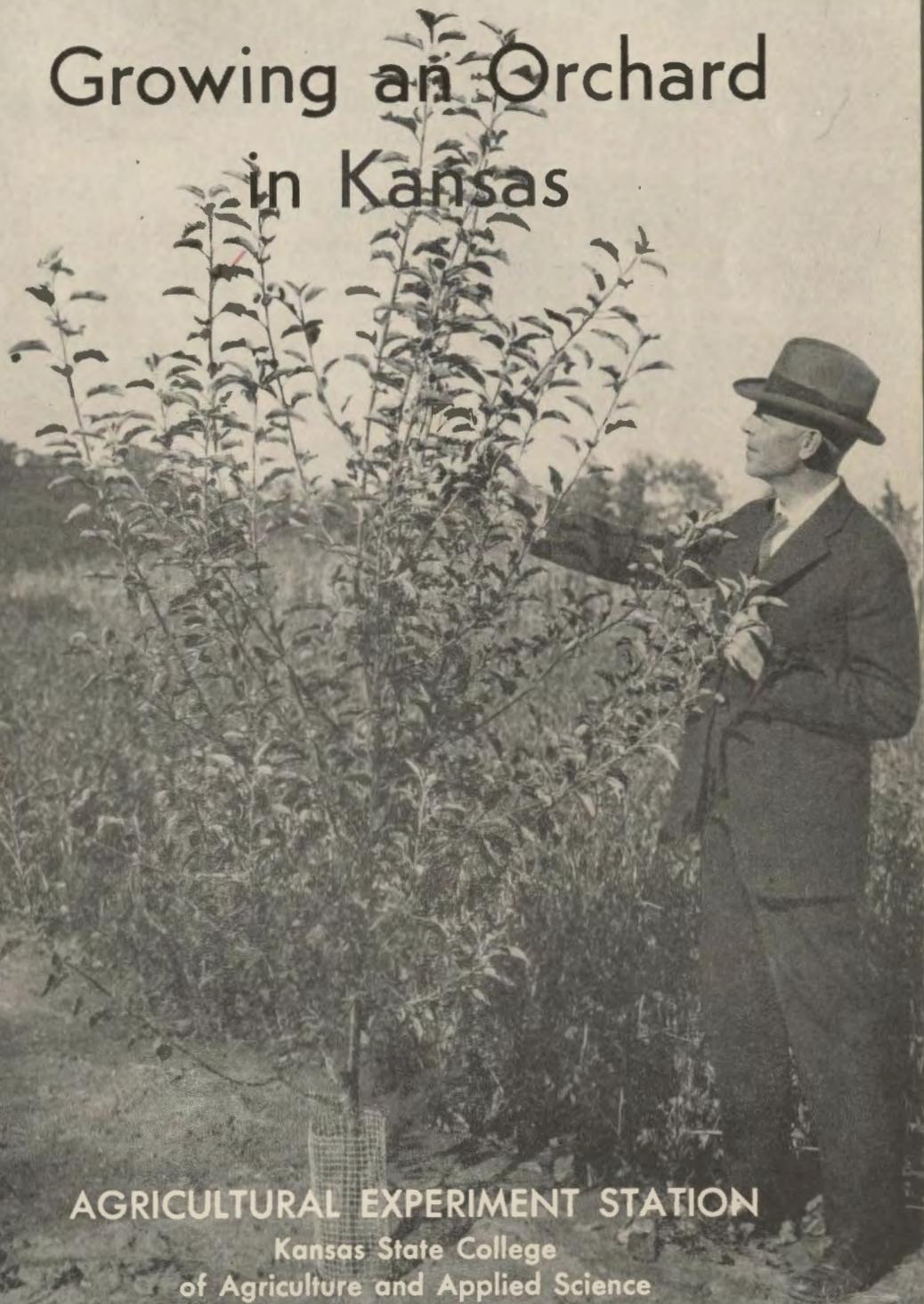


Growing an Orchard in Kansas



AGRICULTURAL EXPERIMENT STATION

Kansas State College
of Agriculture and Applied Science
Manhattan, Kansas

On the Cover

A number of important features connected with growing an apple tree are shown. Note the growth the three-year-old Jonathan has made, the soy bean cover crop in the background, the clean culture in the row, and the wire-cloth rabbit-guard. Comparative size is shown by the author of this bulletin.

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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 theory and practice of fruit growing.

Profitable orchards can be grown in many parts of Kansas, but 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, 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 to 25 feet. Positive steps to prevent erosion on sloping orchard land are an important part of growing a good orchard.

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 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; a mulch of crude organic material ranks high on all these major points but has many minor defects; so it appears that clean cultivation to promote nitrification and 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. Where erosion is a hazard, contour planting and terracing are beneficial.

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 many years 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 organic content of the soil.

On almost all Kansas orchard land a cover-crop system of soil management should supplant intercropping in young orchards. Even where corn or other cultivated intercrops might be grown without immediate loss of growth by the trees, the organic content of the soil is depleted and maintenance of terraces and contour rows is made more difficult.



A vigorous young apple tree, straw mulch culture. Seven years of age and producing its first crop.

GROWING AN ORCHARD IN KANSAS¹

R. J. BARNETT

INTRODUCTION

For 75 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 in 1893, 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 drought and diseases and young ones had not been planted on the farms of the state to replace them. 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 great. This commercial expansion was terminated by the destructive droughts of 1933 to 1937, and the unprecedented freeze of November 11 to 13, 1940. These disasters resulted in the loss of 50 percent of the orchard trees of the state and left the field clear for an even greater development of tree fruit production by a new generation of growers. This rebound has barely started at present, 1948, but is sure to appear when young farmers again realize the opportunity for the fine type of country life, and profit proportional to the efforts expended, in this industry.

To a student of the subject these changes in Kansas orcharding 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 groups of fruit growers is one of extent rather than kind. Both require intensive work and the use of good judgment.

1. Contribution No. 219 from the Department of Horticulture.

Experienced orchardists have all found that there is no *best* method, applicable to all parts of the state, for many of the orchard 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 in others. It is in handling these and a hundred similar problems 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

During the period of expanding commercial orcharding in Kansas two well-developed regions emerged. The first of these was the northeastern counties from Wyandotte north to the state line with the largest concentration in Doniphan county. Many sites having favorable conditions for fruit growing are available in this area. The second was in the Arkansas river valley in scattered locations from Hutchinson to Arkansas City with the most intensive planting tributary to Belle Plaine and Oxford. Both of these regions will at some future time again supply fruit for local markets and for other parts of the state. Apple, sour cherry, and peach are the adapted kinds produced. In general, only meager new plantings have been made during the years since 1940, but the areas around Hutchinson and Wichita now have an extensive revival of commercial apple and peach orcharding.

Commercial fruit-growing centers could be developed in other sections of the state, though probably none of them would equal in acre production the two listed above. They might, however, surpass the old locations in facilities for transporting and marketing the fruit. Minor centers of production now exist or have proved productive in the past near Kansas City, Atchison, Grantville, Council Grove, Baldwin, Lawrence, Fredonia, Strong City, Wamego, and other points. Qualified growers could extend the plantings in any of these localities with profit. Figure 1 shows the distribution of these localities.

Home orchards are no longer common in Kansas, but they could be established again 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 would, to the wealth, health, and pleasure of the farm family.



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

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 weigh carefully the advantages and disadvantages of all commercial dis-

tracts with which he is acquainted and choose the one which promises to be the best.

The principal facts which a grower should have before him to aid in choosing a location for commercial 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.
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 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 penetrate readily should be the minimum for all orchard sites in Kansas.

The droughty years of the 1930's emphasized the importance of a deep supply of soil moisture for orchard trees, especially for the apple. Where they had no reserve of deep-lying ground water on

which they could draw after the supply in the surface layers of soil had been exhausted, they quickly declined and by 1937 many had died, while those on deep, penetrable soil persisted. The roots of a deep-rooted, drought-resistant apple tree are illustrated in Figure 8. Trees grown on such soil can withstand long droughts.

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 percent of the apple crop annually. Insects and diseases together destroy only 7.3 percent.

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. The tree fruits most commonly grown in Kansas resist frost damage to their blossoms in the following order: Least damaged, sour cherry; then in order of increasing damage, apple, pear, and peach.

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.

Windbreaks on the west and south side of the orchard are valuable if started early and composed of good tree species. Ponderosa and Austrian pine, Chinese arborvitae, Russian olive, tamarix, and hackberry are among the best species to use. Figure 2 illustrates a windbreak composed of arborvitae and pine trees. Not recommended are cottonwood, box elder, elm, black walnut, Osage orange, and red cedar. These species all sap the moisture from an excessively wide area, and of the last four each has a second count against it. Red cedar is the alternate host for the cedar-apple rust, elm is a favorite host of the flatheaded apple tree borer, Osage orange is a host of the San Jose scale, and roots of the black walnut injure apple roots when they mingle in the soil.

Hailstorms seem to follow somewhat definite courses and such areas should be avoided when choosing the site for an orchard.

An abundant and ever available supply of water conveniently located is a necessity on a fruit farm, even when irrigation is not practiced. Spraying a mature orchard may require 3,000 gallons

or more daily. If there is no adequate source in the orchard, obtaining a supply elsewhere may be so expensive for the water and hauling that the cost may consume the season's profits. Shallow wells, deep wells, ponds, and streams are common sources of spray water in Kansas.

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.



FIG. 2.—This windbreak protecting the south side of the Atchison experimental orchard was planted at the same time as the apple trees and surpassed them in rate of growth.

ORCHARD COSTS AND YIELDS

Anyone who contemplates growing an orchard must consider costs of development and care as well as probable income from the enterprise. A discussion of these subjects is difficult because no two orchards ever cost the same or return the same profits per unit of area, 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 field of grain or even of potatoes.

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 source other than returns from the apple trees. 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 \$60 to \$150 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.

Preparation of the land for planting may be cheap or expensive. If only plowing and surface working are needed, \$4 an acre is adequate; but if leveling or terracing must be done this expense may amount to \$50 an acre but is usually much less. Apple trees to plant an acre can often be purchased for \$20 and sour cherries for nearly 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 annual care will fluctuate in cost, depending largely on 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.²

Half or more of the cost of developing an orchard is for labor, and the orchard will usually be of much greater value if this labor is actually performed by the owner or under his daily supervision.

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, 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 year. Yields of four tons to the acre have been recorded, but in these days of cherry shortage half that amount would yield a good profit.

Orchard economics 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-

2. The amounts cited were valid before the war. The dollar cost is greater now, perhaps double, but no adequate survey on which to base a revision has been made.

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 and hazardous.

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 principal debt which this generation of fruit growers owes to the preceding one is for their accomplishments in this line. The work is not finished, either. 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 top-working, 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 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 value 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. Pear growing is hazardous in Kansas because of the bacterial disease fire blight.

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 trees of one variety should be planted in blocks not more than six rows wide, preferably four rows, then two or more rows of a good pollinizer variety, with repetition or variation of blocks 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. Experimental evidence shows that the Winesap group (Winesap, Black Twig, Arkansas Black, Stayman, and Delicious) do not cross pollinate well, though all of them except Stayman are potent for unrelated varieties.

A good distribution of varieties for a 30-acre orchard in eastern Kansas would be Jonathan 350; Winesap, 175; York Imperial, 70; and Rome, Gano, or Golden Delicious, 70 trees. This would leave room for about one acre of early apples, Yellow Transparent, and Wealthy. In part of the Arkansas valley Winesap would replace Jonathan as the number one variety and Grimes would be second in importance. Early Cooper seems satisfactory as an early variety there and some growers find King David a profitable fall ripening variety.

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 Pippin 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, Early Cooper, Wealthy, Grimes, Jonathan, Delicious, Golden Delicious, Stayman, York Imperial, Rome, Winesap, Gano.

Cherry: Early Richmond, Montmorency, English Morello.

Peach: Carman, Belle of Georgia, Early Elberta, Champion, Elberta, J. H. Hale. Among newer varieties, Redhaven and Halehaven are at present most promising. Peach varieties are discussed more fully on page 44.

Crab Apple: Whitney, Florence, Hyslop, Martha.

Plum: Wild Goose, Abundance, Lombard, and such hybrid varieties as Oka, Opata, Waneta, Hanska, and Sapa.

Quince: Orange.

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 in most localities will 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. A more detailed discussion of fruits other than the apple will be found on pages 42 to 45.

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.

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 fruit 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 system. If apple, they will usually be straight switches; budded apple on two-year-old roots, peach, cherry, and plum will have side branches. Only one-year-old stone fruit trees should be planted, but apple trees may be two years of

age if they were not yearling culls and were headed at a proper height before making their second year's growth in the nursery. Older cherry trees sometimes do well, but any neglect in handling or dry soil soon after planting will cause much greater loss than among one-year-old trees. The younger trees are also less likely to introduce pests and will bear their first profitable crop as early as the older trees. The increased loss of trees, should a drought occur that summer, is too great a hazard to bear; and well formed framework of the trees will be too difficult to obtain when trees more than one year of age are planted.

Interest in the use of Hibernial, Virginia Crab, and other hardy apple trees as stocks has risen since the destructive freeze of 1940. These stock trees are planted in the orchard at one or two years of age and after one year's growth are topworked to the desired variety. This topworking may be done by budding or grafting, but by either method the desired variety is set 12 to 24 inches from the crotch of the stock on three or more of the framework branches. These grafts will later form the top of a tree which is hardy against injury to its root, trunk, and crotch by cold. Part of the Doniphan Station orchard has been propagated in this way. A tree so grown is shown in Figure 3.

Dwarf trees of the popular varieties of apple and pear are fine for back yard gardens wherever these fruits can be grown but do not have a place in Kansas commercial orchards. Dwarf pear trees are produced by using quince stocks; dwarf apples are grafted on Paradise, Malling VIII, or Malling IX clonal stocks, such trees can be purchased from eastern nurseries.

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. The best trees obtainable will cost more than lower grade trees but will usually prove most economical in the long run.

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 generally should be burned, not planted. 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. The experienced grower will often drive his truck to the nursery on a prearranged date and haul home his purchase of trees well protected.

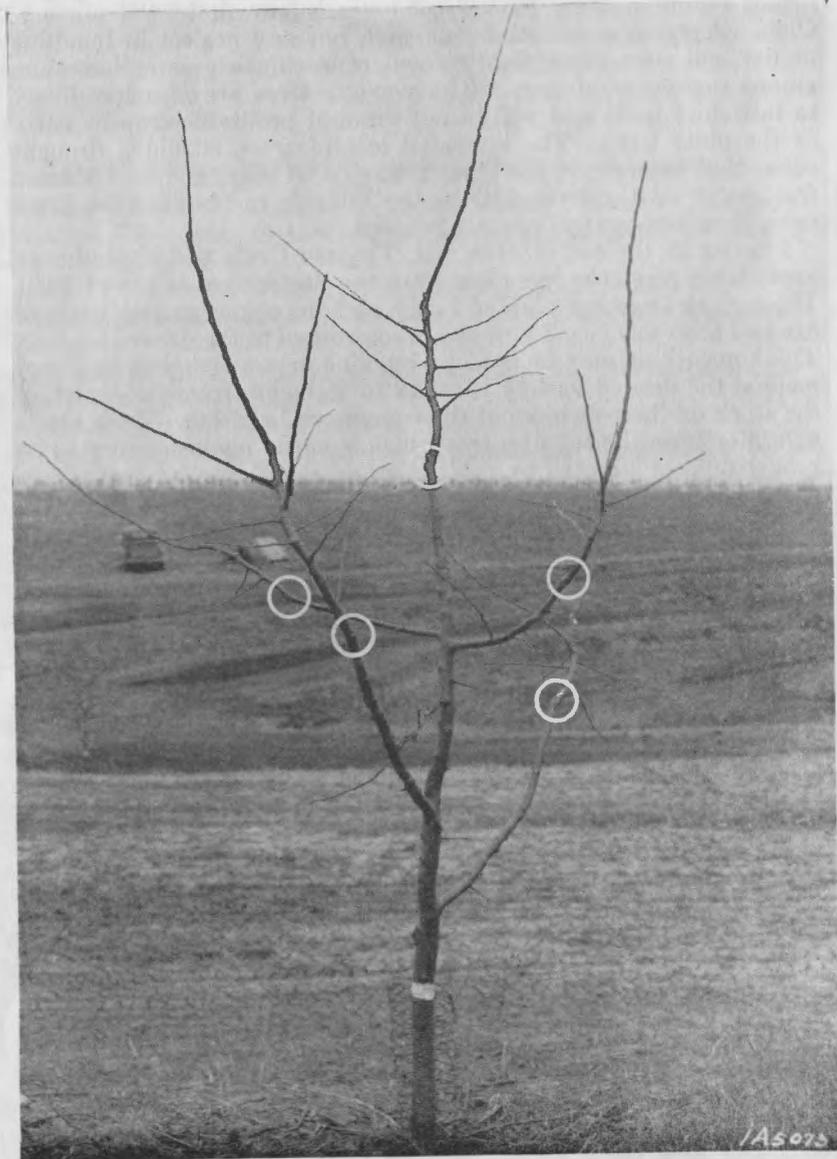


FIG. 3.—A representative topworked apple tree in the Doniphan orchard near Blair. The root and framework of this tree is Hibernal, a hardy, vigorous variety having wide-angled crotches, and the top variety is Winesap. The circles indicate points at which Winesap buds were set.

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 surface cultivation. The plowing may be done in the fall and earlier spring 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. In the past, steep lands have been held from washing by sod culture as described on page 29. Because of the defects of this system of soil management terracing is recommended and has been put into practice in a few new orchards. Terracing orchard lands is still in the experimental stage here, but present experience indicates its great value for sloping lands in good fruit sections. Aid in this work can be obtained from the Kansas Agricultural Experiment Station at Manhattan and from soil conservation agencies in the various counties.

Surface erosion and gullyng of steep orchard lands can be combated by methods other than terracing. Important and effective among these is planting the trees and cultivating on the contour. In planting by this method, the distances between trees remain the same as for the square system of planting, but all trees in a curved row are set at the same altitude. Subsequent cultivation builds up low terraces along each row. These, with some additional work, will control the run-off water from heavy dashing rains without serious loss of top soil. A young orchard planted on the contour is shown in Figure 4. The use of sod or sod strips between rows is another effective means for the control of erosion. It is more fully discussed under "Feeding the Young Orchard" in this bulletin.

Staking.—If a large area is to be planted, it is advisable 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 have been 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. 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 farther 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



FIG. 4.—This aerial view of the Doniphan orchard on the Dubach farm near Blair shows many details of a contour planting and the problems it presents. One-half of this 33-acre orchard is being used to study erosion control, cover crops and hardy apple stocks.

35 to 40 feet between trees; sour cherries, about 25 feet; peaches and plums, 20 to 25 feet. Some experienced growers use a rectangular pattern in planting an orchard. Distance for the various kinds of fruit under this system may be as follows: apple, 35 by 40 feet; cherry 25 by 30; peach, 20 by 30 feet; and plum, 15 by 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 on the square, 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; at 25 feet about 70 trees will be required. It is wise 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 hasten the exhaustion of the fertility and deep ground water of the orchard soil. (3) 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. (4) 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.

The drought period of the 1930's emphasized the hazard of planting orchard trees close together. Experimental work in southeastern Nebraska proved that close planting or the use of fillers hastens the depletion of available soil moisture and shortens the productive life of the tree. "If a certain number of trees must be used they should be scattered over more territory," says Dr. C. C. Wiggins of the University of Nebraska.

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. Frequently 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. Early planting is necessary because the newly set plant must have time to make new root growth for the

absorption of water before growth of twigs and leaves sets up a demand for water which is far beyond the capacity of the old roots to supply. This is one reason why trees planted later than April 15 often leaf out and then die; another is that these trees have been stored too long and are in a badly weakened condition on this date.

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-grade tree. By use of a planting board illustrated in Figure 5 the tree can be placed in the exact spot where the stake stood.

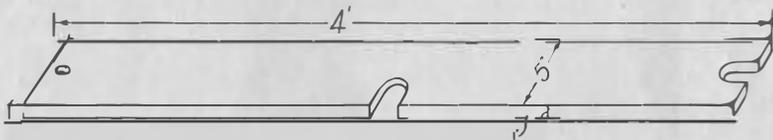


FIG. 5.—A planting board. The use of this board enables the fruit grower to set the tree in the exact spot where the stake stood.

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 tramps 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. Under this condition 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 a clay pan 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.

Newly set fruit trees must be pruned soon after planting. When they were dug one-half to three-fourths of their root system was cut off; consequently a proportional part of the top should be removed to restore the balance between these reciprocally dependent parts of the tree. The kind of tree and its age, the date of planting, and the vigor and condition of the tree all affect the severity of this pruning. It is discussed more fully in the Station Circular, "Pruning Fruit Trees," to which the reader is referred.

CARE OF THE YOUNG ORCHARD

At one time a belief that few orcharding steps intervene between planting the trees and harvesting the fruit was prevalent in Kansas. If this belief were ever true, it is no longer so. Young trees which are to grow into a valuable, productive orchard require a great deal of intelligent care after they are planted. They must be protected from pests, 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 combating 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 almost daily inspections are necessary to detect the very beginning of an attack. Sprays to combat these enemies must then be applied. 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 $\frac{1}{4}$ -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 protectors may be left in place until the trees are too large for rabbits to injure them. Cornstalks, 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 ex-

pensive than the wire cloth. Other methods of rabbit control have been tested widely during recent year. Sulfonated oils act as repellents and afford a high degree of protection under most conditions. These compounds may be obtained from dealers or mixed by the grower. They must be renewed each year. The Forest Service uses strychnine in common salt as a poison for the control of rabbits. Even badly gnawed trees may be saved by bridge grafting as described in United States Farmers' Bulletin No. 1369, 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. It should be placed in the runways under the straw or grass or in partly closed tin cans near the trunks of threatened trees. One thorough treatment each fall will destroy the mice.

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.³

Borers.—Fruit tree borers are the larvæ of insects, but they cannot be controlled by spraying. Among the more destructive borers in Kansas are the peach tree borers, flat-headed and round-headed apple-tree borers, the twig-pruner, and the fruit-tree bark-beetles, or pinhole borers, especially of the sour cherry. Methods of combating these pests are given in Kansas Station Circular 235 beginning on page 17.

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.

Livestock.—Except possibly poultry, no livestock should be allowed in the orchard. All types will sooner or later seriously injure the trees. Pasturing grass or cornstalks 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.

3. Methods of control are discussed in Circular 198 of the Agricultural Experiment Station, "Control of Mammals Injurious to Agriculture in Kansas."

INJURY BY COLD

Winter injury often takes heavy toll from Kansas orchards. Such injury is most serious when frequent, sudden changes in temperature occur or when minimum temperatures are combined with droughts. 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 through the 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 an annual 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 or smudging 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 into his young orchard of San José scale, wooly aphis, crown gall, black spot of the peach, and blotch of the apple. The care or skill given to this inspection is one of the early indications of the success of a beginning orchardist.

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.

FEEDING 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 becomes 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 70 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 will profit from knowing what conditions they should try to produce in the orchard by variations in soil management and how these best can 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. Much may be done, however, 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, and through the control of weeds conserves moisture. To accomplish these objects effectively and economically is the purpose of the various methods of orchard soil management.

Deficiencies in Orchard Soils.—Both experimental studies and the experience of fruit growers prove that orchard lands in Kansas may be deficient in water available to the trees or in available nutrients, especially nitrogen. The deficit of soil water may be due to a shortage of rainfall extending over a whole year or, more frequently, for short periods during the growing season when the demand is greatest. In addition, a thin orchard soil will not supply the tree's water requirement even in years of normal rainfall. The poor physical structure of such soils destroy their permeability, thus lessening absorption of water and increasing run-off. The water capacity and porosity are poor and the ability of the soil to supply water to the trees' roots is low.

The physical structure of the subsoil is, for an orchard, equally important with that of the surface layer. If the subsoil does not absorb water readily or is impenetrable to the roots of trees, the area should never be used for an orchard. In times of drought the deep ground water is the insurance of the crop or even of the life of the trees. The Nebraska Agriculture Experiment Station showed that during the drought period of the '30s available soil moisture was exhausted to great depths by apple trees, to the permanent injury of the orchard and that this shortage of water in the subsoil was related to the number of trees to the acre. Close planting hastened its loss and the early decline of the trees. Poor physical structure and consequent erosion are illustrated in Figure 6.

The fruit grower's defenses against the hazard of drought are four or more in number. First, his studies concerning the choice of an orchard location and site give great weight to the rainfall of the region, its timeliness, and the water capacity of the soil on which the orchard is to be planted. Second, he employs all the means at his command to get water into the soil. These include the maintenance of a physical condition of the soil which will permit penetration of water and the holding of large amounts of it and the prevention of run-off by contour planting, ground covers, or terracing. Incorporation of large quantities of organic matter in the orchard soil is of primary importance in getting water into the soil and in retaining it for the use of plants. Third, he conserves the ground water for the exclusive use of the orchard trees. This requires clean cultivation of the soil during periods of drought and through the principal growing season of the trees. Weeds quickly exhaust soil moisture. Fourth, orchards on favorable sites may be irrigated during periods of water shortage. This defense is available in many of the river valley locations in Kansas, especially near the Arkansas river and its tributaries, if the water is uncontaminated with salts.

Observance of the rule that only soils of high fertility should be planted to orchards will provide against nitrogen deficiency while the trees are young. If during this juvenile period large quantities of organic matter in the form of crop residues, cover crops, and barnyard manure are incorporated in the orchard soil, the nitrogen requirement of the growing trees will be fully met and a store of



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

humus built up to aid in supplying nutrients through the productive life of the trees. Good Kansas soils contain ample supplies of other plant nutrients for orchard trees.

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 drought periods. 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. Clover strips 10 to 12 feet wide between each two rows were used in the experimental orchard at Atchison and gave good protection against erosion on a moderate slope. During dry years when it proved difficult to get a stand of clover, weeds and annual grasses were fairly good substitutes. 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 and lespedeza seem less harmful than grasses, but alfalfa, because of its high water requirement and its deep rooting habit, will 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. In no part of Kansas can sod management be used successfully in the young orchards.

Commercial Fertilizers.—Use of commercial fertilizers in the orchard is, like sod culture, associated with soil management in bearing orchards rather than in a young orchard. If the site for the new orchard is chosen well the soil will contain sufficient nutrients to feed the trees throughout their juvenile period. From this it follows that additions of fertilizers to the soil during this period should be of a type that will build up reserves of nutrients in the soil for use of the trees when they come into bearing and make maximum demands on the soil.

The Kansas Agricultural Experiment Station carried out a project designed to determine the fertilizer needs of young apple trees planted on rather thin upland soil which had been in grass or corn and small grain crops for many years. This soil was known to be deficient in phosphorus for grain crops, so a complete fertilizer test was set up and continued for 10 years. The effects of these treatments were measured by annual determination of twig growth and increase in trunk circumference of the trees. The original plan of the experiment was to clean cultivate the plats, but due to erosion this treatment was amended by growing a cover crop of wheat or rye on these plats during the last eight years. The poor physical condition and resulting erosion of this soil are shown in Figure 6.



FIG. 7.—The row of apple trees on the left has been under straw mulch treatment since planting. The row on the right, of the same varieties, has been clean cultivated with a few good yields of winter vetch worked into the soil. Note the comparative growth during a period of deficient rainfall, 1932-'39.

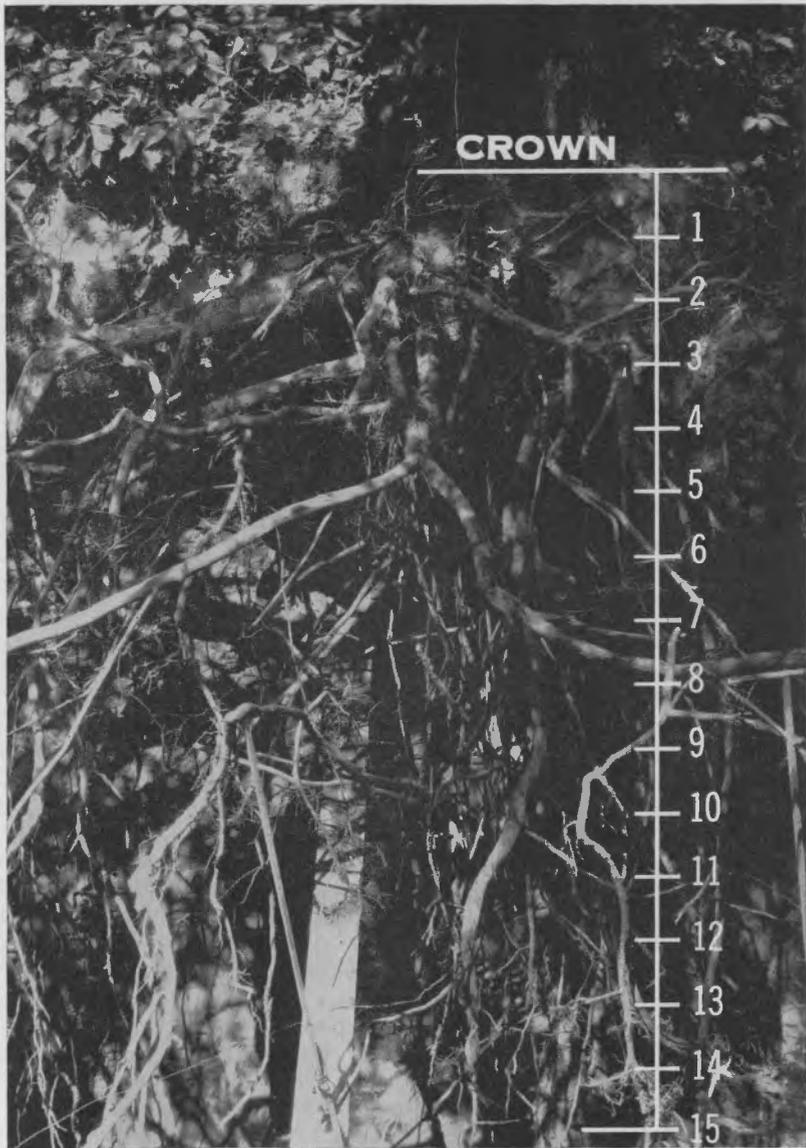


FIG. 8.—This excavated Jonathan apple tree grew in loess soil of Doniphan county. The roots shown are nearly in the position in which they grew. At a depth of 17 feet the digging was stopped although there were still roots. Trees on this soil did not die during the "great drought."

The following general conclusion was drawn from this experiment: Young apple trees on this soil under clean cultivation do not make greater vegetative development due to the application of any of the chemical fertilizers used. Experimental work carried on for many years in other states has, in general, given similar results with young cultivated orchards.

Continued Clean Cultivation.—The clean cultivation method of orchard soil management is an outgrowth of the dry farming systems of the West. 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 harmful 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 done easily where dairying is combined with orcharding as farm enterprises 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 manure must be found to supply the needed organic fraction of the soil. Cover crops grown in the young orchard seem to offer the most 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, most Kansas growers have substituted tractors, which are successful and economical in the hands of reliable and competent operators. The type selected should be 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 10. This implement makes cultivation under the branches of the trees possible. When disk cultivators are used the disks should be reversed for each cultivation, or tandem disks used, except in contour and terraced plantings in which both disks and plows may be useful in maintaining the ridges. Cultivation deeper than four inches close to the trees should be avoided because of injury to valuable feeding roots. 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 discussed, and cover cropping. A cover crop is a crop grown on the orchard soil between the trees and turned back into the soil for its physical improvement and, if the crop be 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 where the slope will not cause excessive soil erosion a cover-crop system of orchard soil management, with which, of course, must be combined clean cultivation for about three 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. Figure 11 illustrates the ability of cover crops to hold snow.

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 1 shows these characters for a number of the more important kinds of plants which are adapted to cover-crop use and have been tested in the station orchards at Manhattan.

TABLE 1.—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			



FIG. 9.—An orchard free from weeds. Droughts do less damage in an orchard that is clean cultivated during June and July. A cover crop is being disked in; the trees are in their fourth year.



FIG. 10.—An extension disk. This type of disk lessens hand labor under the branches of orchard trees.



FIG. 11.—Dead stems of cowpeas held this snow. Cover crops in an orchard lessen drifting of snow.

Yields of cover 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.

Korean lespedeza was used as a cover crop in the Atchison experimental orchard and showed promise of being a valuable plant for such use. It is more drought resistant than other legumes, is hardy, and will reseed if given opportunity. In competition with annual grasses, it behaves much like red clover.

Wheat is unsatisfactory 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 summer or fall droughts. 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 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 12.

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, costing about \$4 for each acre sown. 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. During recent years, several peach and apple growers in the region of Hutchinson have reported excellent growth and marked soil improvement from the use of winter vetch, especially on their sandy soils. Nodule formation on the roots of winter vetch is shown in Figure 13.

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 are 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, such 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



FIG. 12.—Cowpeas make a good cover crop if soil moisture is abundant during the fall.

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.

Rate of Seeding Winter Vetch.—The results of experiments in rate of seeding winter vetch are given in Table 2. These results show that on the basis of cost per pound of nitrogen, seeding at the 20-pound rate is most economical. The cost difference, however, is so slight that 30 pounds to the acre covered is the usual recommendation.

TABLE 2.—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
I.	<i>Lbs.</i> 20	<i>Lbs.</i> 4,460	<i>Lbs.</i> 142	\$6.00	<i>Cents</i> 4.2
II	30	4,812	153	7.50	4.5
III	40	5,750	183	9.00	4.9

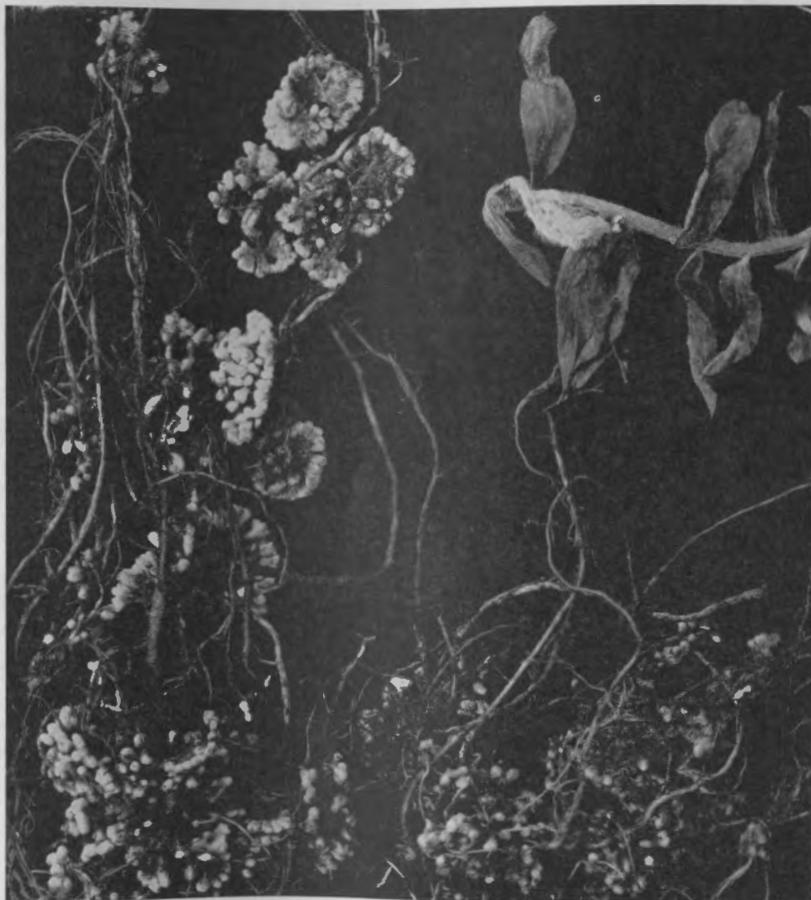


FIG. 13.—Nodules formed by nitrogen-fixing bacteria on the roots of two winter vetch plants.

The best time at which to incorporate hardy cover crops in the soil is difficult to determine and is not 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 hardy cover-crop plants still remain succulent should be chosen for plowing. This seems to be 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 14 show the condition of rye at plowing time, influenced by spring drought. 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 or disking at these times insures optimum soil moisture condition for the early growth of the trees; this is one of the principal advantages of the tender crops.

Straw Mulch.—A thick mulch of straw or other crude organic material applied to the surface of orchard land is the most efficient known method of conserving soil moisture. Consequently, in those parts of the state where droughts are common and such materials are available, this method would seem advantageous. The mulch 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 through the season.

Effect of Straw Mulch—Forty Delicious apple trees in the station orchard were grown under the straw mulch system of orchard soil management for a decade. During this time the mulched trees made a stronger vegetative development and, after coming into bearing, produced approximately twice as much fruit as the adjacent row under clean cultivation. The advantage in vigor was much more marked during seasons of scanty rainfall. This system also has marked disadvantages, some of which might become more evident as the trees become old. These Delicious trees were on a rather thin soil with a heavy clay subsoil. Several trees 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. The mulch induces shallow root development. Figure 7 illustrates comparative growth of straw mulched and clean cultivated apple trees in the Atchison experimental field during a period of years showing marked shortage of rainfall. This system has much to recommend it for orchards approaching maturity, on well-drained soil, and in regions where mulching material is available. Experimental work related to the economical production of mulch material for orchards is needed. Wheat straw has been largely made unavailable by modern methods of harvesting that crop and no substitute has been available for testing. Stover from various sources has been suggested.



FIG. 14.—Rye cover crops should be plowed under at growth stage “1” if the spring is dry but may stand until stage “3” if moisture is abundant.

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 nutrients 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 21, 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. 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.—Second among the tree fruits adapted to production in Kansas is the sour or red cherry. A well-grown and carefully tended small orchard of this fruit will return a high acre profit in almost any community in the eastern two-thirds of the state. Profits as large as \$50 an acre are frequently reported. The cherry tree will bear its first light crop at the age of four or five years and a full crop at eight or nine years. Two and one-half tons to the acre make a normal yield from a good orchard. Well-managed trees should endure for 20 to 35 years.

Soil requirements for this fruit are high fertility, good water drainage, a deep, penetrable subsoil, and a liberal to moderate supply of soil moisture. The sour cherry frequently yields well on sites too dry for apple production; the probable cause of this is the early maturity of the cherry crop and the subsequent reduction of water demand at the time of highest temperature, and of an increasing demand for water by trees bearing winter apples. Good air drainage on the site of the cherry orchard is a necessity. The blossoms appear somewhat earlier than those of the apple, but are later and more hardy than peach blossoms.

Cherry varieties are self-fertile, but there is evidence that interplanting of varieties will increase the set of fruit. A common distribution of varieties is one-fourth Early Richmond and three-fourths Montmorency. Only a small number of English Morello, the late sour cherry, should be planted because high temperatures and drought occur too frequently during its harvest period.

The sour cherry is better adapted to the climatic and soil conditions of Central and Western Kansas than the apple or the old varieties of plum. Peach trees withstand drought equally well but suffer from late spring frosts more frequently; some of the new hybrid plums excel both the cherry and peach in their adaptation to Western Kansas weather. The sour cherry is the leading home garden tree fruit throughout Kansas.

Because of the early bud development of the cherry, special precautions are required for its successful transplanting in Kansas. Only one-year-old trees should be purchased. These should have ripened normally the preceding fall and must be planted in the early spring, prior to April 1. Equally valuable with early planting in saving transplanted cherry trees is immediate pruning. One-half to two-thirds of the branches must be removed soon after planting to balance the loss of roots when dug. Too close planting has proved harmful to cherry orchards in Kansas. The recommended planting distance is 25 feet and this should be increased rather than diminished in most parts of the state. Close planting leads to starvation, poor spraying, and early decline of the trees. Increased early yields do not compensate for this eventual loss.

Cherry leaf spot, a fungous disease, has destroyed a large percentage of cherry trees in Kansas orchards. This fungus can be controlled with relative ease by timely spraying as described in the Station Circular "Combating Fruit Pests in Kansas" and good sanitation. The insects causing wormy cherries can be controlled by adding an insecticide to the spray applications for leaf spot. Any attempt to produce the sour cherry without provision for good modern spraying is hazardous. Avoidance of mechanical wounds of cherry trees is highly important.

Cherry fruits which are to be sold on the market must be picked with the stem attached as soon as they attain full size and good color. Many Kansas growers sell the fruit on the tree and allow

the buyer to harvest it. This is in general the more profitable way to dispose of the crop. No harm to the tree results from allowing such fruit to be harvested without stem or pit.

The Peach.—Kansas is not an important peach-producing state. Cold winters, late spring frosts, and dry, hot summers all conspire against success with this fruit over the greater part of the state. Its habit of early blooming increases the late frost hazard; tenderness of fruit buds and new wood lead to winter injury, and the tree's susceptibility to attacks by both insects and diseases and lack of tolerance of spray materials make it a difficult plant to protect.

For these reasons, commercial plantings of the peach in this state should be confined to specially favorable locations and sites. In addition to extraordinarily good air drainage for protection against winter injury and spring frosts, the peach requires a rather light soil of high fertility and good drainage. The tree is drought resistant, but production of fruit of good marketable size requires a liberal soil moisture supply during the growing season. Many sites which rank fairly well under these tests are found in Eastern and Central Kansas, but they are too uncommon and the best of them have too many defects to allow the general production of this fruit to prove profitable.

Certain items other than a correct choice of site have profound effects on the successful growing of a peach orchard. Budded trees only one year of age and of good vigor should be planted. The trees should be pruned heavily at once after planting. Careful protection against borers and other pests must be provided. Twenty-five feet apart on the square is a good planting distance. This would require about 70 trees to the acre. Three bushels per tree of peaches two and one-half inches in diameter would be a good average crop in Kansas. Such production would require thinning to 6 or 8 inches between fruits as soon as the "drops" have occurred. 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.

A discussion of those peach varieties which may be recommended for planting in a given region is fraught with difficulties. Location and site affect the same variety differently; new varieties are easily produced and are offered to the planter in large numbers; invasion of the oriental fruit moth complicates choice of variety on the basis of season of ripening; variation in winter hardiness and time of blooming is not wide though sometimes important; market preferences for size, color of skin, and color of flesh seem quite fixed, and recognition of high peach quality by the public is generally lacking.

The short list given on page 16 includes old, thoroughly tested varieties, all of which have serious faults when grown in Kansas. Varieties grown from roadside or local sale should be selected, in part, to cover a long period of ripening. Table 3 will aid in choosing varieties on the basis of time of harvest and other characters.

Thirty-four of the more promising varieties of peach are under test on the experiment station farm at Manhattan. These tests may uncover one or more varieties which excel those now recommended in quality of fruit, winter hardiness of buds, later blooming date, yield of fruit, or other desirable characters. If this discovery is made, the planting list will be revised promptly.

No variety of nectarine tested in the station orchard at Manhattan has been able to withstand the ordinary summer droughts. The variety Sure Crop did best of those tested.

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 experiment stations of Minnesota and South Dakota have introduced many promising varieties of hybrid plums during recent years. Some of these are of good quality and otherwise well adapted to Kansas conditions, especially in the western part of the state where so few fruits can be grown. The following named varieties are representative hybrids and are under test at the experiment station near Manhattan: American x Japanese plums, Kahinta, Ember, and Pipestone; sand cherry hybrid, Oka; American x Simon plum, Toka. The sand cherry plums Compass, Opata, Waneta, and Sapa have previously been tested and proved hardy, productive, of rather short life, and not of high quality when compared with the old but less hardy varieties.

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 hilltops.

If new plantings of pears are made, they should be some distance from apple orchards to lessen the hazard of fire blight for the apple trees.

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 cedar-quince rust, and they do not withstand drought well. An apple grower who sells his fruit at the orchard should find a good profit from an acre, 200 trees, of Orange quince.

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TABLE 3.—PEACH VARIETY CHARACTERS—SELECTED LIST.

VARIETY	Season relative to Elberta (days)	Color of flesh	Adherence	Quality	Remarks
Belle of Georgia.	4 before.	White....	Free.	Very good..	Hardy and productive.
Carman.	20 before.	White....	Free when ripe.	Good....	Hardy and productive.
Champion..	5 before.	White....	Free.	Very good to best..	Hardy. May ripen earlier on sunny side.
Early Elberta.	5 before.	Yellow.	Free.....	Good.	Not hardy in bud.
Elberta..		Yellow.	Free.....	Good.	The standard for canning.
Golden Jubilee.	25 before.	Yellow.	Free.	Fair.	Easily bruised. Skin slips.
Halehaven...	20 before.	Yellow....	Free.	Good.. . . .	Lacks in winter hardiness of bud.
J. H. Hale..	2 after....	Yellow.	Free.	Good... . . .	Self sterile. Lacks in winter hardiness of bud.
Redhaven..	23 before.	Yellow....	Free.	Fair...	One of best early peaches.
Rochester...	14 before.	Yellow.	Free.	Fair...	Hardy in bud. Poor tree.
White Hale.	With Elberta.....	White.	Free when ripe..	Good... . . .	Hardy in bud and bloom.

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 six to eight inches between fruits for the peach and about six inches between apples will prove desirable averages. Careful experiments have shown that the growth of an apple of desirable size requires elaborated nutrients from 30 to 50 active leaves on the spur and the twig beyond the fruit. 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. During recent years mass thinning of tree fruits has been gaining in popularity. Clubs, rubber hose, and various chemical sprays are being widely tested.

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 percent. Well-informed bankers will readily lend 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 inexperienced fruit growers who read this bulletin will get the impression that growing an orchard in Kansas is a 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 Kansas 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.

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