one acre of early apples, Yellow Transparent, and Wealthy. In the Arkansas valley Winesap would replace Jonathan and Grimes would be second in importance. Early Cooper also seems satisfactory as an early variety there.

Recommended Varieties.— The lists given below are believed to contain the names of the most dependable varieties for general planting in Kansas. Local environment may cause others to displace some on the list (as an example the Missouri apple is desirable on fertile bottom lands only) but study and experience confirm this selection.

Fruit Varieties Arranged in Approximate Order of Ripening

Apple: Yellow Transparent, Cooper, Wealthy, Grimes (double worked), Jonathan, Delicious, Stayman, York Imperial, Winesap, Ben Davis. Cherry: Early Richmond, Montmorency, English Morello. Peach: Greensboro, Early Crawford, Elberta, Champion,

Crosby. Plum: Wild Goose, Abundance, Lombard, Damson, Omaha, Weaver. Quince: Fuller, Orange, Champion. Crab Apple: Whitney, Florence, Hyslop, Martha.

Apple and sour cherry are the commercial tree fruits best adapted to Kansas. Peach and plum can be grown and may some years show high returns, but over a 10-year period the profit from them will in most localities be small. Pears should not be planted in an apple region and are of questionable value anywhere in the state. Fire blight is the only reason for this and when immune varieties of good quality are available, Kansas will grow an abundance of this delicious fruit. No such varieties now exist. Good varieties of apricots and sweet cherries bear fruit so rarely here that they are not worth growing even in the home orchard.

BUYING NURSERY-GROWN TREES

One of the first steps in starting an orchard is the purchase of the trees. This should be done well in advance of planting time; January is none too early for spring planting. Only a thoroughly reliable nursery should be patronized and it is better to deal directly with the nursery where the trees were grown than through an agent. Many Kansas nurseries grow good orchard trees and are reliable and responsible.

Choice of Trees. — The best nursery trees are the cheapest. Only under unusual conditions can a good orchard be developed from trees which were second grade or poorer when planted. First-grade one-year-old trees will be true to variety name, four to five feet in height, free from pests of all kinds, and have firm bark, plump buds, and good root systems. If apple, they will usually be straight switches; peach, cherry, and plum will have side branches. Only one-year-old drupe fruit trees should be planted, but apples may be two years of age if they were not yearling culls and were headed at a proper height,.

Price to Pay. — The price of good nursery stock varies from year to year. The grower should pay the price, influenced by the number of trees ordered, for first-grade trees. This may be determined by correspondence or, better, by visiting several nurseries.

Care of Trees on Arrival. — The nursery packs shipments of trees well enough to arrive at their destination in good condition. The purchaser should get them from the freight office without an hour's delay. They should be unpacked as soon as received and examined for pests. Trees which show evidence of crown gall, woolly

aphis, scale, or blotch should not be planted. They should in general be burned. Sufficient time should be allowed to make this inspection thorough. Unless everything is ready to proceed with the planting at once, the trees should be heeled in almost to their tips.

PLANTING THE ORCHARD

Soil Preparation.— Kansas orchards are now usually planted on land which has been under cultivation. The preparation of such soil for planting is simple; it involves only rather deep plowing and

FIG. 3.—View of a small terraced orchard soon after the trees were planted. The vertical distance between terraces is five feet.

surface cultivation. The plowing may be done in the fall and earlier planting thus made possible.

Terracing Orchard Lands.— Leveling orchard lands in preparation for irrigation has long been practiced, but terracing sloping lands to prevent erosion and to increase the soil moisture supply is a new development in Kansas. Steep lands have been held from washing by sod culture as described on page 26. Because of the defects of this system of soil management terracing is recommended and has been put into practice in a few new orchards.

The cherry orchard shown in figure 3 was terraced before planting at a cost of $37.50 an acre. There has been no erosion from this area although the difference in elevation between the high and the low points is 30 feet. Terracing orchard lands is still in the

experimental stage here, but old world experience would indicate its great value for sloping lands in good fruit sections. Aid in this work can be obtained from the agricultural college at Manhattan.

Staking.—If a large area is to be planted, it pays to locate the place where each tree is to stand by staking out the orchard, Half laths make good stakes. Base lines are established along two opposite sides of the field and stakes set at regular intervals where the tree rows are to be located. A wire to which "bobs" have been attached at the planting distance is stretched between stakes marking the ends of each row. If care is taken to keep the wire at an even tension, not allowing it to sag down into depressions, the stakes will be accurately check-rowed.

Planting Systems and Distances.—Nearly all Kansas orchards are planted by the square system. By this system a tree is planted on each corner of a square the side of which is the planting distance. The hexagonal system is more difficult to lay out and the trees will not be so convenient to work among, but at the same planting distance 15 per cent more trees may be planted to the acre. Planting distances vary with the kind of fruit, the fertility of the soil, and the soil moisture supply. In general, the more fertile the soil and the more abundant the moisture the further apart the trees should be planted. Wide planting also favors better growth and production in the drier parts of the state. Efficient spraying cannot be done among crowded trees. Apples will need 35 to 40 feet between trees; sour cherries, about 25 feet; peaches and plums, about 20 feet. Too close planting is both more common and more harmful than too wide planting.

Number of Trees to the Acre.—Having determined the acreage to be planted and the planting distance, the number of trees to order may be easily determined. If planted 35 feet apart each tree will occupy 1,225 square feet. This number divided into 43,560, the number of square feet in an acre, gives as quotient 35, the number of trees for planting an acre. It is well to order a small excess of trees.

Use of Fillers.—Some growers plant among the permanent trees of the orchard temporary ones known as fillers. This practice has led to much difference of opinion, but some principles regarding it seem well established: (1) Fillers should be of the same kind as the permanent trees but early bearers and dwarfish in size. (2) Fillers should be used only by those orchardists who are sure they will remove them before they crowd the permanent trees, usually

about the tenth year in the apple orchard. (3) Fillers hasten the exhaustion of the fertility of the orchard soil. (4) Between trees in the rows running the long way of the orchard is probably a better place to set the fillers than in the centers of the squares.

The successful planting of orchard trees is an easy operation if the trees are in good condition, the soil has been well prepared, and the staking accurately done.

Planting Time.—Orchard trees must be planted while they are dormant. This period extends from early in November until about the middle of April and, theoretically, planting may be done during any part of it. In practice, early spring has proved the best planting time in Kansas. Not infrequently the soil and weather will permit planting during late February or early March. This is the most desirable period. April 1 to 10 may serve as planting dates, but are less desirable. Special care must be taken with sour cherries. They must be planted early, before the buds begin to swell, or they are not worth planting at all.

Fall planting is frequently successful in the eastern part of the state but is hazardous west of Topeka. Dry, cold winters badly injure newly transplanted trees. Trees for fall planting should be mature before being dug. This requirement delays fall planting until after November 1.

The Planting Crew.—One or two men can plant an orchard, but if it is of commercial size a planting crew of five men is more economical. The owner, or foreman, hauls, protects, and distributes the trees to the others, who work in pairs on two adjacent rows. The roots of the trees must not be exposed to the sun or wind for even a minute in bright, dry weather. Burlap and wet straw in a light wagon or barrels half-full of water on a stone-boat are easy means of providing such protection. The crew should be large enough to complete the planting in a short period, as the trees should be planted as quickly as possible after conditions become favorable.

Setting the Trees.—Large holes and extreme care are not necessary in planting fruit trees on good soil. The hole should be deep enough that the tree may be set two or three inches lower than it stood in the nursery and broad enough to receive the roots spread in their natural position. Long roots may be cut back to average length. The bend marking the point at which the cion or bud was inserted should be below the surface. The wound at that point will

be healed on a first-class tree. By use of the planting board illustrated in figure 4 the tree can be placed in the exact spot where the stake stood.

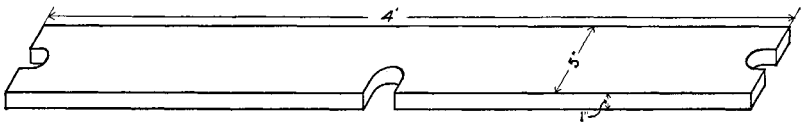

FIG. 4.—A planting board. The use of this board enables the fruit grower to set the tree in the exact spot where the stake stood.

After placing the tree in the freshly dug hole fertile top soil should be filled in by one man of the crew while the other works the soil around the tree roots and tamps it firmly in place. A common serious error made in planting trees is failure to pack the back-filled soil solidly enough. This leaves air pockets, thus drying out the roots, which can absorb moisture only from soil with which they are in very close contact. If a newly planted tree can be pulled out of the ground with any degree of ease the soil was not adequately firmed about its roots. The hole should be filled to slightly above the general level of the field unless the soil is so dry that watering is needed. In this case a basin is left around the tree and the filling in is completed after the irrigation water has seeped away.

Experimental evidence shows that the use of dynamite in planting orchard trees is not to be recommended. A soil which has hardpan close to the surface or which is so tight as to need blasting should never be selected as an orchard site. Blasting such soils does not permanently improve them for orchard trees.

CARE OF THE YOUNG ORCHARD

At one time there was prevalent in Kansas a belief that no orcharding steps intervened between planting the trees and harvesting the fruit. If this ever were true, the time has gone forever. Young trees which are to grow into a valuable, productive orchard require a great deal of care. They must be protected, pruned, and fed.

Protection from Pests.—This publication does not contain descriptions of the common insects and diseases which attack orchard trees or the methods of their control. These subjects are discussed in the "Spray Circular" which is issued by the Agricultural Experiment Station at frequent intervals because of constant changes in the relative importance of these pests and in the methods of com-

bating them. It should be noted, however, that young fruit trees may be attacked and seriously injured by both insects and diseases. A full spray program is never required, but pests must be watched for carefully and proper sprays applied whenever they appear. Pests of other types may attack young trees and do great damage. They are discussed here because measures other than spraying must be used for their control.

Rodents. — Mice and rabbits damage young trees by gnawing the bark of the crown or the trunk. The best protector for the trunks of the trees is wire cloth of ¼-inch mesh. This material should be cut into pieces about 18 inches wide and as long as the average tree trunk height. These, when put around the trunks, will make cylinders six inches in diameter. The ends should be fastened together with light galvanized wires or with hog rings. These may be left in place until the trees are too large for rabbits to injure them. Corn stalks, wood veneers, or stiff paper protectors may be used but, counting the loss which follows any neglect and the necessity of removing them each spring, they are more expensive than the wire cloth. Painting the trunks with any of the many materials recommended will prove only partly effective. Even badly gnawed trees may be saved by bridge grafting as described in United States Farmers' Bulletin No. 710, if the repair is made during very early spring.

Because mice may girdle the crowns of the trees below the protectors these rodents should be destroyed. They are unlikely to be numerous in clean, cultivated orchards but work under trash about the trees in mulched or sod orchards and for considerable distances under heavy layers of snow. Poisoned grain so placed as to be inaccessible to birds will, if properly used, exterminate them.

Gophers often do great damage to young fruit trees, especially when alfalfa or other uncultivated fields are near the orchard. They can be controlled by poisoning.[2]

Borers. — Fruit tree borers are the larvae of insects, but they cannot be controlled by spraying. Among the more destructive borers in Kansas are the peach borers, flat-headed and round-headed apple-tree borers, and the fruit-tree-bark beetles, or pin hole borers, especially of the sour cherry. The peach tree borer has to be dug out of young trees, but the paradichlorobenzine treatment described in United States Farmers' Bulletin No. 1246 is effective

2. Methods of control are discussed in Circular 120 of the Agricultural Experiment Station, "Control of Mammals Injurious to Agriculture in Kansas."

in controlling them in trees six years of age and older. In general the borers have to be dug out of apple trees. If this work is done in midsummer, the borers are difficult to detect but easy to destroy. Later they are easy to detect but difficult to destroy. Good care, such as will keep the trees growing vigorously, is the best protection against the flat-headed borers which attack leaning or weak trees. The branches attacked by fruit-tree-bark beetles should be cut off and burned whenever observed and the fallen branches cut off by the twig-pruner should be gathered up and likewise burned.

Live Stock.— Except possibly poultry, no live stock should be allowed in the orchard. All types will sooner or later seriously injure the trees. Pasturing grass or corn-stalks grown between the trees is sure to result in injury even though small animals such as calves, sheep, or pigs are used. Either the orchard should be fenced against farm animals or these should be securely confined. Growing an orchard is a serious task and is expensive. Success should not be jeopardized for the sake of the small returns obtained by such practices. Careless workmen also do great damage in an orchard. They should be kept out or carefully trained for the work.

Diseases Not Controlled by Spraying.— Orchard spraying and the pests which may be controlled by that method are discussed in another publication of the Agricultural Experiment Station. However, a number of destructive diseases of Kansas orchards are of types which cannot be controlled by spraying. Brief mention of some of these will be made and a number are illustrated in figure 5.

Fire Blight of the Pome Fruits.— Fire blight is a bacterial disease which attacks the cambium layer of susceptible plants, particularly the pear and apple. The principal points of attack are the growing tips of twigs and, through the blossoms, the fruit spurs. This disease is so great a hazard with the pear that the commercial growing of that fruit in Kansas is not recommended. All varieties now grown will contract this disease, though some are more susceptible than others.

Apple trees are best protected against fire blight by destroying all pear trees near the orchard and by the careful removal of all infected branches and cankered areas at the time of winter pruning. Jonathan is very susceptible to this disease whereas Winesap and Grimes are resistant.

Cedar Rust of the Apple.— Cedar rust is a destructive fungous disease which passes its winter stage on twigs of the red cedar,

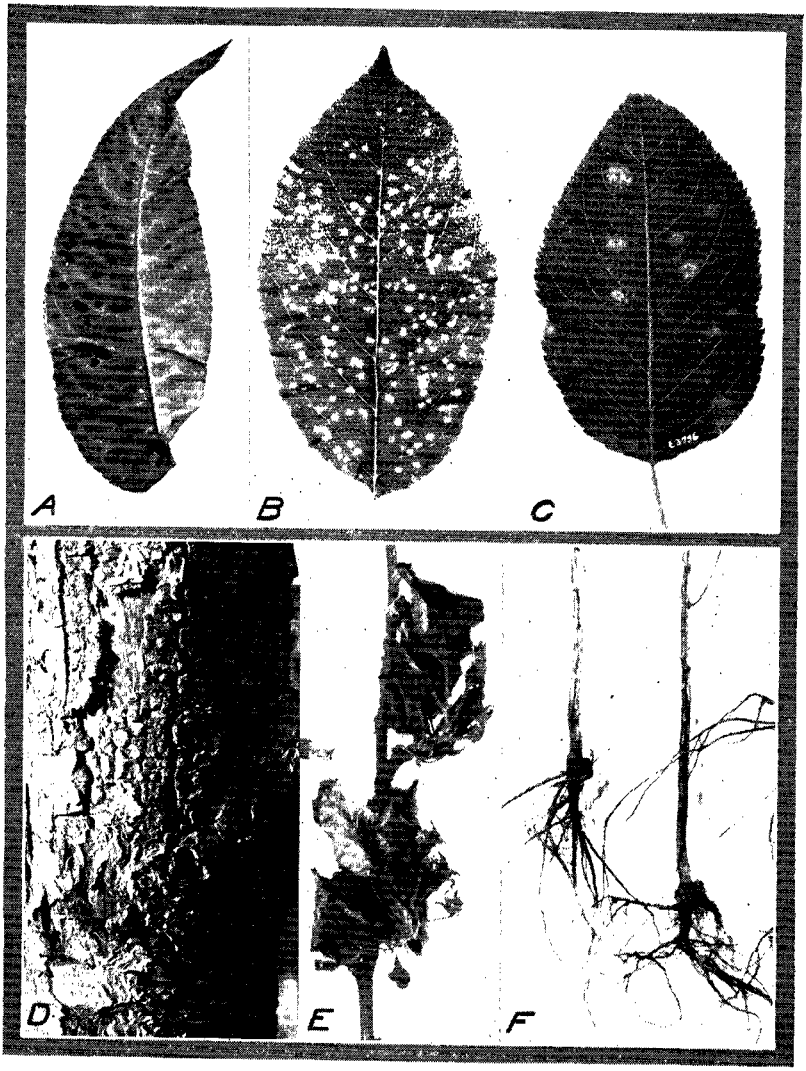

FIG. 5.—Some orchard diseases not controlled by spraying. (A) Bacterial leaf spot of peach. (B and C) Cedar rust of apple. (D) Nailhead stage of blister canker. (E) Apple spurs killed by fire blight. (F) Nursery apple trees showing the tumor form of crown gall.

where it forms galls, and its summer stage on the leaves and other parts of susceptible apple trees. It injures the apples by destroying the leaf surface and by direct attacks on the fruits themselves.

Apple varieties show great variability in resistance to this disease. In the station orchard, Wealthy, Jonathan, and Rome have proved very susceptible, while Winesap, Grimes, Stayman, York, and Delicious are resistant or immune. Another species of rust known as quince rust is prevalent in certain parts of the country and also attacks the apple. It has been found that certain varieties of apples that are resistant or immune to the common cedar-apple rust of Kansas are attacked by quince rust.

Control measures for cedar rust consist in either destroying all cedar trees within one mile of the orchard or in growing only resistant apple varieties. Both spraying and attempts to remove the cedar galls prove ineffective.

Crown Gall.—Crown gall is a bacterial disease which attacks all kinds of deciduous fruit plants. Of the tree fruits, the apple is most commonly infected. The symptoms of this disease vary, but tumors usually form near the crown or on the roots of the tree and interfere with its normal nutrition. Some infected trees die or are badly injured; others continue productive for many years.

This disease is usually brought into the orchard on the young trees from the nursery and is slow to spread to other trees. Since no cure is known for it, very careful inspection should be given the trees before they are planted and any which show abnormal growths near the crown should be rejected and burned. Hairy root is another manifestation of the same disease.

Blister Canker.—Estimates indicate that 90 per cent of the Ben Davis apple trees in Kansas during 1914 have since that date been killed by blister canker. It attacks many other varieties with only slightly less severity. This fungus gains entrance through wounds and makes its vegetative development in the deep tissues of the branch or trunk. When mature the fungus grows through the sap wood and bark and produces its spores from nail-head-like pustules on the bark of the trees. Infection spores are produced most abundantly during late summer and fall.

Blister canker is a very difficult disease to keep in check. However, this can be done by planting resistant varieties, giving the trees such care that they are not weakened by overbearing or because of drouths, and using surgical work to prevent the formation

of "nail heads" on infected trees. The use of dressings on pruning wounds is of value.

Bacterial Leaf Spot. — This disease of the peach is common in Kansas orchards and frequently does vast damage by destroying as many as 90 per cent of the leaves. Badly affected trees have a characteristic appearance, the leaves being reduced to clusters at the ends of the twigs. The casual bacterium passes the winter in lesions on twigs and defoliation usually occurs by midsummer.

As with other bacterial diseases spraying affects this in only an indirect way, through the control of insects and protecting the tree against debilitating fungous diseases. Varieties vary somewhat in susceptibility, but good general care such as will keep the trees vigorous, is the best protection against this disease. It is said to be introduced into the orchards on nursery trees.

Gummosis of Stone Fruits. — Gummosis, in general, seems to be a symptom of abnormal tree conditions rather than a specific disease. The external evidence of it shows as large or small masses of exuded gum on the bark of the tree. There is always a wound under external gum, but gumming may occur internally, especially with the cherry. The actual cause of this disturbance is unproved, but some students of the subject believe the gum is produced by an enzyme acting on the living cells of the plant, a form of digestion.

Control measures are unsatisfactory. Healing will frequently follow cutting out of the diseased areas when this is practical. The disease can in part be prevented by keeping the trees in good vigor, by avoiding wounds made by pickers or otherwise, by protecting the trees against borers, and by any measures which lessen winter injury.

WINTER INJURY

Winter injury often takes heavy toll from Kansas orchards. Such injury seems especially serious when frequent, sudden changes in temperature occur or when minimum temperatures are combined with drouths. The bark of the trees near the crown may crack open; the sapwood may be killed, as frequently happens to the peach and tender plums; areas of bark exposed to the three-o'clock sun may be killed; also twigs and other parts, as crown and roots, may suffer badly during severe winters.

The fruit grower can to a considerable degree avoid losses from low winter temperatures. Choice of sites having good air and water drainage, planting of hardy varieties, soil so managed as to induce

full dormancy before early winter, use of cover crops, and proper pruning are all means at his command to lessen these losses.

The destruction of blossoms by spring frosts is a constant hazard which the fruit grower must face. Among both kinds and varieties this hazard is roughly proportional to the date of blooming, though blossoms of some kinds, as the peach, and of some varieties, as the Delicious apple, are more tender to cold than others at the same stage of development. Frost injury is frequently avoided by late blooming as illustrated by Rome and Ralls apples. The choice of a site having good air drainage is about all the grower can do to counteract this hazard. Keeping the soil cool does not delay blooming, and heating has not proved profitable in Kansas orchards.

ORCHARD SANITATION

Writers on orcharding seem almost without exception to have overlooked or undervalued the possible returns from persistently practiced orchard sanitation. In it often lies the difference between preventing and trying to cure orchard ills. It begins with the trees as they come from the nursery and ends when the last old diseased stump of the orchard has been grubbed and burned.

Nursery Stock. — The reliable nurseryman inspects his trees before he ships them and throws diseased or insect-infested ones on the cull-pile. But no inspection is perfect, so the grower who buys the trees must again examine them with care and reject or treat those which show evidence of pests. This inspection is the grower's sanitary measure to prevent the introduction of San José scale, woolly aphis, crown gall, and blotch into his young orchard.

Soil Management and Sanitation. — Early spring cultivation of orchard soils aids in the control of many pests. Curculio or codling moth are exposed and leaves bearing apple scab and cherry leaf spot are buried so deeply that the spores causing these diseases cannot be discharged into the air. Cultivation discourages the buffalo tree hopper, which feeds on weeds, and makes the orchard a less attractive place for rabbits and mice.

Equipment and Sanitation. — Packing sheds and storages, fruit containers and lug boxes all become hibernating places for orchard pests. Fumigation, screening, and burning must be employed to lessen the hazard from these sources. Codling moth emerge in great numbers from such places and a really efficient method of sanitary control has not yet been devised. Screening all openings of buildings is valuable.

Fruit Trees and Sanitation.— Many orchard pests are carried over the winter on the trees themselves and good pest prevention involves the destruction of these overwintering forms as far as possible. Codling moth larvae are destroyed by scraping off bark scales; brown rot holds over in the mummies on drupe fruit trees; apple blotch, fire blight, and blister cankers should be carefully pruned out and borer-infested branches and stumps should be piled on such prunings and all burned together. Wide planting of trees is an important sanitary measure as it makes pest control more effective. Thinning fruit clusters has been proved to lessen codling moth and curculio infestation and banding of tree trunks, worming, and the destruction of near-by hedges or cedar trees all fall under orchard sanitation. It may, in fact, become the deciding factor in orchard pest control.

SOIL MANAGEMENT IN THE YOUNG ORCHARD

Care of the soil is the most important part of growing an orchard in Kansas. It is from the soil that the young trees must obtain their entire supply of mineral nutrients, including water. If the soil is infertile or is allowed to become deficient in soil moisture the trees will make a slow growth, will be deformed in shape, dwarfed in size, more susceptible to injury by certain insects and diseases, uneven in stand, incapable of yielding maximum crops, short-lived, and thus much reduced in eventual value. There are other ways to ruin an orchard, but none is more certain than neglect of the soil in which it is growing. Even though good soil was selected for the orchard site, improper methods of management may cause it to produce a poor orchard.

Many virgin Kansas soils could bring a stand of fruit trees to maturity and supply them with necessary nutrients through a fairly long and productive life without much care, such as cultivation to keep down competing weeds and grass, or the addition of fertilizers. But now, after 50 years of crop production and erosion only the most fertile soils have their original fruit-producing ability. Careful attention is now required if the trees' supply of soil nutrients and moisture is to be adequate for the production of a high-grade orchard.

The roots of a deciduous fruit tree occupy a body of soil which is shaped somewhat like a saucer with the trunk of the tree at the center. In especially deep soils, such as loess or river bottom lands, the figure tends to become slightly less wide and much deeper. The

horizontal spread of the roots of young trees in the soil is well in advance of the spread of the branches in the air. Moisture is collected and the tree is anchored by the deep roots, but, in the main, soil nutrients are absorbed with the water from the surface 12 to 18 inches of the soil.

Objects of Orchard Soil Management.— Fruit growers should know what conditions they should try to produce in the orchard by variations in soil management and how these can best be brought about. In general the object is to provide the most congenial possible conditions for the roots of the trees. This depends largely on selecting, when choosing the site for the orchard, a soil which is fertile and in which the roots of the trees can penetrate to great depths. However, much may be done by the grower to improve the congeniality of poorer soils and to maintain that of good ones. Fertility is maintained by applications of manures or commercial fertilizers or by the use of cover crops. Manures and plant residues replenish the organic content and, ultimately, the humus supply of the soil, a most important factor affecting both its physical and chemical character. Cultivation makes stored soil nutrients more quickly available to the tree roots, controls weeds, and conserves soil moisture. To accomplish these objects effectively and economically is the purpose of the various methods of orchard soil management.

Sod in the Orchard.— A common method of orchard culture, especially in eastern Kansas and in the older orchards, is to allow grass to cover the ground. Because of the danger of soil erosion under other systems such sod orchards are sometimes the most valuable ones which could be produced on their particular sites. But sod seriously robs the trees of nitrogen every season and of moisture during drouth periods. Also, some experimenters present evidence showing that grass excretes from its roots substances which are injurious to the roots of fruit trees. Strips of sod four to six feet wide between tree rows and at right angles to the slope might be adequate to lessen erosion, or the sloping site could be terraced before planting and the trees set to conform to the terraces. It is probable that maximum returns are never obtained from a grass sod orchard in this state unless large amounts of commercial nitrates are used annually. Clover sod seems less harmful than the grasses, but alfalfa will, over several years, prove even more injurious than grass. Hay should not be taken from a sod orchard, but conclusive

evidence regarding the relative values of mowing the grass or letting it mat down uncut is not available.

Commercial Fertilizing.—A great deal of information is available to growers of grain and alfalfa in Kansas regarding the elements of plant food which may be lacking in the soil and the kind and amount of fertilizers and soil amendments which should be added. In many parts of the state grain lands need phosphorus, alfalfa lands phosphorus and lime, and added nitrogen increases yields of nearly all crops.

Accurate information on this subject in its relation to Kansas tree-fruit plants was lacking, so in 1920 an experiment planned to collect such information was started on the horticultural farm of the Agricultural Experiment Station. Fourteen plats of from 19 to 21 trees each were laid out in the station orchard and various fertilizer treatments applied to them. All the fertilizers were broadcast in the spring about two weeks prior to the date of blooming. The trees of plats 7, 8, and 9 were nine years of age in 1920 and those of the other plats were two years younger. The soil of this orchard site was thin and only moderately fertile, having been cropped for many years. The orchard had previously been intercropped annually, principally to corn. Table I records the plats in this experiment and the treatment given each plat.

TABLE I.—LAYOUT OF COMMERCIAL FERTILIZER TREATMENTS IN APPLE ORCHARD.

Plat No.	Variety.	TREATMENT.
7	Winesap	Acid phosphate 6 pounds and barnyard manure 1 ton to the tree annually.
8	Winesap	Rock phosphate 24 pounds to the tree applied each fourth year, and barnyard manure 1 ton to the tree annually.
9	Winesap	Barnyard manure 1 ton to the tree annually.
25	Winesap	Sodium nitrate 4.8 pounds to the tree annually.
26	Winesap	Muriate of potash 2.4 pounds to the tree annually.
36	Winesap	No fertilizer applied.
37	Winesap	Sodium nitrate 4.8 pounds and muriate of potash 2.4 pounds to the tree annually.
38	Winesap	Sodium nitrate 4.8 pounds and acid phosphate 6 pounds to the tree annually.
39	Winesap	Muriate of potash 2.4 pounds and acid phosphate 6 pounds to the tree annually.
40	Winesap	Sodium nitrate 4.8 pounds, muriate of potash 2.4 pounds and acid phosphate 6 pounds to the tree annually.
41	Winesap	Muriate of potash 2.4 pounds to the tree annually.
46	Jonathan	Acid phosphate 6 pounds to the tree annually.
47	Jonathan	Rock phosphate 24 pounds to the tree applied each fourth year.
48	Jonathan	No fertilizer applied.

The original plan was to keep the plats clean cultivated through the period of the experiment but, due to erosion and poor physical texture of the soil, plats 25 to 48, inclusive, have been seeded to a cover crop of wheat or rye each of the past eight years. This poor physical condition is illustrated in figure 6. The growth of the trees included in this experiment and the amounts of fruit they have borne are shown in Table II.

A study of these tables does not seem to throw much light on the value of commercial fertilizers in the young apple orchard. The

FIG. 6.—An example of puddling and erosion. A ground cover of winter vetch or rye would have prevented this puddling and erosion.

trees of plat 36 to which no fertilizer has been applied have made a satisfactory growth during the term of the experiment and rank high in average length of annual twig growth and in average trunk girth increase. Plat 40, the trees of which exceeded those of plat 36 in twig growth, received a complete fertilizer, and plat 38, which gave slightly greater average girth increases than those in plat 36, received applications of nitrate and phosphate. Since the plats treated with phosphate alone, 7, 8, 46, and 47, show no evidence of benefit from it and since potash failed to increase growth on plats 26 and 41, it would seem that the nitrate applied to plats 38 and 40

TABLE II.—RESULTS OF VARIOUS FERTILIZER TREATMENTS IN APPLE ORCHARD

(Ten-year record, 1920 to 1929)

PLAT NO.	Average annual.		
	Twig growth.	Girth increase.	Yield per tree.
	Cm.	*Cm.*	*Bus.*
7	31.6	6.2	3.1
8	27.9	5.8	3.0
9	34.2	6.1	3.3
25	34.0	6.0	3.2
26	32.3	6.4	3.8
36	35.7	6.9	2.9
37	34.3	5.8	2.0
38	34.0	7.1	3.0
39	36.1	6.6	2.4
40	37.4	7.1	2.7
41	35.8	7.2	2.7
46	29.9	5.8	0.3
47	27.6	6.5	0.2
48	29.5	5.6	0.2

might have had a stimulating effect on growth of the trees. However, their excess growth is small and the trees of plats 25 and 37, which also received nitrogen, failed to show benefit from it.

The trees of plats 7, 8, and 9 have borne five light to medium crops of fruit and those of the remainder of the plats planted to Winesap, 25 to 41, inclusive, have borne four light crops. Plats 46 to 48, Jonathan, bore practically no fruit due to injury by fire blight and cedar rust. The variation in yield shown in Table II is small and would not indicate any significant response to any fertilizer treatment.

The following general conclusion could be drawn from this experiment: Young apple trees on this soil under clean cultivation did not make greater vegetative development due to the application of any of the chemical fertilizers used. However, it is possible that fruit yields may later be favorably affected, and the experiment will be modified and continued.

Experimental work carried on for many years in other states has in general given similar results when the orchard was cultivated.

However, sod orchards have frequently responded in both growth and yield to applications of nitrogen. A common amount to use is five pounds of sodium nitrate or four pounds of sulfate of ammonia to the tree. The usual time of application is two weeks before blooming and the method is to broadcast the fertilizer, principally under and beyond the tips of the branches of the trees. Each grower can determine in his own orchard whether such treatment is profitable and be thus guided in his practices. Only rarely would commercial fertilizers prove profitable on young, cultivated orchards in Kansas.

FIG. 7.—An orchard free of weeds. Drouths do little damage in an orchard that is free of weeds during June and July.

Continued Clean Cultivation.— The clean cultivation method of orchard soil management is an outgrowth of the dry farming systems of the West. The beauty of an orchard so managed is shown in figure 7. It requires early spring plowing or deep disking of the soil and frequent surface cultivations throughout the remainder of the summer. In general, this method of orchard soil management will result in a strong growth of the trees while young and, except in regions of heavy rainfall, early fruit production. But costly experience has proved that this system when long continued robs

the soil of its organic content and leads to early decline of fruit production. Light orchard soils handled in this way became so poor in physical condition that when the trees were about 20 years of age water could not penetrate them and the soil nitrates were so depleted that the trees were slowly starving to death. Even fertile soils so managed will fail to produce an orchard which will have a long productive life.

Obviously since these bad effects are traceable to lack of nitrogen and moisture, the addition of large quantities of organic material to the soil would appear to be the proper remedy. This may be

FIG. 8.—An extension disk. This type of disk lessens hand work under the branches of orchard trees.

easily done where dairying is combined with orcharding as a farm enterprise or where other abundant supplies of animal manures are available. Such conditions are progressively less common in Kansas, so some other materials aside from barnyard manures must be found to supply the needed organic fraction of the soil. Cover crops grown in the young orchard seem to offer the only practical solution of this problem for many locations.

Cultivation Implements.— Implements for orchard cultivation do not differ greatly from those used on the general farm, but a few important variations adapting them to special conditions in the

orchard require mention. Though well-trained mules or horses furnish satisfactory power for this labor, many growers have substituted tractors, which are successful and economical in the hands of reliable and competent operators. The type selected should be

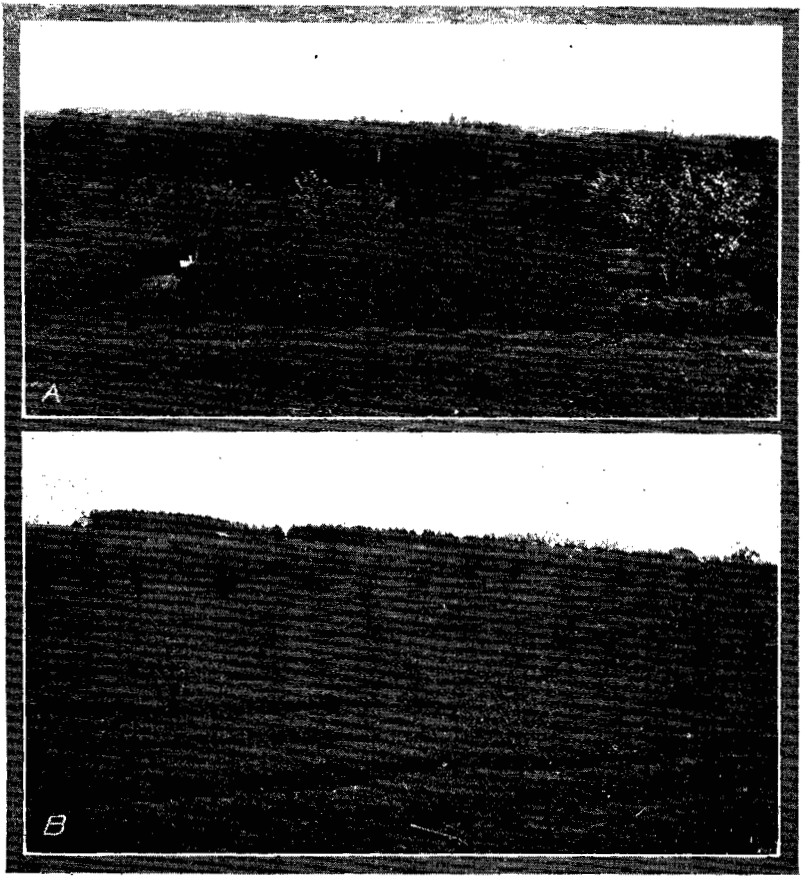

FIG. 9.—Cover crops in young orchards. (A) Rye and wheat between the rows meet in the center. (B) A cover crop of winter vetch.

low and so constructed that it can make short turns. Plows, harrows, and disks are used to destroy weeds. Hand work will be very much reduced in an orchard three or more years of age through the use of an extension disk such as that shown in figure 8. This implement makes cultivation under the branches of the trees possible. The angle of the disks must be reversed frequently to keep

the surface of the land level. Summer growth of weeds must be prevented in the young orchard.

Orchard Cover Cropping.— Every fruit grower recognizes that a young orchard does not fully occupy the soil of the land on which it is growing, and many of them consider the unused portion as being at least temporarily wasted. This attitude leads to heavy intercropping of the young orchard, a method which may or may not be economically sound. It will be discussed later. Other possibilities are clean cultivation and sod culture, which have been dis-

FIG. 10.—Dead stems of cowpeas held this snow. Cover crops in an orchard prevent drifting.

cussed, and cover cropping. A cover crop is a crop grown on the orchard soil between the trees and turned back into the soil for physical improvement and, if the crop be a legume, for chemical enrichment. Whether it be a legume or a nonlegume, it gathers plant nutrients from the soil during the fall while they are still available but when the young trees do not need them and returns these nutrients to the soil the following spring when the need of the trees is greatest.

Under orchard conditions in many parts of Kansas a cover-crop system of orchard soil management, with which, of course, must be combined clean cultivation for about four months of the year, is the best system to follow with young orchards. The trees of older

orchards too fully shade the ground to permit the successful use of cover crops. Because of this necessity of building up the organic content of the soil while the trees are young it is probable that the organic material added to the soil is the most valuable contribution of the cover crop. In the final form, humus, it may persist for a long time after the trees become large and so stimulate activities of the soil flora and contribute to the formation of available nitrates of which organic substances are the only natural source. Examples of cover crops are illustrated in figure 9 and their ability to lessen drifting of snow is shown in figure 10.

Plants for Cover Crops.—Cover-crop plants lend themselves to classification on two bases: Hardiness and botanical characters. The principal botanical basis is the ability of the plant to fix free nitrogen from the air through the aid of certain bacteria which attach themselves to the roots of the plants. This is true of leguminous plants only. Table III shows these characters for a number

TABLE III.—CLASSIFICATION OF COMMON COVER CROPS

Legumes.	Nonlegumes.	Hardy.	Half hardy.	Tender.
Winter vetch.	Wheat.	Winter vetch.	Oats.	Cowpeas.
Cowpeas.	Oats.	Rye.	Canada field peas.	Soybeans.
Soybeans.	Rye.	Wheat.	Dwarf Essex rape.	
Austrian field peas.		Austrian field peas.		
Canada field peas.	Dwarf Essex rape.			

TABLE IV.—COVER-CROP YIELDS AND VALUES

Crop.	Years grown.	Average dry weight of tops per acre.	Nitrogen added per acre.	Seed sown per acre.	Cost per acre.	Remarks.
		Lbs.	*Lbs.*	*Lbs.*		
Winter vetch	9	5,075	161.3	30	$6.76	No failures.
Rye	9	4,104	44.0	90	4.50	No failures.
Wheat	3	2,965	29.4	90	4.50	Subject to pests.
Cowpeas	6	1,875	79.4	90	6.35	Requires moist soil.
Soybeans	3	2,650	67.8	90	6.35	Heavy seed production.
Canada field peas	1	2,122	51.3	60	5.80	High moisture requirement.
Dwarf Essex rape	3	1,318	39.8	8	3.75	Requires moist soil.
Austrian field peas	1	3,345	80.8	60	10.50	Requires further test.

of the more important kinds of plants which are adapted to cover-crop use and have been tested in the station orchards at Manhattan.

Yields of these crops vary widely from year to year, but, on the average, the tender and half-hardy crops have been unable to make large growths before killing frosts occurred, so the hardy group has proved more productive. Among these the legume, winter vetch, and the nonlegume, rye, head their respective classes in yield and apparent value. Table IV shows average yields of dry matter in the tops of these various crops.

Some additional discussion of the facts shown in Table IV seems desirable. Wheat was discarded as a cover crop because it must be planted August 15 to September 15 if a good ground cover is to be established before freezing weather. When planted during this period the Hessian fly attacks it, reducing the growth and constituting a hazard for near-by wheat fields. This insect does not injure rye. Dwarf Essex rape fails because it cannot withstand late sum-

FIG. 11.—Cowpeas make a good cover crop if soil moisture is abundant during the fall.

mer or fall drouths. Like all the other tender or half-hardy cover crops, the seed will germinate in comparatively dry soil and the seedling plants will die unless rain falls within a few days. Of the

FIG. 12.—Nodules formed by nitrogen-fixing bacteria on the roots of two winter vetch plants. These add over $30 worth of nitrogen to each acre on which winter vetch is grown as a cover crop.

tender group, the cowpea probably has more good characters than any other of the crops tested. An excellent growth of it is illustrated in figure 11.

Winter vetch leads the entire list. Its yield is large without

undue competition with the trees in early spring; it checks tree growth and makes a good ground cover in the fall; it decays quickly after being plowed under and does not use an excessive amount of moisture during the process; it leaves the soil in good physical condition, and it adds greater amounts of nitrogen to the soil than any other of the crops. The seed of winter vetch has been expensive, averaging about $4 for each acre sown, but is now becoming more abundant, and cheaper. Inoculation is required when this plant is first grown in the orchard. If a strip four feet wide in the center of each space is allowed to mature seed young trees will not be injured and, usually, a good stand of winter vetch will develop after cultivation ceases. Nodule formation on the roots of winter vetch is shown in figure 12.

Cover Crop Culture.--Time of planting a cover crop should vary with the season, the crop used, and the age of the trees. Seeding may be delayed if the late summer is dry and the trees likely to suffer for lack of moisture upon the cessation of cultivation. Rye or winter vetch may be seeded in dry soil, but some of the other crops, as dwarf Essex rape and cowpeas, will germinate in soil too dry to sustain the seedlings. They should be planted only in moist soils. Better stands are obtained if the seed is drilled rather than broadcast.

Young fruit trees tend to grow too late in the season, so, among them, the cover crop should be planted early as its competition tends to hasten their maturity and dormancy. Young bearing trees may in contrast need all available soil moisture and nutrients to mature their crop. The best calendar dates for planting seem to vary because of these influences between about August 1 and September 10. Later-sown cover crops have, as a rule, been of very little value in the station orchard at Manhattan. Recommended rates of seeding are given in Table IV.

Rate of Seeding Winter Vetch.—The results of experiments in rate of seeding winter vetch are given in Table V.

TABLE V.—RESULTS OF EXPERIMENTS IN RATE OF SEEDING WINTER VETCH

PLAT NUMBER.	Seed sown per acre.	Air-dry tops per acre.	Nitrogen added per acre.	Cost per acre.	Cost of nitrogen per pound.
	Lbs.	*Lbs.*	*Lbs.*		*Cents.*
I	20	4,460	142	$6.00	4.2
II	30	4,812	153	7.50	4.5
III	40	5,750	183	9.00	4.9

The best time at which to plow under hardy cover crops is difficult to determine and is not just the same for all years or all crops. Considering the moisture and nitrate content of the soil and the response of the trees, experiments indicate that the period of maximum growth while the stems of the cover-crop plants still remain

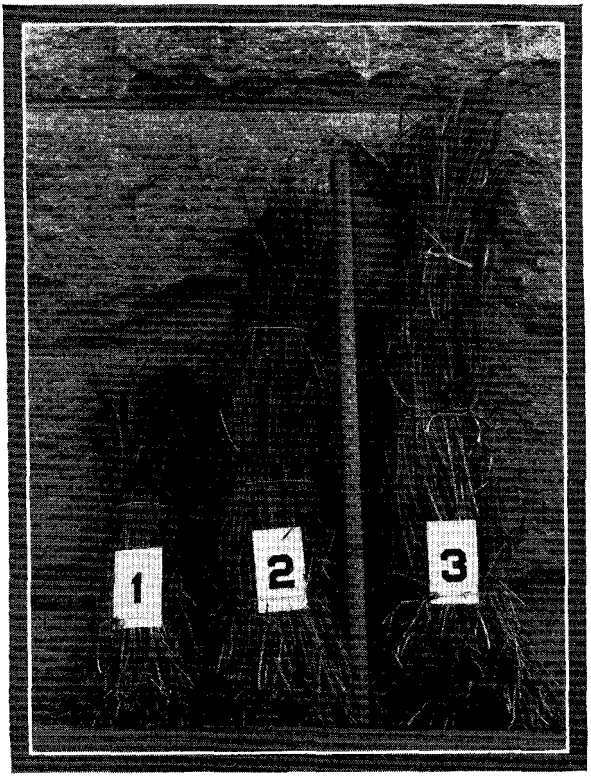

FIG. 13.—Rye cover crops should be plowed under at growth stage "1" if the spring is dry but may stand until stage "3" if rains are frequent.

succulent should be chosen for plowing. This seems to be just about the time of first bloom for both winter vetch and rye. It will vary between April 15 and May 20. The drier the spring and the older the orchard the earlier the crop should be plowed under. The stages of growth illustrated in figure 13 show the condition of rye at plowing time, influenced by spring drouth. Tender cover crops may be turned under just before they are killed by frost, in early winter, or in early spring without measurable difference. Plowing at these

times insures optimum soil moisture condition for the early growth of the trees, and this is one of the principal advantages of the tender crops.

Straw Mulch.—A thick mulch of straw over the surface of orchard land is the most efficient known method of conserving soil moisture. Consequently, in those parts of the state where drouths are common and straw is available, this method would seem advantageous. The straw is applied annually at any convenient season in sufficient quantity to make a four-inch layer after it has settled. The soil is not cultivated at any time. With straw costing $1 a load and a one-mile haul, costs are about the same as for clean cultivation.

Effect of Straw Mulch.--Forty Delicious apple trees in the station orchard have been under the straw mulch system of orchard soil management since the summer of 1921. During these nine years the mulched trees have made a stronger vegetative development and, since coming into bearing, have produced approximately twice as much fruit as the adjacent row under clean cultivation. The advantage in vigor has been much more marked during seasons of scanty rainfall. This system also has marked disadvantages, some of which may become more evident after a number of years. These Delicious trees are on a rather thin soil with a heavy clay subsoil. Several trees have died, the apparent cause being the water-logged condition of the subsoil. This would not occur in better adapted land. Mice congregate in the mulched rows, attracted by the grain in the straw and by the protection it affords. They have to be poisoned each fall. Fire hazard is high during dry, windy weather.

This system has much to recommend it for orchards approaching maturity and in regions where straw is available.

INTERCROPPING YOUNG ORCHARDS

Principles Involved.—Young orchard trees do not occupy a very large part of the soil for the first three or four years if planted at correct distances. Properly managed, the strips between the trees can produce other crops for four to six years without immediate injury to the orchard. Roots of vigorous young fruit trees will spread horizontally at the rate of two or more feet each season and the trees are injured if their roots are required to compete with an intercrop or weeds for nutrients and water. Also, it should always be kept in mind that the orchard demands first place on the land which it occupies; that the intercrop is always to be subordinated

to the good of the trees. If this is not done the trees should be taken out as they are sure to interfere with the best yields from the intercrop. An intercropped orchard should have fertilizer applied at least to the amount of that removed by the intercrop; otherwise, the trees will suffer for soil nutrients after they come into bearing.

Intercropping Methods. — Only cultivated crops should be grown among orchard trees. Over the greater part of Kansas corn will be found the least injurious crop to use and the one most likely to return a cash profit, considering the expense of growing. Truck crops such as potatoes, beans, peas, and melons may also be used. The first year the tree row should have at least eight feet of land unoccupied by the intercrops and thoroughly tilled. Each subsequent year, this space should be widened two feet on each side to provide for free growth of the tree roots and tops and space for cultivation. Grain or other untilled crops should never be grown between fruit trees. Filler trees, discussed on page 16, should be considered an intercrop.

FRUITS OTHER THAN THE APPLE

Because of the outstanding importance of the apple among the tree fruits grown in Kansas, the material presented in this publication applies directly to that fruit. However, although nearly all of the practices which make for success with the apple are also applicable to the other deciduous tree fruits, each of them has its own peculiarities which the successful grower must know. Some of these special points will be discussed briefly here.

The Sour Cherry. — Sour cherries come into bearing several years sooner than apples, but, in Kansas, have a productive life of only 25 to 30 years. Their worst enemies are the cherry leaf-spot, gummosis, wood rots, termites, rabbits, and the diseases and insects which attack the fruits. Cherry trees are more sensitive to free water in the soil but will withstand drouths somewhat better than apple trees. Early planting, before the buds have made any spring development, is necessary if a vigorous growth is to be made the first year. Aside from lack of control of cherry pests, especially leaf spot, the most common mistakes of Kansas growers are too close planting and neglect of soil fertility. Wide planting, 25 feet, and fertile soils are necessary for continued high yields from sour cherry trees. If properly cared for, the sour cherry is a very profitable orchard fruit, in many parts of Kansas.

The Peach. — Kansas is not a peach state. Cold winters, spring frosts, and dry, hot summers all conspire against success with this fruit. Occasionally one good crop will pay for the whole cost of the orchard but, except in the most favorable location and on very carefully chosen sites, continued income from peaches is not to be expected. The peach requires a fertile soil and the orchard should be brought into bearing early, allowed to produce maximum crops, and replaced by a new orchard as soon as diseases become abundant and production declines. If land is not too expensive, growing a new peach orchard will prove more profitable than rejuvenation of an old one by deheading, fertilizing, and constant spraying.

No variety of nectarine tested in the station orchard at Manhattan has been able to withstand the ordinary summer drouths.

The Plum. — Successful plum trees are found in Kansas home orchards and a commercial grower will sometimes have a wonderfully profitable crop from a young plum orchard, but the writer has not seen in the state a large orchard of plums which yielded valuable crops over a 10-year period. Pests, unfavorable climate, and competition of the western-grown Italian prune combine to leave but a small place for this fruit. The Hansen hybrid plums, Opata, Sapa, etc., may prove valuable in the western part of the state where so few other fruits can be grown.

The Pear. — Were it not for the bacterial disease fire blight Kansas could produce great quantities of pears, using in general the same methods that prove successful in apple production. At present no pear variety is immune to blight and none bearing high-quality fruit shows any considerable degree of resistance. Commercial production of this fruit is unlikely to prove profitable, although some fairly good old pear orchards are still to be found growing in sod on Kansas hill tops.

The Quince. — Fruit from comparatively small plantings of quince trees should find a ready local market in Kansas. The trees are not difficult to grow but they are subject to many pests, including fire blight, and they do not withstand drouths well. An apple grower who sells his fruit at the orchard should find a good profit from an acre, 200 trees, of Orange or Champion quinces.

The Pecan. — The introduction of improved hardy varieties of the pecan will probably lead to a large production of this delicious nut in southern Kansas. Fertile bottom lands with good air and water drainage are favorable for pecan culture. None of the south-

ern thin-shelled varieties is hardy in this state. The pecan is slow coming into bearing and requires good culture and careful protection against its pests, but large yields of an easily marketed product are eventually secured. Much experimental work with this fruit remains to be done before its final place in Kansas horticulture can be determined.

THINNING FRUIT

Thinning is an important orchard operation the value of which is unappreciated by many Kansas orchardists. The necessity of thinning heavily loaded peach trees if fruit of marketable size is to be grown is admitted in all commercial peach districts. Growers of really high-class apples now appreciate that thinning this fruit is almost equally important and profitable.

Results of Thinning. — The primary object of thinning is to obtain an increase in the size of the individual fruits. This result follows, under favorable conditions of growth, very much in proportion to the severity with which the thinning is done. Many other advantages appear in well-thinned peach and apple orchards. Control of pests is made easier and the red color, which with these fruits is developed by sunlight, is more intense. The onset of biennial bearing may be postponed, broken trees due to overloading avoided, and a very much increased acre value of the crop result.

Thinning Time and Methods. — Fruit should be thinned as soon as possible after the June drop, though the operation will pay even when delayed several weeks. Definite distances to which apples and peaches should be thinned cannot be stated because of differences in varieties, tree capacity, soil fertility, and other factors, but four to six inches between fruits for the peach and about six inches between apples will prove desirable averages. Only one apple should be left on any spur and approximately half of the spurs should have all the apples removed. All defective fruits should be taken off at thinning time. The work of thinning is usually done by hand, although quick acting shears are an aid with some apple varieties. Spurs and fruits left on the tree must not be injured. Good self-supporting ladders are a necessity. Beginning thinners should not look at the fruits on the ground.

Cost of Thinning. — Carefully kept records show that from one-half to three or even five hours' time is required to thin a mature apple tree. This would appear to be an expensive piece of work were it not remembered that the grower is fully recompensed for

this outlay by the reduced cost of picking and grading his fruit. Added income because of larger size and better color is clear profit. In some accurately checked tests careful thinning has increased the growers' profits 100 per cent. Well-informed bankers will readily loan money to finance the cost of thinning apples or peaches from overloaded orchards. Cherries are not thinned, plums but rarely, and grapes principally through pruning, though bunches may sometimes be thinned by the removal of individual berries. This is done on varieties which produce compact bunches and for the production of fruit for exhibit.

CONCLUSION

Prospective or experienced fruit growers who read this bulletin will get the impression that growing an orchard in Kansas is a very complicated operation, one to be undertaken only by highly trained men. This is in part true, but they should remember that they have four to eight years while the orchard is growing to gain this training. True interest in fruit growing, ability to concentrate on details, a desire to learn the art, and financial backing are the personal requirements. The Agricultural Experiment Station and the extension service will aid in every possible way, even after the orchard comes into bearing when many additional and possibly more interesting phases of fruit production must be learned.