

UNIVERSITY OF MISSOURI

COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

BULLETIN 208

GRAPE GROWING IN MISSOURI



An eight-year-old Concord grape vine which in 1922 produced 18 pounds of marketable fruit. The vine is trained to the four-cane Kniffin system. Note the even distribution of the clusters.

COLUMBIA, MISSOURI

JANUARY, 1924

UNIVERSITY OF MISSOURI

COLLEGE OF AGRICULTURE

Agricultural Experiment Station

BOARD OF CONTROL

THE CURATORS OF THE UNIVERSITY OF MISSOURI

EXECUTIVE BOARD OF THE UNIVERSITY

E. LANSING RAY
St. Louis

P. E. BURTON
Joplin

H. J. BLANTON
Paris

ADVISORY COUNCIL

THE MISSOURI STATE BOARD OF AGRICULTURE

OFFICERS OF THE STATION

STRATTON DULUTH BROOKS, A. M., LL. D., PRESIDENT OF THE UNIVERSITY
F. B. MUMFORD, M. S., DIRECTOR

STATION STAFF

JANUARY, 1924

AGRICULTURAL CHEMISTRY

A. G. HOGAN, Ph. D.
L. D. HAIGH, Ph. D.
W. S. RITCHIE, Ph. D.
E. E. VANATTA, M. S.
A. R. HALL, B. S. in Agr.
JOHN L. NIERMAN, A. M.
H. M. HARSHAW, M. S.
J. E. HUNTER, M. S.

AGRICULTURING ENGINEERING

J. C. WOOLEY, B. S.
MACK M. JONES, B. S.
W. C. BONEY, B. S. in Agr.

ANIMAL HUSBANDRY

E. A. TROWBRIDGE, B. S. in Agr.
L. A. WEAVER, B. S. in Agr.
A. G. HOGAN, Ph. D.
F. B. MUMFORD, M. S.
D. W. CHITTENDEN, B. S. in Agr.
M. T. FOSTER, B. S.

BOTANY

W. J. ROBBINS, Ph. D.
I. T. SCOTT, B. S. in Agr.

DAIRY HUSBANDRY

A. C. RAGSDALE, B. S. in Agr.
WM. H. E. REID, A. M.
SAMUEL BRODY, M. A.
C. W. TURNER, A. M.
D. H. NELSON, A. M.
W. P. HAYS, B. S. in Agr.
J. B. NELSON, A. M.

ENTOMOLOGY

LEONARD HASEMAN, Ph. D.
K. C. SULLIVAN, A. M.
O. C. MCBRIDE, B. S. in Agr.
NEELY TURNER, B. S. in Agr.

FIELD CROPS

W. C. ETHERIDGE, Ph. D.
C. A. HELM, A. M.
L. J. STADLER, Ph. D.
O. W. LETSON, A. M.
MISS REGINA SCHULTE, A. B.*

RURAL LIFE

O. R. JOHNSON, A. M.
S. D. GROMER, A. M.
E. L. MORGAN, A. M.
BEN H. FRAME, B. S. in Agr.
D. R. COWAN, Ph. D.
W. L. WITTE, A. M.

HORTICULTURE

T. J. TALBERT, A. M.
H. D. HOOKER, JR., Ph. D.
H. G. SWARTWOUT, B. S. in Agr.
J. T. QUINN, A. M.
A. M. BURROUGHS, A. M.

POULTRY HUSBANDRY

H. L. KEMPSTER, B. S. in Agr.
EARL W. HENDERSON, B. S. in Agr.

SOILS

M. F. MILLER, M. S. A.
H. H. KRUSEKOPF, A. M.
W. A. ALBRECHT, Ph. D.
F. L. DULEY, Ph. D.
WM. DEYOUNG, B. S. in Agr.
H. V. JORDAN, B. S. in Agr.
RICHARD BRADFIELD, Ph. D.
E. B. POWELL, B. S. in Agr.
R. E. UHLAND, B. S. in Agr.

VETERINARY SCIENCE

J. W. CONNAWAY, D. V. S., M. D.
L. S. BACKUS, D. V. M.
O. S. CRISLER, D. V. M.
A. J. DURANT, A. M.
H. G. NEWMAN, A. M.

OTHER OFFICERS

R. B. PRICE, JR., Treasurer
LESLIE COWAN, B. S., Secretary
S. B. SHIRKY, A. M., Asst. to Director
A. A. JEFFREY, A. B., Agricultural Editor
J. F. BARHAM, Photographer
MISS JANE FROSHAM, Librarian
E. E. BROWN, Business Manager

*In service of U. S. Department of Agriculture.

Grape Growing in Missouri

H. G. SWARTWOUT

Abstract.—All the essential factors in the successful management of a commercial vineyard under Missouri conditions are carefully set forth. The most desirable soils are described with reference to their character as well as their location in the state. The ideal site, topographically, is described. Two commercial varieties and about a dozen home garden varieties are recommended. The successive steps in establishing and maintaining a thrifty vineyard are carefully explained, including propagation, care of vines in nursery, preparation of soil, laying out the vineyard, setting the vines, constructing the trellis, pruning the vines, cultivating, fertilizing, harvesting, packing, and grading. Directions are also given for the treatment of frosted vines, for intercropping, for the management of cover crops, and for the control of insects and diseases. A spraying schedule is included, together with a description of spray materials and equipment. A section is devoted to the fruiting habits of the grape and to definitions of the several parts of the vine. Nineteen half-tone illustrations are presented to make clear the steps in pruning, the management of vine and trellis, the compound nature of the eye, the identification of insects and diseases and the essential items of spraying equipment.

Recently Missouri has experienced a revival of interest in grape growing, especially in the southern part of the state. Thousands of acres of vineyards have been planted during the past two or three years and as a result the State may regain the position of importance it once occupied in the grape growing industry.

Grape growing on a commercial scale in Missouri had its beginning about 1850. Between 1860 and 1870 it developed into a very important industry especially about St. Louis, Hermann and other river towns. In 1870 Missouri produced more wine than any other state except California and for several years Missouri was among the leading grape producing states of the country; but from 1875 production steadily decreased because of serious attacks of black rot and other diseases for which there was at that time no effective control.

Missouri stood seventh in grape production in the United States for the 10 years from 1909 to 1919. But this position was held in 1919 with a production 5,000,000 pounds less than in 1909. This decrease in production was due in part to the decreased number of bearing vines. In 1909 there were 3,000,000 bearing vines; in 1919 only 2,500,000. The number of young vines also decreased from 486,000 in 1909 to 410,000 in 1919.

The present revival of interest in grape growing has resulted in a demand for trustworthy and definite information, and in response to this demand the present publication has been prepared.

SOILS

Grapes do well on a wide range of soil types. As a rule the loose, warm, gravelly and sandy loams are the best; but any of the loams are satisfactory if well drained. Coarse, sandy soils are undesirable unless underlaid with a more or less clayey subsoil which is retentive of moisture. Stiff clayey soils are also undesirable and should be avoided so far as possible. Gravel and stone in the soil make but little difference unless the stones are large enough to interfere seriously with cultivation.

Grape lands should be fertile, but not excessively rich. Although grapes do remarkably well on land too poor for ordinary crops, such land is not, as many suppose, the most desirable for growing grapes. On poor land the vines will not make a good growth nor will they produce heavy crops. On the other hand, if the soil is too rich the vines will make a large amount of wood growth at the expense of fruitfulness; the wood will not mature properly, and the fruit will be of inferior quality. Garden soils which have been heavily manured year after year and bottomland soils are too rich for growing grapes.

The character of the subsoil is of considerable importance. Grapes will not succeed where there is excessive soil moisture or where water stands for any length of time. The soil must be porous enough to allow excess water to pass through quickly. It is also desirable that the subsoil be loose and open enough to allow the roots to penetrate to a considerable depth as deeply rooted vines are less liable to injury from heat and severe droughts. It must not be too open, however, or it will not be sufficiently retentive of moisture.

The most desirable grape soils in Missouri are the brown loess soils along the Missouri River and parts of the Mississippi River, and the limestone soils of South Missouri with porous clay subsoils found in many parts of the Ozarks. Not all soils in these regions, however, are well adapted to grapes. This is particularly true of the Ozarks where one piece of land may be well suited to growing grapes while that adjacent to it may be totally unfit. Moreover, grapes differ in their adaptations; varieties that are well adapted to one section or locality may not succeed in another. In general, however, any deep, loose, well drained soil that is fertile enough for the growing of ordinary farm crops is suitable for growing grapes.

SITES

Where possible the site chosen for a vineyard should be somewhat above the level of the surrounding country. Cold air settles to the lower levels and there frosts are more likely to occur, while more elevated sites may escape. Vines situated on high ground are therefore less likely to be injured by late spring frosts and freezes. It is not necessary that the land be of high elevation, but only higher than the land surrounding it. Steep hillsides may be used for grapes, but they are not as desirable as land having a moderate slope. Steep land washes badly and makes the care of the vineyard difficult and expensive. Level land as a rule does not have as good atmosphere and soil drainage as rolling or sloping land. The direction in which the land slopes makes but little difference except where an early variety is being grown for early market. A south or southeastern exposure which favors earlier ripening is then preferable.

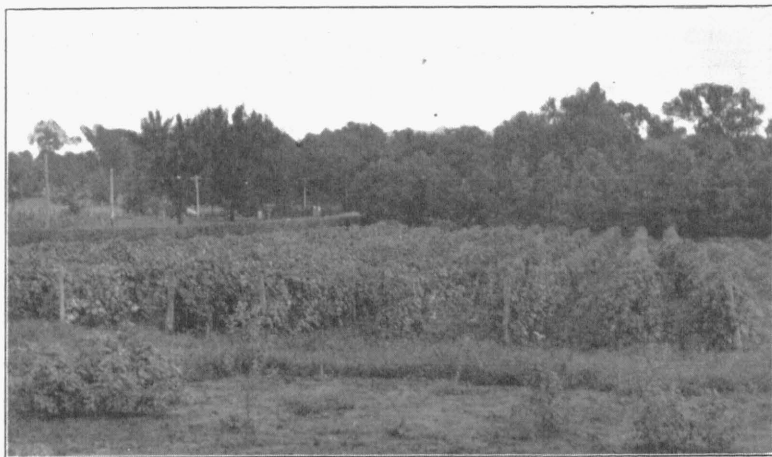


Fig. 2.—View of one of the experimental vineyards on the Horticultural grounds at Columbia.

VARIETIES

Commercial Varieties.—The commercial production of grapes in Missouri is limited at present to practically two varieties, Concord and Moore Early. There are a number of other varieties that can be grown successfully in certain localities and for special purposes, but they are not suitable for general commercial planting.

The Concord is the most extensively planted, by far the greater part of both old and young plantings being set to this variety. It is the variety most in demand by grape juice manufacturers and the only one accepted by some. The vines are vigorous, hardy, productive and fairly resistant to the attack of insects and diseases. The clusters and berries are of good size and attractive in appearance but the fruit is not of very high quality. It has a tendency at times to ripen its fruit unevenly, but with proper pruning this tendency can be largely overcome.

Moore Early is the standard early grape for Missouri. It is a seedling of the Concord which it rather closely resembles. It differs from the Concord, however, in being less hardy and less productive. As grown on the Station grounds at Columbia the clusters are as large and as attractive as those of Concord although in flavor the fruit is hardly equal to that of Concord. Moore Early ripens from seven to ten days earlier than the Concord. It requires a rather fertile, loose and well drained soil for the best results.

Home Garden and Local Market Varieties.—For the home garden and local market a collection of varieties from early to late is desirable in order to furnish a continuous supply of fresh fruit. It is also desirable that the collection include varieties suitable for various uses. The following varieties are suitable for both the home garden and local market. The varieties are arranged in the approximate order in which they ripen and will furnish a succession of fruit over a period of about eight weeks.

An Eight-Weeks Succession of Home Garden Varieties of Grapes.

Variety	Color	Remarks
Eclipse	Black	Good quality, moderately vigorous and moderately productive. Self-sterile. Clusters and berries medium in size. An extra early variety.
Winchell (Green Mtn.)	Green	Very good quality; sweet. Clusters often small and loose, berries small. Ripens about with Moore Early.
Moore Early	Black	Good quality. Fruit similar to Concord but not as good flavor. Requires fertile soil. Ripens seven to ten days earlier than Concord.
Delaware	Red	Best in quality; very sweet. Clusters and berries small, but bunches compact and attractive. Vine small and slow growing. An excellent table grape.
Diamond	Green	Very good quality. Large, handsome clusters and berries. Requires close pruning to prevent overbearing. To be preferred to Niagara for the home garden.
Worden	Black	Good to very good in quality. Fruit very similar to Concord, but clusters and berries larger. Ripens a few days earlier than Concord.
Brighton	Red	Excellent quality. Quickly deteriorates in quality after maturity. Self-sterile. Ripens about with Worden.
Concord	Black	Good quality. Very productive. Good for grape juice, jelly, etc. Ripens mid-season.
Niagara	Green	Good quality. Very productive. Large, handsome clusters. The standard commercial green variety. Ripens about with the Concord.
Goethe	Red	Excellent quality. Vigorous and productive. An excellent table grape.
Catawba	Red	Excellent quality. Productive. Keeps well. An excellent late variety.

PROPAGATION

Cuttings.—The most common method of propagating grapes is by means of cuttings made from dormant wood. They may be made any time after the leaves drop in the fall and until just before growth begins in the spring. As a rule, however, cuttings made in the fall or early winter give better results because of the larger amount of food then stored in the wood and the longer time in which they have to callous. Winter-injured wood is also avoided by making the cuttings early. When it is necessary to make the

cuttings late in the season they should be buried in the ground in some cool, moist spot and planting delayed as long as possible.

For making the cuttings only one-year-old wood (canes) should be used. Vigorous, well matured, medium sized, short-jointed wood is the best. Overly vigorous wood does not root as readily as moderately vigorous wood, while immature, diseased and small, weak wood if it roots at all makes poor plants. The cuttings are usually made 8 to 12 inches long or long enough to include three or more buds.

In making the cuttings a slanting cut is made through or slightly below the lowest bud while one or more inches of wood is left above the upper bud. For convenience in handling and planting the cuttings should be sorted according to length and tied into bundles with the butt ends (lower ends) even and all at the same end of the bundle. They are then buried in trenches with the butt ends up and covered with 3 or 4 inches of soil. As

soon as cold weather approaches they should be covered with straw or manure; but the covering should be removed as soon as the weather warms up in the spring. The butt ends in the warmer top soil become calloused and are ready to throw out roots as soon as the cuttings are planted while the tops in the cooler soil beneath remain dormant.

As early in the spring as the soil is in condition to work, the cuttings should be planted in the nursery. A V-shaped trench is dug or trenches furrowed out with a turning plow running the plow twice in the same direction. The cuttings are placed along the smooth side of the trench just far enough apart to allow the use of a hoe between and with the top bud high enough so that it will be just above ground after the trench has been filled. In filling the trench care should be taken to tamp the soil firmly about the cuttings. With good cultivation and a favorable season the vines will be large enough to plant by the following fall and may be either dug and stored or left in the nursery until spring.

Layering.—All varieties of grapes may be propagated by layering but it is a method very little used except with varieties which do not root readily from cuttings. Where only a few new vines are wanted propagation by layering however is often more convenient and satisfactory than by cuttings, layering being more certain and usually producing stronger plants. It is also an excellent way of filling in vacancies in old vineyards as the young vines supported by the mother vines are enabled to gain a foothold under conditions where vines not so favored would have but a poor chance. For this purpose a vigorous cane from an adjacent vine in the same row is placed upon the ground in the vacant place and several buds near the end

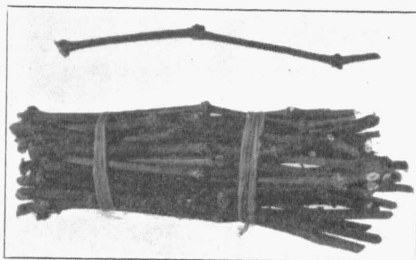


Fig. 3.—Grape Cuttings. Above.—A 3-eye cutting showing where to make the lower cut and where to make the upper cut. Below.—A bundle of cuttings ready to be placed in the callous pit.

covered with soil, leaving one or two buds at the tip of the cane above ground. After one or two seasons the young vine may be separated from the parent vine.

In ordinary layering, a trench 3 to 5 inches deep is dug and the canes bent down and fastened in the bottom with wooden or wire pegs. The trench is then partly filled with fine, moist soil which is firmly packed about the canes. Canes so treated will usually strike root and produce shoots at each of the covered joints. When the young shoots are well above ground the trench is completely filled and as soon as they have reached a height of 8 to 10 inches they are tied to stakes to hold them out of the way of the cultivator. By the following fall the plants are ready to be taken up, being divided by severing the old canes just back of each shoot. Canes may be layered either in the fall or in the spring but spring layering is to be preferred.

Grafting.—Grafting as a method of propagating grapes is less certain, requires more time and is more difficult than either layering or making cuttings. It is not a common practice. It has its uses, however, and can often be employed to advantage. Grafting is of value in increasing hardiness, disease resistance, vigor and fruitfulness of weak or slow growing varieties. It is also a practical means of increasing the commercial range of varieties with limited soil adaptations. Perhaps the most common use of grafting where it is used in the east and middle west is in top-working worthless or undesirable varieties to better and more profitable sorts.

In top working vines the soil is first removed from about the base of the vine to a depth of 3 to 4 inches and the trunk sawed off at about the level of the ground. With a thin-bladed saw a cut is then made through the center of the stock to a depth of two inches. The scions are cut with two buds and the lower end shaped into a thin wedge as long as the cut in the stock. The cut in the stock is then opened with a chisel and the scion inserted in such a way that the inner bark or cambium of the scion is in contact with the inner bark or cambium of the stock. Where the stock is three-quarters of an inch or more in diameter two scions, one on either side, should be inserted. If both grow the weaker one may be removed. After the scions have been placed in position earth should be drawn up to the vine and mounded about it until only the top bud of the scion shows. No wax should be used in grafting grapes. When the new shoots appear they should be tied to a stake to prevent their being whipped about by the wind. Top-worked vines will come into full bearing within two or three years after they have been reworked.

Where the grafting is done on unrooted stock the operation is performed in much the same manner as apple grafting. The wood used as stock is cut into uniform lengths of about 10 inches, making the lower cut through a node and leaving 2 inches or more of wood above the top bud. The stock is then disbudded to reduce the number of suckers. The scions are cut to one bud leaving about 2 inches of wood below the bud and 1 inch above. The stocks and scions are then sorted to size and may be either whip grafted or united by making a long slanting cut on both stock and scion and then pushing the two pieces together over a short piece of wire inserted

in the pith. Whichever method is used for uniting stock and scion, care should be taken to have the cut surfaces fit closely and the inner bark or cambium in contact.

The grafts should be made as early in the winter as possible and stored in a cool moist place (above freezing) where they will callous. Early in the spring they should be planted in the nursery, mounding up the soil about the grafts until they are covered to a depth of 1 or 2 inches. The soil above the grafts must be kept loose and mellow so that the tender young shoots will have no trouble in pushing their way through. From time to time during the summer the rows should be gone over and the suckers and scion roots (roots above the union) removed.

VINES FOR VINEYARDS

At the reasonable price for which high quality nursery-grown plants can usually be purchased, it will generally be found cheaper and more satisfactory to buy plants from a reliable nursery firm than to attempt to grow them at home. There are, of course, several advantages in home-grown stock: the vines may be dug and transplanted at any time; one is usually more sure of getting the variety desired; plants are always available for making resets, and only the best plants may be selected for setting in the vineyard. But the production of new vines is properly the business of the nurseryman and not that of the grower. The nurseryman is more skilled in the art of propagation, has better equipment and conditions better suited to the production of vines of high quality. A good vineyard site is seldom a good place to grow nursery stock. Whatever the source of the plants, however, one thing should be remembered; only strong healthy vines should be planted. Poor vines are expensive at no cost.

First grade, one-year-old vines are the most desirable. Two-year-old vines may be used, but as they are often those that have been culled from the nursery the year before because of poor growth, there is danger of obtaining weak or stunted plants which may never develop into highly profitable vines.

Thrifty, well grown vines are not necessarily the largest. The appearance of the vine is of more importance than the size, especially the size of the top. Medium sized vines with a good root system are probably as good as large ones, but small vines, particularly those with a small root system, should be discarded. The plants should have a bright healthy look; the canes should be large enough to indicate vigor and should be firm and well matured; and the roots should be strong, healthy, free from knots or excrescences and the larger ones alive to the tips.

Reputable nurseries only should be patronized. Jobbers and itinerant fruit tree agents should be avoided. Stock from such sources is likely to be badly mixed as to variety and is usually of a very low grade. "Pedigreed" vines are better than ordinary vines only so far as more care has been exercised in the selection of the propagating stock and the vines have been given better care in the nursery.

CARE OF VINES WHEN RECEIVED FROM THE NURSERY

As soon as the vines are received they should be unpacked and heeled out in some well drained spot until time for planting. To heel out the vines, a trench is dug large enough to hold the roots and the vines are spread out along one side of the trench. If tied in bundles, the vines should first be separated so that the roots can be well spread. The roots are then covered with fresh moist soil, taking care to work the soil well down in among the roots and to pack it firmly about them by tramping the soil as the trench is filled.

Vines that are badly dried out should be soaked in water for several hours before being heeled out. After heeling out, the tops should be covered with moist soil or wet sacks. If the vines are to be left heeled out over winter, the tops should be protected by covering with soil or by throwing straw over them.

TIME OF PLANTING

Grapes may be planted either in the fall or early spring. Spring planting is preferable, but where there is a large acreage to be set and conditions are favorable, planting should begin in the fall. Fall-set plants, however, are subject to heaving and winter killing and should be protected by covering the tops with soil, removing it in the spring before the plants start into growth.

PREPARATION OF THE SOIL

It is better if newly cleared land can be cropped for several years before being set to grapes. The plowing and cultivation aerates the soil, improves its physical condition and aids in the thorough incorporation and decay of organic matter. Sod land or land that has not been in cultivation for a number of years should be plowed and planted to some cultivated crop the year before the vines are to be set. The working of the soil will improve its physical condition and help to destroy weeds.

Soils lacking in humus should be planted to some such crop as clover, cowpeas or soybeans, to be turned under; or they should have, if available, liberal applications of stable manure. At no time will the vines be more greatly benefited by the addition of humus forming materials to soils deficient in that respect than while the vines are young, and there is no better time for incorporating such material than before the vines are set.

The plowing is done preferably in the fall, plowing deeply, especially in the heavier soils. Subsoiling is of doubtful value. Fall plowing is not advisable, however, on steep hillsides which are subject to washing. Sod land to be plowed a short time before planting should be well disked before plowing, to cut the sod so that the soil will pack without leaving air spaces and thus hasten the decay of vegetable matter. Repeated disking and harrowing with cross disking and cross harrowing is necessary to level the land and reduce the soil to the finest possible state of tilth.

LAYING OUT THE VINEYARD

Whenever possible, it is better under Missouri conditions to lay out the rows to run north and south. Rows running in that direction are exposed equally on both sides to the sunlight, and the fruit and trunks of the vines are shaded during the hottest part of the day. The direction that the rows shall take, however, is usually determined by the shape of the field or by the lay of the land. On a steep hillside or land with a decided slope the rows should be run across the slope or made to follow the contour of the land. Laid out in this way, cultivation, spraying and other vineyard operations are made easier and soil erosion is checked. If the vineyard is located where it is exposed to strong winds, there will be less damage to the vines if the rows are run in the direction of the prevailing winds so that it will blow down between the rows rather than across them.



Fig. 4.—A loaded vine in a well kept Missouri vineyard.

In large vineyards, for convenience in cultivating, spraying and harvesting, driveways should be provided at regular intervals. Driveways lengthwise of the vineyard are made by increasing the distance between two adjacent rows or by dropping out a row. Where the rows are 10 feet apart, no driveways lengthwise of the field are necessary. Cross alleys are necessary to avoid long hauls, especially at harvest time.

At the ends of the rows a headland should be left wide enough to permit turning a team and vineyard equipment without damage to the equipment or to the vines.

Marking Out the Field.—A common and very satisfactory method of marking out the field is with a turning plow, first laying off the rows the length of the field, then crossing at right angles at the distance the vines are to be set in the rows. The vines are set at the intersection of the furrows. By placing tall stakes at the ends of the rows as guides and by using a marker to locate the next row better alignment can be secured.

For perfect alignment, staking is necessary. Unless the land is very hilly cross alignment is desirable in order that the vineyard may be cultivated in both directions for the first year or two after the vines are set. On steep hill-sides, only the rows are marked out, a measuring stick being used to locate the position of the vines in the rows. No attention is given to cross alignment.

Arrangement of the Varieties.—Except with self-sterile varieties which will not produce fruit when planted alone, planting in solid blocks of one variety is to be recommended. Harvesting is facilitated and, where the cultural requirements of the different varieties differ, each can be better and more economically cared for when the varieties are planted together in large blocks. Fortunately, all of the more important commercial varieties, such as Concord, Worden, Moore Early, Niagara and Catawba, are self-fertile and will produce fruit when planted alone. Barry, Brighton and other self-sterile varieties should be planted in small blocks of from two to four rows, alternating with an equal number of rows of any strongly self-sterile variety. Alternating every other row is hardly necessary and increases the cost of harvesting and caring for the vines.

Planting Distances.—The distance between the rows is usually determined by the convenience with which vineyard operations can be conducted. In the small planting, where most of the work is to be done with one horse, where land is high and where it will not result in overcrowding, the rows may be placed as close as 7 or 8 feet. In commercial plantings, rows 10 feet apart are to be preferred in order to allow the passage of ordinary farm equipment between the rows and to permit the use of a two-horse team.

The distance apart of the vines in the rows is determined for the most part by the growth that the vines will make. Vigorous growing varieties like Concord and Niagara need more room than moderate and weak growing varieties like Delaware and King Phillip. The slower and weaker growing varieties are usually set from 6 to 8 feet apart. The more vigorous varieties, such as Concord, Worden, Moore, Niagara, etc., may be set as close as 8 feet, if the soil is fertile and if it will not result in too great an overlapping of the tops of the vines; but 10 feet apart is usually to be preferred. At 10 feet apart, fewer vines will be required to set an acre, thus lowering the initial cost of starting the vineyard and, with the increased feeding area for the roots, the total yield per acre will usually be found nearly if not quite as great as if the vines were set closer together.

PREPARING THE VINES FOR PLANTING

In preparing the vines for planting, all the dead and injured roots should be removed and the main roots shortened to 6 or 8 inches. Where there is more than one whorl of roots, all except those at the bases of the vines should be removed. This forces a deeper rooting of the young vines, enabling them the better to withstand prolonged droughts. No attention need be given to the small fibrous roots as they are of no value to the plants and their removal is a needless expenditure of time. To compensate for the heavy root pruning, the tops of the vines should be pruned to a single cane, and that cut back to two buds. Since there is danger of injuring some of the buds in setting, the tops of the vines may be trimmed to single canes, delaying the cutting back of the canes until after the vines have been set.

SETTING THE VINES

The first step in setting the vines is digging the holes. If the land has been well prepared and the rows marked off with a plow, little effort will be required to make a hole large enough to hold the vines without bending or crowding the roots. After the vine has been properly placed in the hole, a few shovelfuls of good soil are thrown into the bottom and firmly tramped,

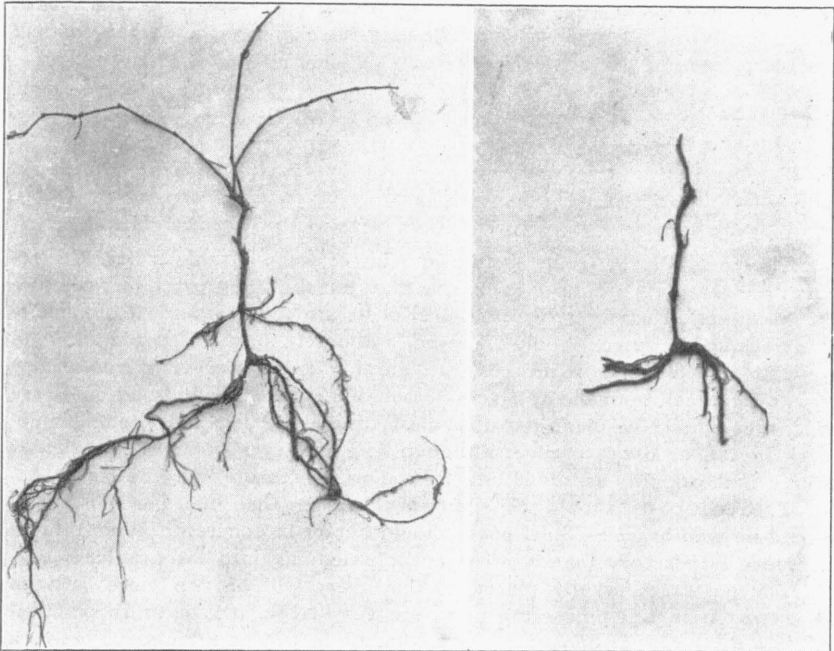


Fig. 5.—At the left is a No. 1 one-year-old vine before pruning. At the right is the same vine after pruning preparatory to planting. The upper whorl of roots has been removed and the bottom whorl shortened to about 8 inches. The top has been cut back to one spur of two buds.

but not packed, about the roots. Tramping of the earth about the vines is continued as the holes are filled until the top is reached where the soil should be left smooth and loose.

In setting the vines, a good arrangement is for two men to work together. One trims the vines, holds them in place and tramps the soil about the roots while the other digs the holes and covers. Where a large acreage is to be set, it may be advisable to divide the men into gangs, each gang to consist of four men, two to dig holes and two to set the vines. Nothing is gained by digging the holes in advance of the time the vines are to be set.

The depth to which the vines should be set depends upon the soil. On heavy, wet soils, shallow planting is advisable; on light warm soils, deep planting. As a rule, the vines are set with only the top two buds above ground, about an inch deeper than they stood in the nursery. If the soil is too shallow to allow the vines to be set at the proper depth, they should be slanted sufficiently to bring the tops of the vines to the desired level.

THE TRELLIS

The type of trellis to be constructed depends upon the system of training to be used. For the four-cane Kniffin system, the system most commonly used in Missouri, the vertical two-wire trellis is used. The lower wire of the trellis is placed from $2\frac{1}{2}$ to 3 feet above the ground, 3 feet being preferred, and the top wire 2 to $2\frac{1}{2}$ feet above the lower wire. Number 10 or 11 smooth galvanized wire is generally used. The amount of wire needed can be easily calculated from the following table giving the number of feet per 100 pounds of different sized wire:

Size of Wire	Feet per 100 lbs.
No. 9	180
No. 10	223
No. 11	273
No. 12	343

The posts for the trellis should be made of some durable material. Frequent replacements are more expensive than the slightly greater cost of more durable posts. Heavily galvanized steel posts are the best and, if obtainable at a reasonable price, should be used. Concrete posts, if made of good material and properly reinforced, are durable and make very satisfactory posts. They can be made at a very reasonable cost. Where wood posts are used, they should be made out of some lasting wood like cedar, chinquapin, black locust, or osage orange, although oak and even some of the lighter woods, if thoroughly seasoned and treated with creosote, may be used.

The end posts should be somewhat heavier than the line posts and should be well braced. Steel posts should be set in concrete. Wood braces are more satisfactory than a wire anchor extending into the headland.

The posts are usually placed so that there will be two vines between each two posts, but unless the vines are very large, it is entirely practical to place the posts far enough apart so that there will be three vines between posts.

The wires of the trellis will stretch from year to year and will need to be tightened each spring. In order to facilitate the work of tightening, the wires should be fastened to the posts in such a way that they can be tightened from the ends of the rows.

FRUITING HABIT OF THE GRAPE

Correct pruning practices are based on the way in which the grape bears its fruit. A knowledge of the fruiting habit of the grape is essential, therefore, for intelligent pruning. Grapes produce their clusters of fruit laterally near the base of the current seasons growth. These come from buds, developed in the axils of the leaves of the previous years growth; that is, the grape produces its fruit on shoots that come from one-year-old wood (canes). Shoots that come from old wood are usually either sterile or produce fruit of inferior quality. Wood older than one year cannot therefore be depended upon for fruiting purposes.

All canes are not equally productive. Medium sized short-jointed canes are the most productive and produce the largest clusters and fruit of the best quality. Overly large canes (bull canes) and canes with long joints

have expended their energy in wood growth at the expense of fruit bud formation and do not make desirable fruiting wood. Small canes are not sufficiently developed to produce large well formed clusters. Canes that come from two-year-old wood are generally considered better than canes that come from older wood. Lateral canes if of good size are as productive if not more so than the main canes and may be used when available.

The number of clusters produced by a shoot varies from one to five, the average number varying mostly with the variety although the age of the vines and the conditions under which they are grown influence the number to some extent. After determining the average number of clusters a variety produces on a shoot and the average weight of the clusters it is easy to calculate how many buds should be left on a vine of that variety to produce a given amount of fruit.

PARTS OF THE VINE DEFINED

Certain definite technical terms are employed to designate the different parts of a vine. In order to understand more fully a discussion of the pruning and training of the grape the definitions of the following important terms are given:

TRUNK: The main unbranched stem or body of a vine.

ARMS: The main divisions or branches of the trunk.

SHOOT: The new growth coming from a bud. It is known as a shoot only during the growing season. With maturity and the fall of the leaves it becomes a cane.

CANE: A dormant shoot of the past season's growth.

FRUIT CANE: A cane that is left to produce fruit; usually a cane from two-year-old wood.

LATERAL: A side branch of a shoot or a cane.

SUCKER: A shoot coming from below ground.

WATERSPROUT: A shoot coming from old wood.

RENEWAL SPUR: A cane that has been cut back to two buds to produce next year's fruiting cane.

NODE: The joint on a shoot or cane where a leaf or bud appears. The length of wood between two nodes is the internode.

EYE: The compound bud at each node on a cane.

MAIN OR PRIMARY BUD: The central or stronger bud of an eye.

SECONDARY BUDS: The smaller buds of an eye.

PRUNING THE GRAPE VINE

Pruning Young Vines.—The pruning of young vines has as its object the development of a vigorous root system and the establishment of a system of training. The main object the first year is the development of a vigorous root system and to that end the treatment of the vines should be such as will produce as much leaf growth as possible. The second year the trunks of the vines are formed. If the vines are vigorous and a good root system has been developed the general shaping of the vines may be completed the third year. With weak and only moderately vigorous vines four or five years may be required to bring the vines to the desired form. Under no consideration should the vines be allowed to fruit the first two years but if vigorous they may be allowed to produce some fruit the third year.

The pruning of the vines the first year is the same for all varieties, and for all systems of training. After the first year the way in which vines are pruned will vary somewhat with the system of training to be followed. The system best adapted to the Concord, Moore Early, Worden, Niagara and nearly all other varieties grown in Missouri is the one-trunk, four-cane Kniffin system.

Directions for Pruning to Kniffin System.—*First year.*—No summer pruning should be done the first year. Thinning the growth to one or two shoots or pinching back the shoots weakens the vines and another year may be required to develop a vigorous root system. As a rule, the shoots are allowed to grow on the ground at will; but, if vigorous, they should be staked to hold them up out of the way of cultivation and to prevent their being whipped about by the wind.

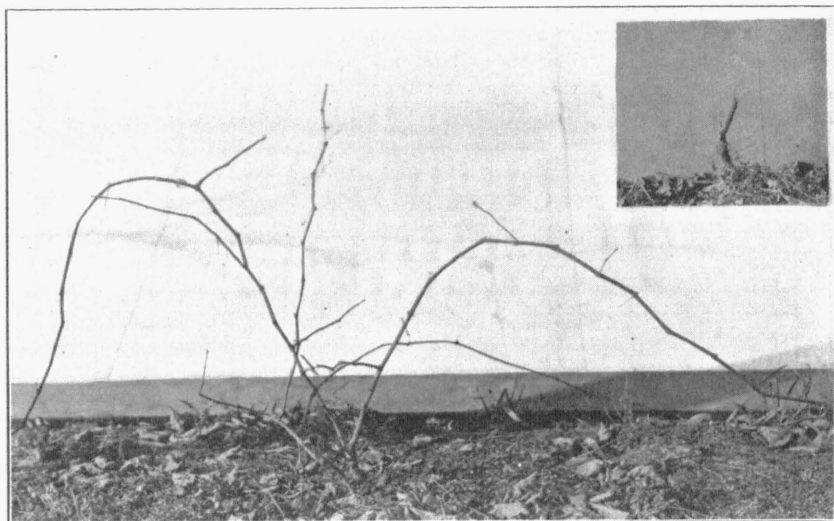


Fig. 6.—Vine at end of first year's growth in the vineyard. In upper right hand corner is shown the same vine after pruning. All the canes have been removed but one, and that shortened to two buds.

Pruning at the end of the first year consists in removing all the canes but one and cutting that back to two buds the same treatment as that given the vines at the time of setting. The pruning should not be done until after all danger of cold weather is over. The buds to be left may then be selected without danger of later winter injury.

Second year.—The trellis to which the vines are to be permanently trained should be set up before growth starts the second year. All the shoots but two should be removed as soon as growth starts. When the two shoots are 10 to 12 inches high the stronger and straighter one should be selected to form the trunk and the other one removed. This will direct the whole energy of the vine into the development of one shoot. This shoot should be tied to the lower wire of the trellis and again to the upper wire. If vigorous it should be pinched as soon as it reaches the height of the top wire. This

will force out laterals all of which should be removed as soon as they start except three or four near the upper and lower wire. If the vines do not make a vigorous growth no summer pinching should be done.

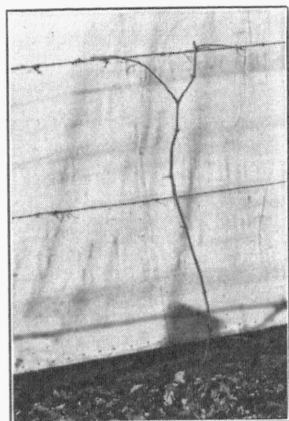


Fig. 7.—Vine after pruning at end of second year in the vineyard. Two short fruit canes have been left on the top wire to produce a small crop the third year.

Third year.—The only summer pruning to be done the third year is the removal of shoots that come from that part of the trunk between the wires, between the lower wire and the ground, and shoots that come from below ground. At the end of the third year the vines are pruned to four canes and these shortened to produce the amount of fruit the vines are capable of carrying. Vines that were cut back to the ground the second year should be pruned according to the directions given for the second year.

Pruning Bearing Vines.

—The pruning of bearing vines is largely a matter of maintaining a proper balance between growth and fruit production. If the pruning is too light, that is, too much fruiting wood is left, there will be more fruit clusters produced than the vines can properly mature. As a result the clus-

The way in which the vines are pruned at the end of the second year depends on the growth they have made. Where strong laterals have been produced the vines are pruned to leave one lateral to run in either direction along each wire of the trellis. The laterals should be shortened, however, to leave a total of not more than 10 or 12 eyes to each vine. More than this is likely to result in overbearing. When no strong laterals are produced the vines are pruned to a single cane, reaching from the ground to the top wire. Vines that have not made a good growth should be cut back to two buds or at least to the lower wire of the trellis. Nothing is to be gained by attempting to form the trunk of a vine until a root system has been developed strong enough to produce a vigorous shoot growth.

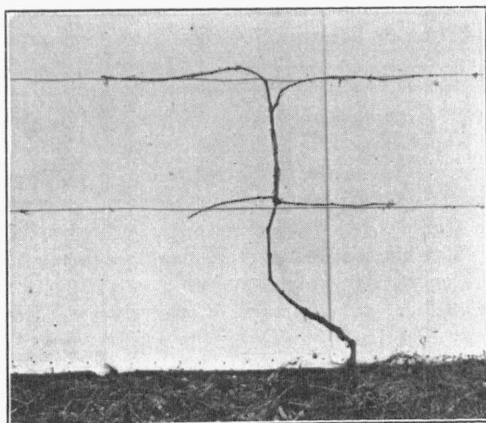


Fig. 8.—A vigorous young vine pruned at the end of the third year in vineyard. The vine is pruned to produce a fair crop of fruit the fourth year.

ters will be small, the fruit of inferior quality and the vines may be so weakened by over production that several years will be required for their recovery. On the other hand too close pruning reduces the crop and causes excessive wood growth.

The amount of fruiting wood that should be left varies with the vigor of the vines. An average Concord vine, or other vine of like vigor can mature about 15 pounds of grapes and at the same time produce good fruiting wood for the next year. To produce 15 pounds of grapes, a Concord vine will require 30 to 35 buds. Other varieties may require a few more or a few less depending on the size of the clusters and the average number of clusters they produce to the shoot. If the vines are vigorous more buds may be left. Weak vines should be pruned heavily in order to secure a vigorous wood growth.

The systems of pruning bearing vines are many. Only one will be described here, the single trunk four-cane Kniffin. Of all the systems tried it has been found the best for the varieties commonly grown in Missouri. To prune vines to the four-cane Kniffin system four medium-sized, short-jointed canes are selected for fruiting wood; one to run in either direction along each wire of the trellis. Where possible the canes selected should arise close in to the trunks of the vines. By choosing as fruiting wood canes that arise close to the trunk, the arms can be kept short and the vines close and compact. It also permits a reduction of old wood which is an important consideration since the accumulation of old wood lowers the quality of the fruit and tends to cause an uneven ripening of the clusters. When suitable fruiting wood cannot be found close in on the arms, canes are selected farther out on the arms, and a spur of two buds is left near the head of the vine to furnish a fruiting cane for the next year. The following year the old arms may then be cut back to these renewal spurs. Having selected the fruiting wood and provided for renewal spurs, all other wood is removed and the fruiting canes shortened to the number of buds the vines can carry.

Time of Winter Pruning.—The vines may be pruned any time after the leaves drop in the fall and until growth starts in the spring. In small plantings where most of the work can be done within three or four weeks it is better to delay the pruning until late winter or early spring. There will then be less danger of winter injury to the canes that are left for fruiting. In large vineyards the work will have to be done at all times that the weather permits. Pruning should not be done while the vines are frozen. The canes are then very brittle and are easily broken in handling.

The time at which the vines are pruned influences to some extent the time at which growth starts. As a rule, the earlier the vines are pruned the earlier growth starts in the spring. The pruning of vines planted in frosty locations and where there is danger of late spring frost should therefore be delayed until rather late in the season. By delaying the pruning until the buds near the terminal ends of the canes have started the buds at the basal ends of the canes may be delayed several days. In a large vineyard it would be impractical to delay pruning until this late in the season and it is doubtful if it would be advisable even where there are only a few vines because of excessive bleeding. The more so, as practically the same results can be secured by doing all the pruning except the cutting back of the fruit-

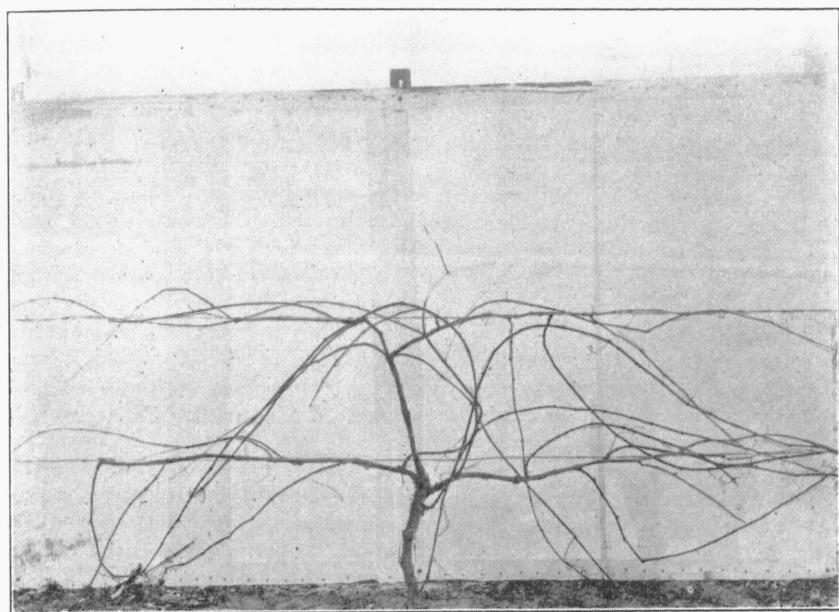


Fig. 9.—A bearing vine before pruning.

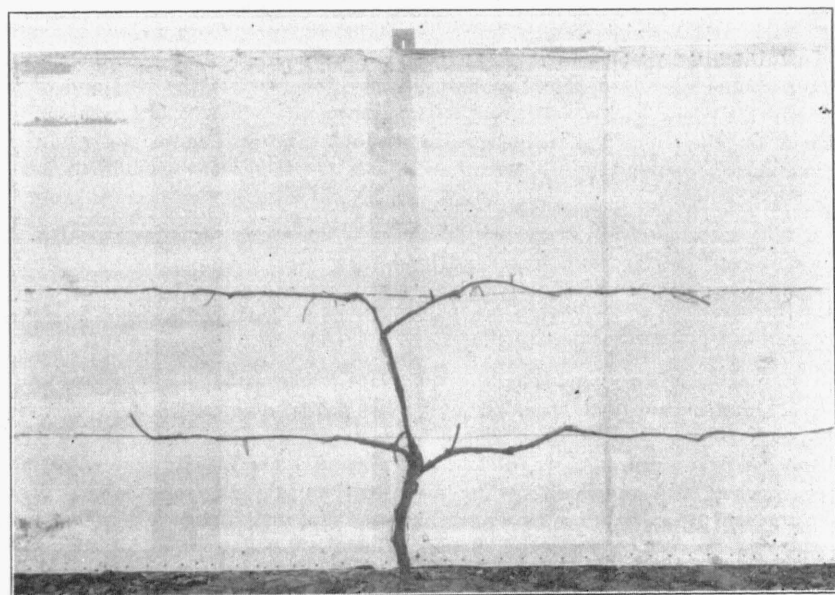


Fig. 10.—Same vine as in Fig. 8 after pruning to the single trunk 4-cane Kniffin system. Note the four renewal spurs close in to the trunk. These spurs are to produce next year's fruiting canes and in pruning the following year the arms of the vine will be shortened to these spurs.

ing canes before growth starts. The canes may then be cut back in short time and with little bleeding as soon as the buds near the ends of the canes have started.

Summer Pruning.—Summer pruning consists in pinching off the tips of growing shoots, cutting back the new growth (topping) and removing superfluous shoots. The effect is to concentrate the growth of the vines on the parts which remain. It also has a devitalizing or weakening effect on the vines which is sometimes very pronounced. The ratio of the concentrating effort to the weakening effect varies with the kind of pruning, the time and the amount. Topping or cutting back the new growth several feet has a decided weakening effect and if persisted in will practically ruin the vines. Pinching is less drastic than cutting back but unless the soil is fertile and the vines vigorous general pinching of all the shoots if continued year after year will soon decrease the yield and lower the quality of the fruit. The removal of superfluous shoots if done early just as growth starts will have a decided concentrating effect but if delayed until the shoots have grown several inches the weakening effect will be greater than the concentrating effect. Summer pruning is less harmful if done early or late in the season, the weakening effect being greatest during midsummer when growth is proceeding most rapidly and when the vines are in need of the greatest amount of food.

Summer pruning is less harmful to young vines than to old vines and may be used to advantage to direct their growth in a desired direction. With old vines about the only summer pruning that should be done is the removal of weak and injured shoots, those shoots that come from below ground, and those that arise from the trunk other than near the heads of the vines. Such shoots usually develop at the expense of the rest of the vine and their removal if done early will greatly strengthen the vines. The weakening effect on the vines and the decrease in future crops due to the summer pinching of fruiting shoots more than offsets the temporary gain in the size of the clusters.

The cutting off of several feet of the new growth is sometimes practiced to check overly vigorous vines and hold them within bounds but the most desirable method of checking excessive vegetative growth is by heavier fruiting. If necessary an additional wire might be added to the trellis to take care of the extra fruiting wood.

Renovation Pruning.—The tops of grape vines sometimes become very large, cumbersome and unwieldy and need to be renewed. Also, fungous diseases, insect injuries, mechanical injuries and the like sometimes make it necessary to renew parts of the above-ground portions of vines. With proper care such renewals can be made without the loss of a crop. For the renewal of an arm or the upper part of the trunk a shoot or cane from farther down on the old wood is selected and trained to take the place of the part to be renewed. When the entire top of the vine is to be renewed a shoot or cane coming from below ground must be used. If such a shoot or cane is not available it will be necessary to force the growth of a shoot from below ground by heavy pruning and by applying nitrate of soda or other nitrogenous fertilizer. If the vine is vigorous and it is given good care a

cane can be developed into a new arm or trunk in one year and a shoot in two years, after which the old or diseased wood may be removed.

Neglected vines and vines that have not been properly pruned and trained can also be brought into shape by using suckers and water-sprouts in forming new tops. Too much should not be expected, however. It takes several years to remodel such vines and it is seldom ever possible to bring neglected vines into as high a state of productiveness as vines that have been properly pruned and cared for from the start.

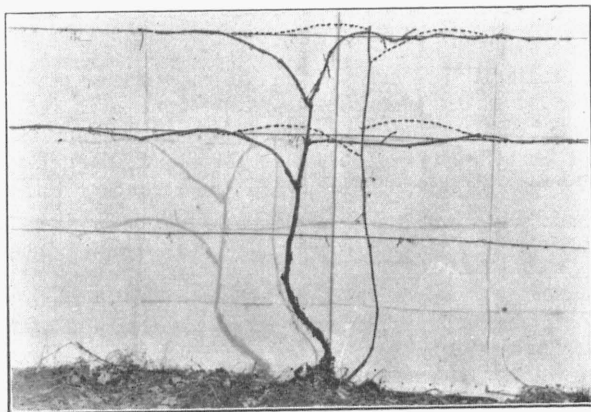


Fig. 11.—Showing how a sucker (shoot coming from below ground) may be used to replace the entire above ground portion of a vine. Next summer shoots to be used as fruiting wood will be developed as indicated by the dotted lines and the following winter the old trunk can be removed.

TREATMENT OF FROSTED VINES

The "buds" so called, that are produced during the summer in the axils

of the leaves of growing shoots and which appear in the winter as single buds at each joint on the canes are in reality groups of buds, usually three in number. Technically, they are known as eyes. Normally only the strongest and best developed bud from each eye produces a shoot, the two secondary buds remaining dormant. If, however, the primary bud or the shoot that develops from it is killed then one or both of these secondary buds may push out into a shoot and produce fruit. Grape vines are therefore able to recuperate from a late spring freeze or frost that may kill the first shoots. As a rule, only a partial recuperative crop will be produced since the secondary

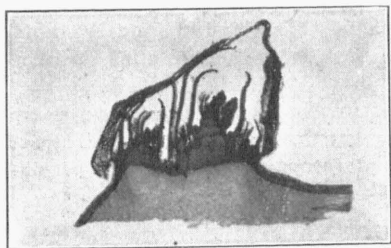


Fig. 12.—A vertical cross section through a grape eye showing the three buds normally present in a grape eye. All are enclosed within a common outer covering which gives to the eye the outward appearance of a single bud. The middle bud shows two well developed flower clusters. The bud at the left shows one cluster.

buds are not so well developed as the primary buds and the shoots coming from them produce fewer and smaller clusters than are produced by shoots from primary buds.

Unless the freeze or frost is severe enough to kill the first shoots to their bases they may continue their growth from lateral buds below the injury and few secondary buds will be forced out. This is probably what happens when only the flower clusters or tips of the shoots have been injured. Then as no more fruit clusters will be produced on the shoots or the laterals coming from them no fruit is produced, and this explains why there is sometimes a larger crop following a rather severe freeze than following a light freeze.

To profit to the fullest extent from the recuperative power of grapes it is necessary that frosted vines be carefully gone over and the injured shoots broken off close to the canes. It is important that the removal of the injured shoots be complete, and breaking them out is better than cutting them off. To prevent possible injury to the secondary buds the frost-injured shoots should be broken off sidewise.

The recuperative capacity of grapes varies with the variety and the care that the vines have received. Old, diseased, injured and neglected vines will not produce as large recuperative crops as young, healthy, and well cared-for vines. Some varieties produce secondary buds nearly as well developed as the primary buds and will produce a recuperative crop almost as large as the first crop.

INTERCROPPING

Where conditions are favorable, intercropping may be permissible, but as a rule it is not a profitable practice and is not to be generally recommended. Only on fertile land, and with the best of care can returns be secured without serious injury to the vines.

If an intercrop is grown, one should be chosen which requires about the same general care as the grape, does not compete too heavily for moisture, and will not overshadow the vines. It should also be a crop for which there is a ready market. Truck crops such as early potatoes, cabbages, tomatoes and the like most nearly meet these requirements. Corn and the small grains, as well as gooseberries, currants and other bush fruits, should not be grown. Crops that require cultivation late in the fall are also to be avoided.

Intercropping should not be practiced longer than the first two years after the vines are set. The grapes will by that time require the greater part of the space between the rows and further intercropping may result in permanent injury to the vines.

CULTIVATION

The grape requires rather intensive culture. Cultivation should begin as soon as the vines are set and should be frequent and thorough. The first two or three years after the vines are set are the most critical in the life of the vineyard and nothing should be spared to keep the vines healthy and vigorous. The number of cultivations required varies with the soil and the season, but they should be frequent enough to keep down weeds and to conserve moisture. Deep cultivation is advisable the first few years after the vines are set in order to force a deeper rooting of the vines and to prevent

injury from too deep cultivation in later years. After the vines come into bearing, cultivation should be shallow, especially next to the vines.

The first operation in the spring is the turning under of the cover crop; or, if there is no cover crop, the turning of the soil with a plow. The plowing should be shallow, not deeper than three or four inches, and the soil should be thrown away from the rows except on land that does not drain well. On such land the soil should be thrown to the rows, leaving a "dead" furrow in the middle to carry off the excess water that sometimes falls in the spring, gradually filling in the furrow as the season advances. In about a week or ten days after plowing, the ground should be leveled with a disk or heavy spring-tooth harrow. Subsequent cultivation consists in keeping down weeds, breaking the crust on the soil after rains and preventing the soil from becoming hard and compact. This work may be done with a disk, harrow or other implement suitable for keeping the soil properly stirred. Cultivation should cease about the last of July or from one to two weeks before the grapes begin to color. Late cultivation favors late growth and prevents the vines from properly maturing their wood, thus making them tender and subject to winter injury.

COVER CROPS

Under a system of clean tillage, the growing of cover crops is necessary in order to keep up the supply of humus in the soil. A crop that will live through the winter or one that will freeze down may be used. It may be either a legume or a non-legume. Rye is perhaps the most commonly used non-leguminous plant and, as it makes a very rank growth, it is a very desirable cover crop on soils deficient in humus. It should be sown not later than the first week in September, at the rate of $1\frac{1}{2}$ to 2 bushels to the acre. Spring oats sown in early fall at the rate of $2\frac{1}{2}$ to 3 bushels to the acre are very satisfactory for a non-legume that freezes down during the winter. One of the best crops, however, is cowpeas, which add nitrogen to the soil as well as humus. Cowpeas may be sown broadcast in late summer or drilled between the rows the first half of July. Other crops that may be used as cover crops are mammoth clover, winter vetch, soybeans, millet and the like. A rotation of crops alternating between a legume and a rank growing non-legume like rye is a good arrangement. With such a rotation, the greatest possible benefit will be derived from the use of cover crops.

Early in the spring, the cover crops should be plowed under, or if the cover crop is a winter-killing one, it may be worked into the soil with a disk. Plowing under cover crops in the fall is not advisable, since it is desirable to have the crop cover the ground during the winter. Cover crops such as rye and clover which live through the winter should be sown with a drill. If broadcasted, considerable hand hoeing may be necessary to clean the crops out of the rows.

FERTILIZERS

The use of fertilizers in the vineyard has not become a general practice. As a rule it has not been found necessary where careful attention has been given to spraying, cultivation, pruning, cover crops and other standard practices; and the use of fertilizers is not to be recommended unless all these other practices have been carried out. If the vines remain unproductive after

having been given good care in all other respects, and it has become certain that their failure has not been due to poor drainage, damage by frost or other causes, then fertilizers may be tried.

Reliable information on what fertilizers to use and their relative value is scarce. The information available, however, indicates that if fertilizers are to be used they should be nitrogenous fertilizers. Commercial fertilizers such as nitrate of soda or sulphate of ammonia may be used; or if the soil is deficient in humus, manure or a leguminous cover crop might be used, since in addition to acting as a nitrogen fertilizer, they increase the supply of humus in the soil. Even when manure or a leguminous cover crop is used, it might be well to supplement them with an early spring application of from 50 to 75 pounds of nitrate of soda or from 40 to 60 pounds of sulphate of ammonia per acre, since nitrogen in a quickly available form, applied just before the blossoms open, is of value in increasing the set of fruit.

Experimental work on the use of fertilizers for grapes is now being carried on, but until further information is available the excessive use of fertilizers is not recommended.

HARVESTING THE GRAPE

When and How to Remove From Vine.—Grapes will not ripen after they have been picked, and should not be gathered until fully ripe. Grapes that are picked before they are ripe are sour and lacking in flavor and do not hold up in shipment as well as fruit that is fully matured. As most varieties color before they are ripe, some experience and considerable judgment is necessary to tell just when the fruit is ready to pick. When fully ripe the stems of the clusters turn brown and shrivel slightly; the seeds separate readily from the pulp, usually turning from green to brown; and the berries develop their full flavor and aroma. Fully ripened fruit also has a characteristic color by which the experienced picker can tell whether the fruit is ripe or unripe without examining the clusters.

Grapes should be harvested by cutting off the clusters with a pair of shears, not by pulling them from the vines. In cutting the fruit, the clusters should be held by the stems. It is also important to place the fruit carefully in the picking basket or tray instead of dropping it. As soon as the trays or baskets are full they should be placed under the vines out of the sun until they can be gathered up and taken to the packing shed.

GRADING AND PACKING

Usually grapes are divided into but two grades, first grade and culls. The requirements for the first grade are as follows: the bunches must be of a good size for the variety, uniform in size, full and with few or no berries missing from the clusters; the berries must be clean, fully ripe and uniformly colored and must be free of insect injuries, fungous diseases, broken skins and other mechanical injuries, and must be relatively free of spray material. All grapes that do not meet these requirements are culls. Poor fruit seldom pays for the cost of grading and should be sold with little or no grading other than that which may be done in the field by the pickers. Needless to say, such fruit should not be packed in small containers and sold as table grapes.

After the grapes have been brought to the packing house, they should be allowed to wilt 4 to 6 hours before grading or packing begins. Wilting tends to prevent shattering and the breaking of the clusters in grading and packing, lessens shrinkage in transportation, and the fruit usually arrives on the market in better condition. Before the fruit is packed, all green and defective berries should be cut from the clusters. This is best done with a pair of shears or scissors specially made for the purpose.

Table grapes are usually packed in 2-quart and 4-quart climax baskets. Grapes for grape juice factories are packed in various styles of packages: 12-quart climax baskets, bushel and half-bushel baskets and open boxes—the last usually supplied by the factory. In packing table grapes, the bunches are placed in the baskets with the stems downward and packed tightly, the smaller bunches being used to fill in about the larger ones. The top of the fruit should be even and level and a little higher than the top of the basket, but not so high that the fruit will be crushed when the lid is put on. When shipping to grape juice factories, no particular skill is required in packing the fruit.

To comply with the net weight amendment of the Federal food and drug act the quantity of the contents of all packages containing grapes must be plainly marked on the outside of the container, either in terms of dry measure or in terms of net weight. For example, 4-quart climax baskets must be marked "Contents 4 quarts dry measure" or "Net weight 5 lbs." or with some similar statement. The more common practice is to mark grapes in terms of net weight. Allowance should then be made for shrinkage during transportation. In this connection it might be mentioned that there is also a Federal law which prohibits the shipment from one state to another of climax baskets either filled or unfilled of sizes other than those designated by law, namely 2-quart, 4-quart and 12-quart and of dimensions other than those specified by law.

INSECTS AND DISEASES

Grape Berry Moth.—This is the insect which causes most of the wormy grapes in Missouri. The caterpillars feed on all varieties but are especially destructive to grapes with tender skins and to those that grow in compact bunches. Affected berries at first show only a small purplish spot at the point where the insect has entered, but later become discolored and shriveled. Frequently several injured berries will be found more or less webbed together where the caterpillars have passed from one berry to another in the course of feeding.

CONTROL.—The grape berry moth can be easily and effectively controlled by spraying with arsenate of lead, using the poison at the rate of $1\frac{1}{2}$ pounds of the powder to 50 gallons of water. The addition of 1 pound of resin fish-oil soap to each 50 gallons of spray mixture is of value in increasing its adhesiveness. Two applications are necessary; the first as soon as the petals have fallen or the fruit has set, the second 10 to 14 days later. If the insect has been especially injurious, another application should be made early in July just as the caterpillars of the second brood begin to hatch. As bordeaux mixture for the control of fungous diseases is usually applied at the same time as the berry moth sprays are made, the arsenate of lead may be added to the fungicide instead of water.

As the grape berry moth pupates and lives over the winter on the grape leaves, these should be either raked and burned or left fully exposed to the weather. Fall plowing of the earth to the vines is undesirable as it covers the leaves and protects the hibernating pupae. Grass and weeds in the vineyard are also undesirable as they give more or less protection to the pupae, thus increasing the chances of their living through the winter.

Grape Curculio.—The curculio is injurious to the grape principally through its egg laying punctures and the subsequent development of the eggs into small grubs or worms which feed upon the pulp and seed of the berries. It is sometimes quite injurious, especially in the southern part of the state.

CONTROL.—Clean cultivation and the destruction of the hibernating places of the adult beetles is the first step in control. The second is to spray with arsenate of lead to kill the beetles. The first spray should be made as soon as the fruit has set, followed by a second application in about ten days and perhaps a third two weeks later.

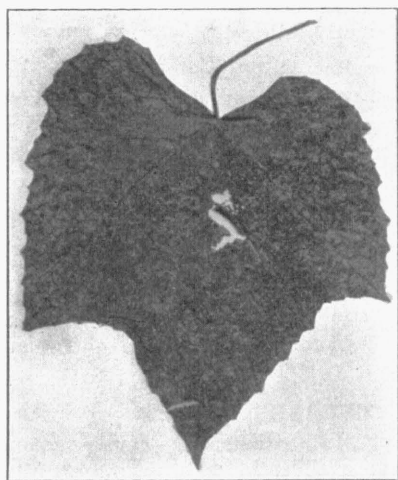


Fig. 13.—Work of the grape leaf hopper. The small light colored specks scattered over the upper surface of the leaf are the places where the insects have been feeding.

maturing of the fruit and for storage. As a result the grapes are often undersized, poorly colored and lacking in flavor, and the vines are unable to mature their wood properly and are stunted and so weakened as to fall an easy prey to other parasites.

CONTROL.—Clean cultivation, the destruction of hibernating places near the vineyard, and avoiding the planting of raspberries and blackberries near the grapes, are effective in holding the leaf hopper in check. Where the insect has been abundant in the past, the vines should be sprayed with nicotine sulphate at the rate of $\frac{1}{2}$ pint to each 100 gallons of spray. In applying the spray, care should be taken to wet the under sides of the leaves thoroughly, as it is necessary to hit this insect with the spray in order to kill it.

Grape Leaf Hopper.—This insect is found in every vineyard in the State. While the injury done is not as evident as that of some other pests, it has nevertheless damaged many vineyards. Lack of any effort to control it is making it more serious each year. The insects infest the lower surfaces of the leaves, puncturing them with their sharp pointed beaks and sucking the juices. The injured leaves at first show small yellowish spots as though some small insect had been chewing on the surface, but as the spots become more numerous, the leaves become pale yellowish-brown. The effect of the injury is to prevent the leaves from manufacturing food for the proper

One application, if made just before the first hatched nymphs develop wings, will kill the greater part of the first brood and as a rule no further spraying will be necessary. If, however, nymphs continue to appear, a second spray should be made about two weeks later.

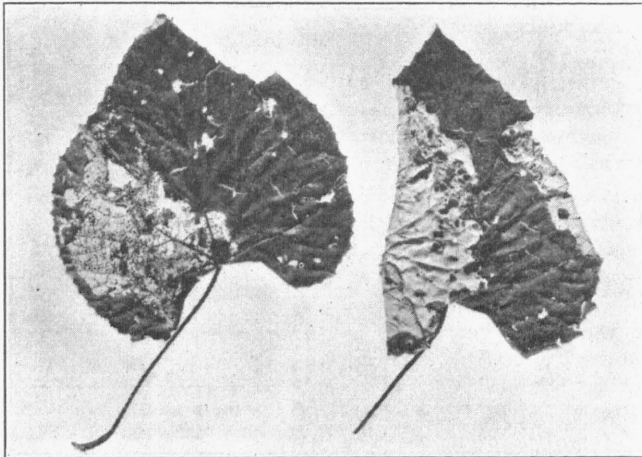


Fig. 14.—Work of the grape leaf folder. The leaf at the left has been spread out to show how the caterpillars skeletonize the inner surfaces of the leaves.

Grape Leaf Folder.—The grape leaf folder is sometimes a serious pest on neglected vines, but is seldom troublesome in vineyards that have been regularly sprayed with arsenate of lead. The first brood does but little damage, the larvae of the second brood being responsible for the many folded leaves seen during midsummer and early fall on wild and neglected vines. The larvae fold together the upper surfaces of the leaves and skeletonize them within the folded areas, the injury causing many of the leaves to drop prematurely.

CONTROL.—The regular spraying schedule as outlined for the grape berry moth is usually sufficient to hold in check the grape leaf folder, but in vineyards subject to attack and during serious outbreaks, special effort should be made to spray the foliage with arsenate of lead (1½ pounds to 50 gallons water) as soon as the first folded leaves are noticed. Another application should be made seven to ten days later. It is very important that these sprays be applied at the proper time, for once the leaves are folded it is impossible to reach the insects with the poison.

Grape Phylloxera.—This is a small plant louse which appears in two destructive forms, one producing the irregular wart-like galls so often found on the under side of grape leaves, the other attacking the roots, on which it produces swellings similar to those found on the leaves, and later causes their decay. The root inhabiting form, which is very destructive to *Vinifera* grapes such as are grown in California, is seldom injurious to our native American grapes, although occasionally it has seriously damaged Concord and some others of the *Labrusca* species and some of the *Vinifera* hybrids.

There is no control for the leaf gall producing form of the insect and grafting upon resistant stock is the only practical method of checking the ravages of phylloxera on the roots of susceptible varieties. The insect, although common, is of little economic importance in Missouri.

Flea Beetle.—As an insect of any importance, the flea beetle is comparatively new in Missouri and so far has been reported as serious in only a few parts of the state. It is the earliest insect enemy of the grape to appear in the spring, the small, shiny, steel-blue beetles eating into the swelling buds, injuring them so that they never develop.

CONTROL.—To control the beetles the vines should be sprayed with arsenate of lead at the rate of 3 pounds of the powder to 50 gallons of water as soon as the buds swell in the spring or as soon as the beetles make their appearance, followed in about a week with a second application of the same strength. The regular summer spraying for the control of the grape berry moth and other chewing insects is effective in killing the larvae that appear later in the season. Destroying all possible hibernating places is also effective in controlling the flea beetle.

Climbing Cutworms.—Many vineyards in Southwest Missouri have been greatly damaged during the past two or three seasons by climbing cutworms eating out the swelling buds and cutting off the tender young shoots. The attacks so far have been more or less localized, some vineyards suffering severely while others nearby have entirely escaped. Sometimes only certain parts of a vineyard will be attacked. The insect seems to be more prevalent in loose, gravelly soils and in vineyards that have been allowed to grow up in grass and weeds. Vineyards that have been given clean cultivation throughout the growing season and especially during midsummer have not as a rule been greatly troubled with cutworms.

CONTROL.—A band of tree tanglefoot applied to the wires, posts and trunks of the vines will prevent the worms from reaching the buds. Poisoned bran

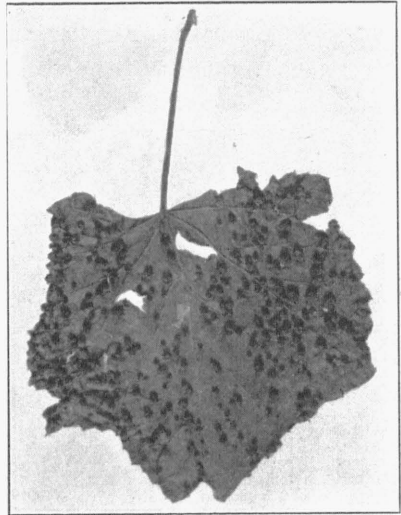


Fig. 15.—Under side of a grape leaf showing the irregular wart like galls caused by the grape phylloxera.

mash (see formula on page 34) for destroying the insects may also be sown broadcast at the bases of the vines.

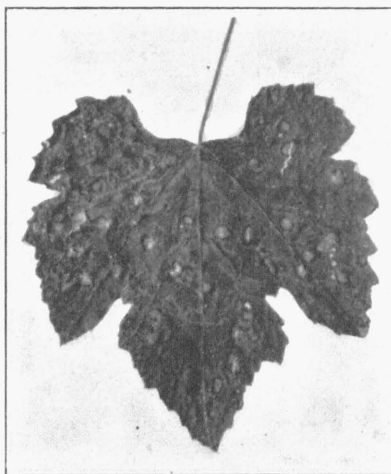


Fig. 16.—Grape leaf affected with black rot. Note the dark borders about the diseased areas. The centers of the spots are light brown or gray in color scattered over the surfaces of which are numerous small black pimples.

Black Rot.—Black rot is the most common and most destructive fungous disease of the grape in this section, probably doing more damage than all other diseases and insect pests combined. The disease is found every year but is more abundant in wet seasons than dry ones. Under favorable conditions it may cause a loss of 50 to 100 per cent of the crop, besides seriously injuring the vines by its attack on the leaves and shoots. All varieties are subject to attack though some are more susceptible than others.

All green and growing parts of the vine are susceptible to black rot, though the fruit is usually the most severely affected. The disease appears first on the leaves, producing reddish brown, circular spots with darker margins. Scattered over these spots are numerous, small, dark brown pimples or pustules. When numerous, two or more spots may run together to form large irregular areas. On the stems, tendrils, leaf petioles, etc., the disease appears as small dark brown sunken spots or cankers. Affected berries at first show a small whitish spot. As the spot increases in size it becomes brown and sunken and numerous black pimples or pustules appear on the surface. The rot soon spreads over the entire berry which becomes a shriveled black mummy.

CONTROL.—Black rot can be effectively controlled by thorough and timely spraying with bordeaux mixture. (See spraying schedule on page 31).

Downy Mildew.—Downy mildew is frequently found on both wild and cultivated vines throughout the state but has never caused any serious losses. It affects the leaves principally, though the berries, stems, leaf

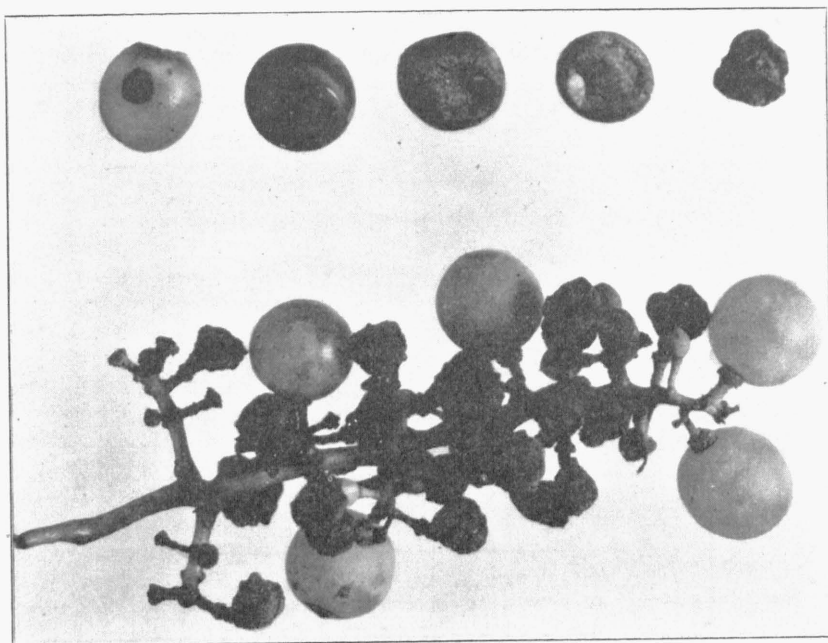


Fig. 17.—Black rot on the fruit. The berries at the top show the disease at different stages of development. Black rot first appears on the fruit as a small light colored spot which soon becomes blackish in appearance. The rot develops rapidly and soon involves the entire berry which dries into a black mummy.

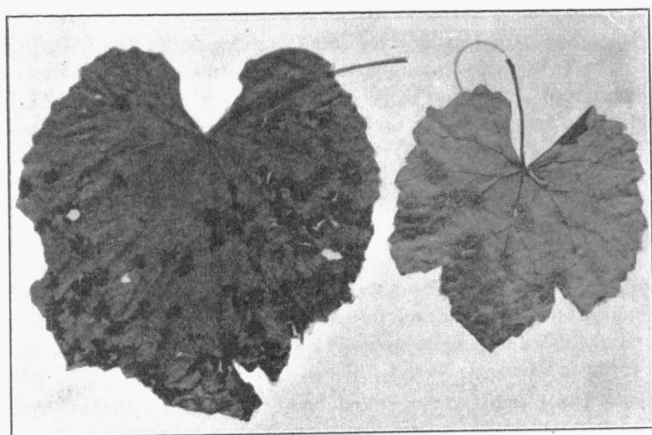


Fig. 18.—Downy mildew on grape leaves; at left the disease as it appears on the upper surfaces of the leaves; at right the appearance of the disease on the lower surfaces of the leaves.

petioles and other green and succulent parts of the vine are subject to attack. On the upper surface of the leaves it produces irregular greenish yellow spots which later become reddish brown. These same spots on the under surface of the leaves are covered with a thin grayish white downy growth. If the fruit is attacked while small, it also becomes covered with a grayish white downy growth, but if nearly grown the disease appears as a brown rot.

CONTROL.—Downy mildew is controlled by the same spraying used to control black rot. (See spraying schedule on page 31).

Anthracnose.—Grape anthracnose, sometimes called bird's eye rot because of the peculiar spots produced upon affected berries is a very serious disease in some localities, but in general has not caused much trouble in Missouri. Fortunately, Concord is rather resistant to the disease, but Niagara, Diamond, Brighton, Agawam, Catawba and a number of other varieties are very susceptible. On susceptible varieties the disease is difficult to control.

All green parts of the vine are subject to infection, but the disease is more common and conspicuous on the shoots and berries. On the shoots it produces small reddish brown, circular spots. As the spots enlarge the centers turn gray and become sunken. The spots when numerous tend to run together and form irregular sunken cankers. On the fruit the disease appears first as small dark brown spots. As these increase in size the center becomes grayish white and somewhat sunken. Surrounding the gray center is a band of bright red giving to the spots the characteristic bird's-eye appearance. The affected areas remain firm for a time, but the berries finally shrivel and become dry and hard.

CONTROL.—Cut out and burn all diseased wood. Spray the vines thoroughly with liquid lime-sulphur at dormant strength (1—8) just before growth starts in the spring. Follow this during the growing season with bordeaux mixture, making applications as directed for black rot.

SPRAYING SCHEDULE

Dormant Spray.—Apply winter strength lime-sulphur solution (1 gal. of the commercial concentrate to 8 gals. of water) before the buds swell in the spring, for scale and anthracnose. If only anthracnose is present, bordeaux mixture 8-8-50 may be used in place of the lime-sulphur. If neither scale nor anthracnose is present, this spray will not be needed.

Bud Spray.—This is a special spray made for flea beetle only and need not be made unless flea beetle is present. Apply as soon as the buds swell and repeat one week later, using 3 pounds of the powdered arsenate of lead to 50 gallons of water.

First Regular Spray.—This spray is a part of the regular spraying program for grapes and, except in vineyards relatively free of black rot, should always be made. Apply when most of the shoots show the second or third leaf, using bordeaux mixture 4-4-50 for black rot and anthracnose, and arsenate of lead (dry) 3 pounds to 50 gallons for flea beetle. If flea beetle is not present, the lead may be omitted.

Second Regular Spray.—Apply just before the blossoms open, using 4-4-50 bordeaux for black rot, anthracnose, downy mildew and other fungous diseases, and arsenate of lead (dry) 1½ pounds to 50 gallons of water for

curculio and other chewing insects. This is an important spray and should always be made.

Third Regular Spray.—Apply just as the petals fall or as soon as the fruit has set, using 4-4-50 bordeaux for black rot, anthracnose, downy mildew, and other fungous diseases, and arsenate of lead (dry) $1\frac{1}{2}$ lbs. to 50 gal. for curculio, berry moth, and other chewing insects. Also an important spray which should always be made.

Fourth Regular Spray.—Apply 10 to 14 days after the third spray, using bordeaux 4-4-50, arsenate of lead (dry) $1\frac{1}{2}$ pounds to 50 gallons and nicotine sulphate at the rate of $\frac{1}{2}$ pint to each 100 gallons of bordeaux mixture for black rot, anthracnose, downy mildew, curculio, berry moth, leaf folder, and the grape leaf hopper. This is the most important spray for the leaf hopper, and care should be taken in applying this spray to thoroughly cover the under sides of the leaves. This is also an important spray for grape curculio.

Fifth Regular Spray.—Apply in about two weeks after Number 4, or about the first of July, using the same materials at the same dilutions as used in the fourth spray.

Sixth Regular Spray.—Apply two weeks after the fifth spray or about the middle of July using bordeaux 4-4-50 for black rot and arsenate of lead (dry) $1\frac{1}{2}$ pounds to 50 gallons for chewing insects. This spray is seldom necessary in North Missouri and is usually omitted; but it should be made in South Missouri.

Later Sprayings.—The above regular foliage sprays if properly made are usually sufficient except for varieties very susceptible to the attack of black rot and in warm damp summers favorable to black rot, when one or two additional sprayings at intervals of ten days to two weeks may be necessary. To prevent spotting the fruit, some non-staining spray such as ammonical copper carbonate should be used. No arsenate of lead should be added to these later sprays unless chewing insects are present in destructive numbers. When used, add the powdered arsenate of lead at the rate of 1 pound to each 50 gallons of spray mixture.

SPRAY MATERIALS

Bordeaux Mixture.—Standard bordeaux composed of 4 pounds of copper sulphate and 4 pounds of stone lime to 50 gallons of water and known as 4-4-50 bordeaux, is the strength commonly used in spraying grapes. To prepare a 4-4-50 bordeaux mixture, dissolve 4 pounds of copper sulphate in 25 gallons of water and in a separate vessel slake 4 pounds of stone lime, using just enough water to keep the lime from becoming dry. Then add enough water to make up to 25 gallons and pour the two solutions simultaneously into the sprayer.

When considerable bordeaux mixture will be needed it is more convenient to prepare stock solutions of copper sulphate and of lime. Stock solutions of copper sulphate are usually made by dissolving the copper sulphate in water at the rate of 1 pound of the copper sulphate to 1 gallon of water. If suspended in a bag near the top of the water, the copper sulphate will dissolve in a few hours. Wooden or stoneware vessels should be used for holding or handling copper-sulphate solutions. Stock solutions of lime are made by weighing out a definite amount of stone lime and slaking with

a small quantity of water and after slaking adding enough water to make as many gallons of mixture as there were pounds of lime. This gives a stock solution of copper sulphate with 1 pound of copper sulphate to 1 gallon, and a stock solution of lime with 1 pound of stone lime to 1 gallon.

To make 50 gallons of a 4-4-50 bordeaux mixture from the stock solutions, fill the sprayer about two-thirds full of water and add 4 gallons of the copper sulphate solution. Then while the mixture is being agitated pour in 4 gallons of the lime stock solution, and add enough water to make a total of 50 gallons. One hundred or two hundred gallons of bordeaux mixture may be prepared in the same way, using two times and four times the amount of the stock solutions respectively as used above. The stock solutions should be thoroughly stirred each time before using.

Very good bordeaux can be made from fresh hydrated lime and this may be used when it is impossible to obtain good stone lime. However, one-third more hydrated lime is needed than stone lime; that is, 6 pounds of the hydrated lime is necessary for each 50 gallons of bordeaux. Air slaked lime should never be used in making bordeaux mixture.

Ammoniacal Copper Carbonate.—Ammoniacal copper carbonate is not as effective a fungicide as bordeaux mixture and is more likely to burn, but is of value in spraying grapes during the few weeks before ripening time when spotting the fruit with bordeaux is undesirable. Ammoniacal copper carbonate solution leaves no stain on the fruit unless arsenate of lead has been added. It is made by dissolving copper carbonate in ammonia water in the following proportions:

Copper Carbonate	6 oz.
Ammonia (26° Baumé)	3 pts.
Water	50 gal.

To prepare the solution add the copper carbonate to about 2 pints of the ammonia to which a little water has been added and shake to dissolve the copper carbonate. If it does not all dissolve add more ammonia, continuing to add the ammonia until all or nearly all of the copper carbonate has been dissolved. Do not use more than 3 pints of ammonia for each 50 gallons of spray, even though all the copper carbonate is not dissolved. A small portion of undissolved carbonate in the spray is more desirable than too much ammonia.

Lime-Sulphur Solution.—Lime-sulphur should not be used as a summer spray on grapes, but only as a winter spray for scale or anthracnose. Commercial lime-sulphur usually tests 32° to 33° Baumé and as a winter spray for grapes should be diluted at the rate of 1 gallon of the concentrate to 8 gallons of water.

Arsenate of Lead.—Arsenate of lead is a stomach poison used in controlling such biting or chewing insects as the grape berry moth, curculio, leaf folder and the like. The powdered arsenate of lead is usually used at the rate of 1 to 1½ pounds, to 50 gallons of spray. When arsenate of lead is used alone, from one to two pounds of stone lime should be used with each 50 gallons of the spray; but when combined with bordeaux mixture, no lime is necessary. Before the powdered arsenate of lead is added to the spray, it should be made into a thin paste with a little water.

Nicotine Sulphate.—This is a nicotine extract from tobacco that has been treated with sulphuric acid to render the nicotine more stable. It is a contact poison used against such soft-bodied sucking insects as aphids and leaf hoppers. The standard commercial product contains 40 per cent nicotine and is diluted at the rate of $\frac{3}{4}$ pint to 100 gallons of spray for grape aphids and $\frac{1}{2}$ pint to 100 gallons of spray for leaf hoppers. Commercial nicotine preparations are compatible with all the commonly used spray materials and may be safely combined with them when aphids or leaf hoppers are present. When used alone 2 to 3 pounds of soap should be dissolved and added to each 50 gallons of water before the nicotine is added. The soap aids in liberating the nicotine and adds to the spreading qualities of the spray.

Poisoned Bran Mash.—Poisoned bran mash, although not a spray material, is nevertheless an insecticide preparation and will be so considered here. It is of value in controlling the climbing cutworm and is made according to the following formula:

Paris green (or white arsenic)	$\frac{1}{4}$ pound,
Bran	5 pounds,
Molasses	1 pint,
Orange or lemon	1 fruit,
Water	enough to moisten.

Mix the poison and dry bran. In a separate container add the molasses and fruit juice to the water; also grind or cut up the pulp and add it. Then mix the sweetened water with the bran and poison. The poisoned mash should be made into small balls and scattered about the bases of the vines late every evening as long as cutworms remain troublesome.

SPRAYING EQUIPMENT

The type and size of a spraying outfit for grapes depends upon the size of the planting. Where there are only a few vines to be sprayed a small compressed air or bucket pump sprayer will suffice. For vineyards up to

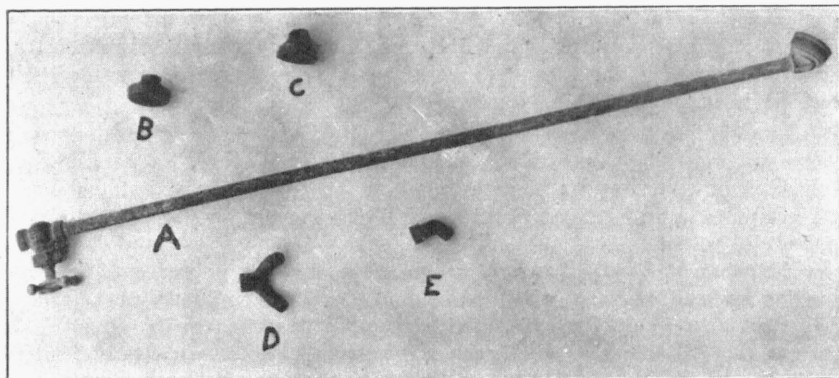


Fig. 19.—A Spray rod made of quarter inch gas piping and fitted with an angle nozzle and a straight cut-off; B, straight nozzle; C, angle nozzle; D, angle Y for use with two straight nozzles; E, crook for use with one straight nozzle.

one or two acres a barrel pump is satisfactory. For larger acreages a power sprayer is needed. Outfits specially assembled or designed for spraying grapes may be used, though ordinary orchard power sprayers are more commonly used with just as satisfactory results. The size of the sprayer will depend on the number of nozzles it is desired to operate. A sprayer with a pump capacity of $3\frac{1}{2}$ to 4 gallons a minute will supply one lead of hose with two nozzles or two leads of hose with single nozzles and is large enough for small vineyards. For large vineyards outfits of greater capacity are desirable. Sprayers with a pump capacity of 8 to 9 gallons a minute will operate six nozzles and are as large as can be economically used in vineyard spraying.

Under Missouri conditions the so-called trailer method of spraying in which the nozzles are operated by hand is to be preferred to stationary nozzles. By operating the nozzles by hand all parts of the vine can be reached and the fruit and foliage thoroughly coated with spray material, thus affording better protection against diseases and insects. In spraying for the grape leaf hopper it is absolutely necessary to operate the nozzles by hand if the under sides of the leaves are to be reached properly. Hose for trailers is usually 35 to 50 feet long. When using two leads of hose it is desirable to have one somewhat longer than the other so that the men handling the rods can keep out of one another's way. With large capacity outfits three leads of hose can be used to advantage, one directly behind the sprayer and the other two held over the rows by means of a support fastened to the back of the sprayer in the middles on either side. The rods should be about 3 feet long and may be either bamboo or made of quarter-inch gas piping.

The nozzles should be of the large-chambered disc type. Either angle nozzles or straight nozzles with a crook are satisfactory when used singly; but for clusters of two, straight nozzles with an angle Y will be found easier to set at the correct angle for proper spraying. For the best work the rate of discharge of each nozzle should be between 1 and $1\frac{1}{2}$ gallons a minute at 200 pounds pressure.

GRAPE GROWING IN MISSOURI

Missouri was one of the leading grape producing states of the country from 1870 to 1900. Even as late as 1919 Missouri was seventh among the states of the Union in production of grapes.

Revived interest in grape growing in Missouri within the last three years has led to the planting of thousands of acres of commercial vineyards especially in the southern part of the State.

The most desirable grape soils are the brown loess soils along the Missouri River and parts of the Mississippi River. The limestone soils of South Missouri with the porous clay subsoils found in many parts of the Ozarks are also excellent grape soils.

For use on a commercial scale in Missouri only two varieties of grapes are recommended, namely; Concord and Moore Early. For home use and the local market a succession of varieties is recommended in the order of their ripening, as follows: Eclipse, Winchell, Moore Early, Delaware, Diamond, Worden, Brighton, Concord, Niagara, Goethe, and Catawba:

Grape vines may be propagated by cuttings, by layering, or by grafting. It is usually more satisfactory to buy plants from a reliable nursery than to propagate them.

One-year-old vines are most desirable for setting. They may be planted either in fall or spring, though spring planting is preferable. Rows should be 10 feet apart for commercial plantings, with the vines 8 to 10 feet apart in the row.

Training the vine to the four-cane Kniffin system is recommended, using a two-wire trellis with the lower wire 2½ to 3 feet from the ground and the upper wire 2 to 2½ feet above the first.

Pruning for the first two years should have as its object the development of a vigorous root system, and should not allow vines to fruit prior to third year.

Vines may be pruned any time after the leaves drop in the fall and until growth starts in the spring; but the work should not be done when the vines are frozen.

Grapes require intensive cultivation, beginning as soon as the vines are set and continuing as a frequent and thorough practice.

The most important insect enemies of the grape are the grape berry moth, grape curculio, grape leaf hopper, grape leaf folder, grape phylloxera, flea beetle and climbing cutworm. The diseases affecting grapes in Missouri are black rot, downy mildew and anthracnose. Both insects and diseases can be controlled by spraying, by use of poisoned bait and by choice of resistant stocks.

Grapes should not be gathered until fully ripe, for they will not ripen after removal from the vine.