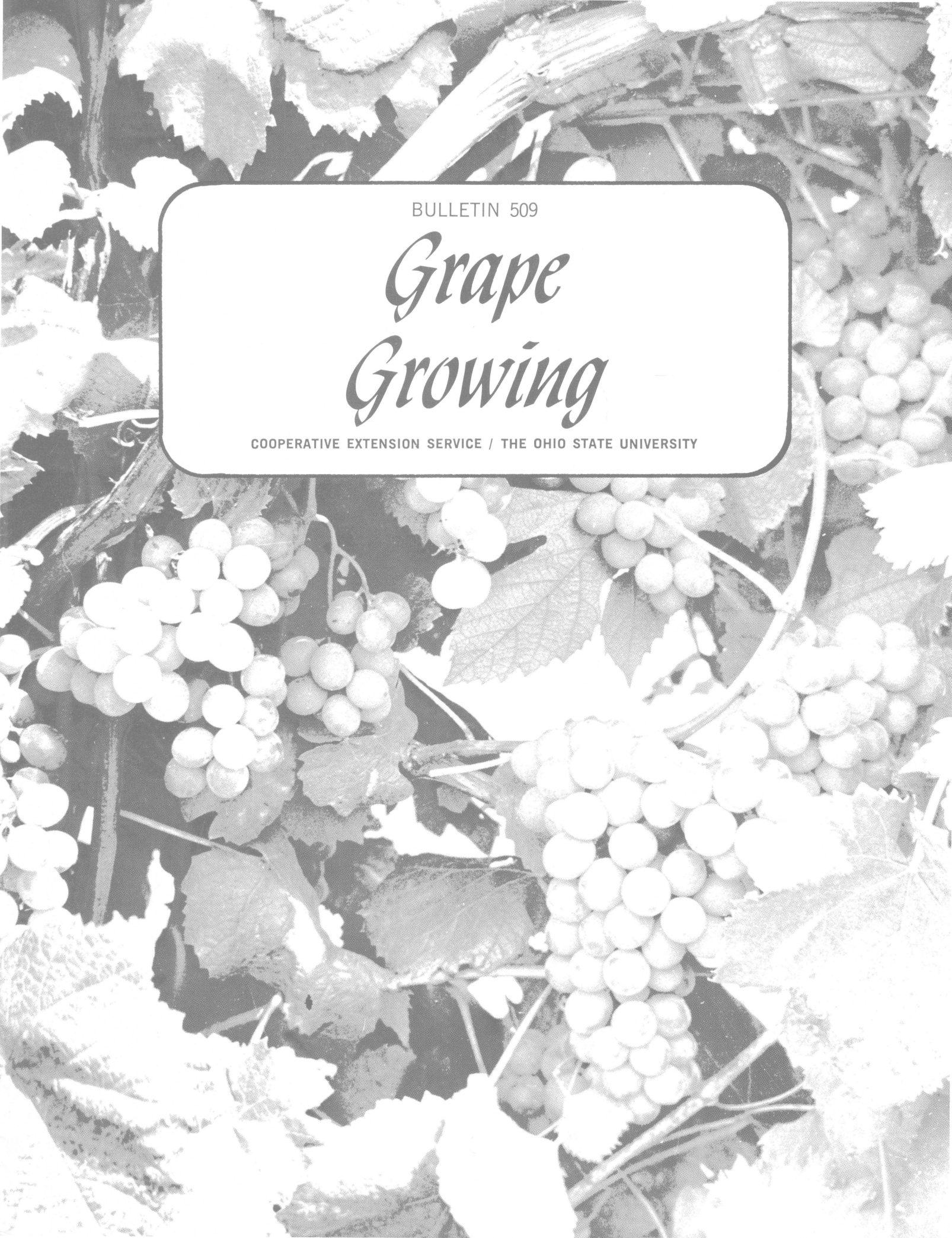

BULLETIN 509

# Grape Growing

COOPERATIVE EXTENSION SERVICE / THE OHIO STATE UNIVERSITY

# Grape Growing


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Ohio's increasing population provides a ready and expanding market for fresh grapes and grape products. The many new cultivars[1] make it possible to produce grapes on a wider and more diversified scale. This is especially true for marketing fresh grapes through roadside or farm markets, or for processing into wines and such new products as grape juice concentrates. New techniques and developments in vineyard practices are making possible higher yields of grapes per acre, hence the opportunity for greater returns from investment and labor.

Commercial grape growing in Ohio has a long and colorful history. It began with the work of Nicholas Longworth, a young lawyer who moved from New Jersey to Cincinnati in 1803. His interest and efforts in grape growing brought him the distinction of being the "father of American Grape Culture." In 1825, he received the Catawba Cultivar from John Adlum of the District of Columbia, who introduced it about 1823 as the first dependable American grape. Longworth disseminated the new grape, became a promoter for the region in which he lived, and made Cincinnati the center of what was then the foremost grape growing and wine producing district in the country. As a result, the Ohio River became known as the "Rhine of America."

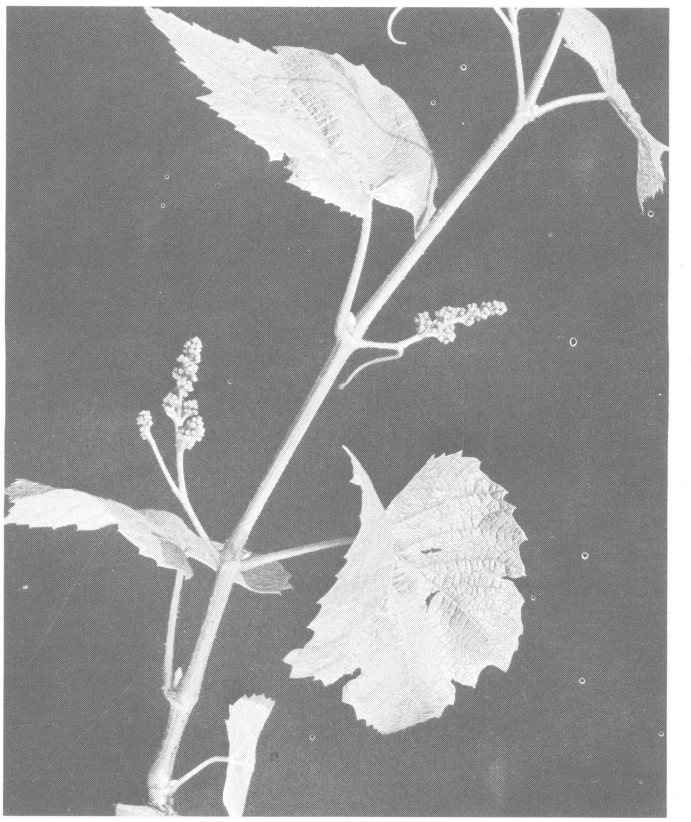
By the mid-1800's, vineyards in the Cincinnati district were plagued with what was called a "terrible sickness." Leaves yellowed and fruit failed to ripen properly. Undoubtly, the "sickness" was due to a combination of insect and disease injuries and nutritional deficiencies. Black rot and mildew were probably foremost among the causes. Within a few years, grape production of the district began to decline and large numbers of vineyards were pulled out. About this time the first commercial vineyards were beginning to show up in the Lake Erie region.

Vineyard development in Northern Ohio during 1865-66 progressed at such a rapid pace it became known as the time of the "grape fever." The early success of grape growing along the shore and on the islands of Lake Erie attracted wide attention and promoted planting of a large number of vineyards within the next few years. The extent of new plantings was limited only by the supply of vines. The state's acreage of grapes in 1874, after 10 years of planting, was estimated at 10,983 acres. It reached its peak of 1889 with some 28,000 acres.

Today, commercial grape production remains concentrated in the Lake Erie region. According to the 1964 U.S. Census of Agriculture, Ohio had at that time a total of 2,514,163 vines of which only 142,084 vines (236 acres) were of non-bearing age. The total acreage was slightly over 4,000 and remained about the same through 1967.

Production for the state in 1965 amounted to 21,500 tons, or an overall average of about 5 tons per acre. In 1966, 90 percent of the present acreage was planted to the Concord cultivar. The bulk of the Concord crop moves to processing plants outside of Ohio. In the future, this trend could be reversed with increased processing facilities developing in Ohio.

[1] The term cultivar replaces that of variety.



**Growth and fruiting habit of the grape vine: Flower clusters develop at the 3rd, 4th, and 5th nodes, each opposite a leaf. Small shoots develop in the axils of some leaves.**

## THE GRAPE VINE

The grape in many ways is fundamentally similar to other fruit crops in its manner of growth. However, it is sufficiently different to warrant some special study in order to understand the application of many cultural practices.

Grape flowers and fruit clusters are born only on the new shoots arising from dormant buds. These buds were formed in the axils of leaves the previous season. They are classed as compound buds. That is, a large bud or "eye" contains a group of 2 to 5 separate, smaller buds. Upon initiation of growth in the spring, the primary or central bud breaks dormancy and produces the fruiting shoot. This shoot may, on young vines, remain entirely vegetative and produce no fruits.

Spring frosts may occasionally kill the tender primary shoot in its early stages of growth. In this case, one of the smaller buds in the "eye" develops a shoot that may or may not bear fruit. It is normally less vigorous and much less productive than the primary shoot. This characteristic of the grape, however, does permit development of a partial crop even though the primary shoots are lost. Severe spring frosts may kill both primary and secondary buds in the "eye". In such cases, fruit production is lost for that season, and the remaining shoot growth may be extremely vigorous.

As the new primary shoot develops, flower clusters are formed, each opposite a leaf. Where a flower cluster does not develop, a tendril may grow opposite the leaf. Each species of grape has a definite number of flower clusters per shoot. Location of these clusters on the shoot is also specific. The American grape (Vitis labrusca) characteristically forms 2 to 4 flower clusters per shoot. These are usually at nodes 2, 3, 4 and 5 from the base of the shoot. Many species of grape form only two flower clusters per shoot. On the other hand, French hybrids as a group, tend to flower very prolifically, having 5 or more clusters per shoot.

The location and number of flower or fruit clusters on the shoot is a factor to consider in determing the vine training and pruning system. One reason for leaving longer but fewer canes on American than on European grapes is that a greater number of flower clusters are born per shoot on American vines. French hybrids, however, have a greater number of clusters born on the first 2 or 3 shoots, hence a greater number of canes, but shorter in length, are left after pruning.

The grape fruit cluster, morphologically, is a modified tendril. Whether a tendril or a flower cluster develops is determined by the genetic code of the vine. The number of flower clusters that may develop from a single dormant bud and mature fruits is determined to a great extent by vine vigor and growing conditions the previous season.

During the growing season, new compound buds develop in the axils of leaves on the shoots. These are similar to the dormant buds from which the shoots developed. Frequently during the growing season, a short weak shoot is produced on the axil of the leaf adjacent to the bud. After the leaves fall, the term "cane" is applied to what was the shoot. It is from the canes that next year's fruiting wood is selected at pruning time and from which propagation wood is taken.

The growth habit of the grape vine makes some kind of support necessary for commercial or even home production of grapes. The support can be wire trellises, fancy arbors or any other kind of structure desired for a specific purpose or design. The function of the vine support is twofold. It holds the vine up where it can be managed and cared for properly and efficiently. It also makes possible the exposure of a greater portion of the foliage to sunlight, thus predisposing the vine to greater bearing surface. Even with the use of supports, pruning cannot be neglected or else vines will become unmanageable and unproductive.

## LOCATION OF THE VINEYARD

Climatic conditions in many sections of Ohio are favorable for growing American as well as many other types of grape cultivars. Most American and French hybrid grapes can be grown successfully where the frost-free period is from 150 to 180 days in length.

The longest frost-free growing seasons are found along the shores of Lake Erie, on the off-shore islands, and in the southern part of the state bordering the Ohio River. Information presented in climatological charts is general. Therefore, individual sites which have more or less desirable conditions may be found within any general area. It is important to evaluate each site individually and select cultivars in relation to the length of growing season for a given area of the state.

If the growing season is too short for a particular cultivar, fruits may fail to mature properly. They will be poor in quality and low in sugar content at harvest time. In addition, the vines may not mature properly in the fall, thus predisposing them to possible winter injury.

Disease problems in vineyards may be related in part to climate, especially humidity and temperature. Diseases such as black rot and mildew tend to be more prevalent under warmer temperatures with high relative humidity than in drier, cooler areas. Consequently, spray programs may need altering from one climatic condition to another, as from Northern to Southern Ohio.

Selection of a site that offers desirable climatological characteristics can do much to reduce cultural problems and assure success of the enterprise.

## SITE AND SOIL

The best vineyard sites are those with maximum sunlight, the greatest freedom from frost injury, and good soil drainage. The most frost-free sites are those above the level of surrounding areas. Cold air drains from higher sites into lower areas. Avoid low areas in which cold air may settle because substantial reduction in yields is likely where low temperature injury prevails. Sites south and east of large lakes often provide favorable air drainage and temperature conditions in both spring and fall. Even in these locations, vineyards on higher elevations are less subject to frost damage than those in low areas.

Generally, sites with steep slopes should be avoided in commercial plantings because of soil erosion and difficulty of operating vineyard equipment. Cool temperatures on slopes to the north often delay vine growth enough in the spring to avoid frost damage. The opposite effect may occur on a southern slope, resulting in somewhat earlier spring growth and increased risk of frost injury. A western slope may have the disadvantage of being exposed to prevailing winds which, in some areas or seasons, could be strong enough to cause vine damage and special trellising problems.

On many sites where direction of slope permits, it may be advantageous to plant rows in an east-west direction. By so orienting the rows, there is less shading by the trellis, hence better leaf exposure. In addition, prevailing winds help dry dew and rain from the foilage quicker. This helps reduce disease problems.

Grapes can be grown on a wide range of soil types. However, highest yields and most efficient production are achieved on soils with good internal drainage. Under good management, vineyards have produced satisfactorily on soils ranging from gravelly loams to heavy clay and silty clay loams. Avoid soils that are persistently wet during the growing season. These soils have an impervious subsoil or other imperfect drainage problems. In a poorly drained soil, roots may penetrate only a couple of feet or less, whereas on a deep, well-drained soil they will penetrate six feet or more. Growers who use soils with only fair drainage must understand that management of these soils will be more exacting and expensive, and satisfactory yield may not be attained.

Characteristics of the subsoil are important considerations in choosing a vineyard site. These factors will often indicate the nature of internal drainage. For example, a bright, uniformly yellowish-brown or brown subsoil indicates good internal drainage. Subsoils showing slight mottling of yellow, gray, and orange indicate only moderate drainage. Poorly drained subsoils are

characterized by greater mottling or, in some cases, by a rather uniform dark gray color. Soil maps available through local Soil Conservation Service offices are helpful in determining soil drainage characteristics and in evaluating potential sites. However, these are not substitutes for taking soil borings on the site and making visual evaluations of the subsoil.

While grapes produce best on the more fertile soils, a highly fertile soil is not essential. Through proper fertilizer applications and soil management practices, a soil low in fertility can be improved economically to the point where high yields of fruit are possible.

It is generally more economical to improve soil fertility than to compensate for poor soil and air drainage of the site. Thus, drainage considerations are usually more significant than soil fertility in site selection.

## SELECTION OF CULTIVARS

Selection of the proper cultivars to plant is a major step towards successful viticulture. Commercial growers need to give serious thought to the market outlet and the requirements of the processor or consumer who will purchase the crop.

Following are some of the more important considerations to keep in mind when choosing a cultivar:

**Fruit characteristics**—fruits outstanding for the use or market intended.

**Vine characteristics**—vines possess the inherent capacity for producing consistently high yields under anticipated growing conditions.

**Vine hardiness**—tolerant of low winter temperatures and/or spring frosts; vines that are characteristically winter hardy and withstand spring frost periods.

**Resistance to or tolerance of diseases and insects**—may exhibit resistance to or tolerance of one or more diseases or insects.

**Season of ripening**—fruits mature during a desirable period for use or marketing or can be satisfactorily stored for a future marketing period.

For a new grape cultivar to have real commercial value, it must first produce fruit superior or at least equal to the quality accepted in cultivars presently available. Not only must the fruit quality be high but also the vine characteristics and productivity must be superior to those of the cultivar being supplanted. It is difficult to obtain a new cultivar with both fruit and vine characteristics superior to one already established, but this is the objective of grape breeders. A new cultivar is often quite worthy of planting on a trial basis to determine its adaptability to specific growing conditions. The trial planting should precede any extensive commercial planting.

Hybrid cultivars are also being developed by grape breeders in this country and Canada. These cultivars are often referred to as American hybrids and result largely from crossing two or more American type cultivars. Many of the newer American hybrids, however, involve crosses of V. labrusca with one or more grape species such as V. vinifera, V. aestivales or V. riparia.

Among the newer American hybrid cultivars are Himrod, Bath, Schuyler, Fredonia, Buffalo, and Steuben, all developed at the New York Agricultural Experiment Station. Certain cultivars of both the American hybrid and the French hybrid offer possibilities of high yields per acre in Ohio.

Many older cultivars of the American type grape are thought to have more than one species involved in their development but, in all, the V. labrusca characteristics predominate.

For convenience, all cultivars that have been developed from the Vitis labrusca species or from crosses that exhibit predominantly labrusca characteristics are referred to as American grapes. This is to distinguish this broad group of cultivars from the French hybrids and the strictly vinifera types grown in other parts of of the world. Modern American type and French hybrid grapes are self-fruitful, thus cross-pollination is not of importance in cultivar selection.

The Old World or European type (Vitis vinifera) constitutes the bulk of production in California and other southwestern states. Cultivars of the European type include Thompson Seedless, Tokay, Malaga, Muscat and others. A common characteristic of the European grape is adherence of the skin to the flesh of the fruit, commonly referred to as "tight-skinned." European cultivars generally are not winter hardy enough for growing in Ohio.

The Muscadine type ( Vitis rotundifolia ) is grown primarily in the South Atlantic and Gulf States. Cultivars include Scuppernong, James and Mish among several others. Muscadine grapes are not suited to Ohio's growing conditions.

Three basic types or species of grapes are commercially produced in America today. The American type ( Vitis labrusca ) has widest distribution throughout the northern half of the country. Major producing areas are the Great Lakes Region, Pacific Northwest, the midwest and eastern states from Delaware to New England. Of primary interest in Ohio are the cultivars of this type which include Concord (blue), Catawba (red), Delaware (red), and Niagara (white). Most American type grapes are "slip skinned," that is, the flesh separates readily from the skin of the berry. Highest production in Ohio vineyards has consistenly come from American cultivars.

Also of interest in Ohio is the group known as "French Hybrid" grapes, most of which have been introduced since World War II. This group includes new cultivars or hybrids produced by crossing the European type with one of the native American species, primarily V. ruprestris and V. Lincecuni. Most of the breeding work has taken place in France and the cultivar name generally incorporates the name of the breeder. Two examples are Seibel 10878 and Couderc 7120. There has been only limited evaluation of these by research centers and growers, thus less is known about their adaptability to Ohio climatic conditions than about many of their American counterparts.

As a group, French hybrids are primarily wine grapes, although several have potential for other processing purposes and for table use. Their suitability for wine is due in part to a flavor more nearly like the European grapes, and in part to the lack of the "foxiness" so commonly associated with most American cultivars. Wine made from French hybrid grapes is often described as having a more neutral, subtle, or refined flavor than wine made from the American type grapes.

Many of the more recent American type introductions, when grown under favorable circumstances, have excellent yield and vigor and are equal to or often superior to the standard cultivars. These cultivars mature over a long period, from mid-August through September and October, thus extending the ripening season of the standard cultivars. This can be a decided advantage for

the grower who markets grapes retail, or uses them in the home.

There is a difference of approximately 10 days to 2 weeks between the maturity dates of the same grape cultivars grown in Southern as compared with Northern Ohio. A goal of breeding programs has been to produce a series of high yielding cultivars with a broad range of maturity, vine vigor, and cold hardiness.

## CULTIVARS FOR OHIO

Extensive evaluation of grower and research plantings has served as the basis for the following lists of grape cultivars suggested for use in Ohio vineyards, Tables 1 and 2. Cultivars considered standard for Ohio are in capital letters. Others have shown excellent potential and warrant further consideration and more extensive trial plantings by growers.

**TABLE 1: American Grape Cultivars for Ohio**

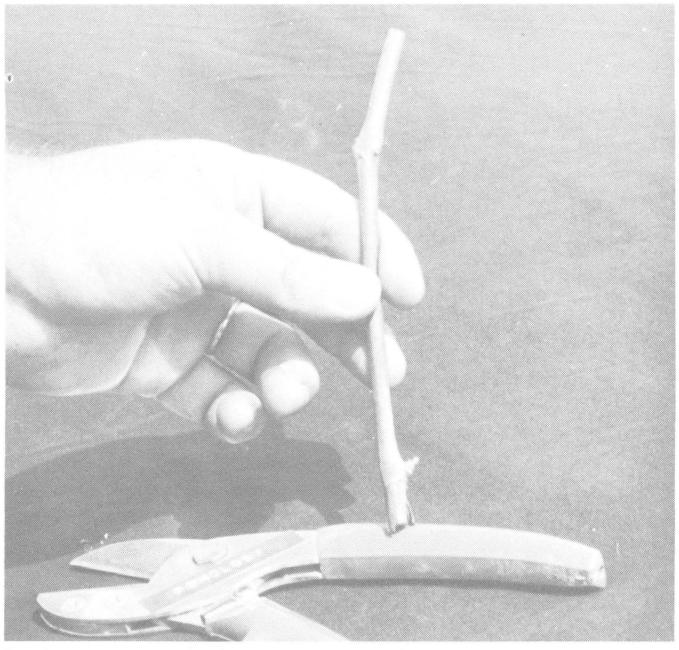
| Cultivars | Color[1] | Climatic Adaptation[2] | Approx. Season | Approx. Days from Bloom to Harvest[3] | Principle Use[4] | Remarks |
|---|---|---|---|---|---|---|
| Himrod (seedless) | W | 2–3 | V. Early | 75 | T-H | High dessert quality—medium to low productivity susceptible to black rot. |
| Seneca | W | 4 | V. Early | 80 | T | European characteristics predominate. |
| Van Buren | B | 1 | Early | 80 | T-W | Vigorous, hardy, Concord type. |
| Ontario | W | 3 | Early | 85 | T-H | Good for wine use. |
| Schuyler | B | 3 | Early | 85 | T | European characteristics predominate. |
| Buffalo | B | 2 | Early | 80 | T-W-J | Excellent quality, distinctive flavor. |
| FREDONIA | B | 1–2 | E. Mid. | 95 | T-J | Concord type, vigorous, hardy. |
| Romulus (seedless) | W | 2 | E. Mid. | 90 | T-H | High dessert quality, tight clusters. |
| Alden | B | 2–3 | E. Mid. | 100 | T-W-H | Large berries, non-slipskin type. |
| Bath | B | 1 | Mid. Season | 105 | T-H | Productive, hardy, Concord type. |
| Captivator | R | 2 | Mid. Season | ... | T | Good mid-season red grape. |
| Steuben | B | 2 | Mid. Season | 105 | T-W | Concord type, vigorous. |
| Bokay | W | 3 | Mid. Season | 100 | W-T | European characteristics, high dessert quality, susceptible to mildew. |
| DELAWARE | R | 2 | Mid. Season | 100 | W | Excellent for wine, high sugar, good keeping quality. |
| NIAGARA | W | 2 | Late Mid. Season | 110 | W-T | Excellent for wine, standing white grape of Ohio. |
| Golden Muscat | W | 2 | Late Mid. Season | 110 | T-H | Large clusters and berries, uneven ripening. |
| CONCORD | B | 1 | Late Season | 115 | J-W-T | Standard quality in Ohio. |
| Blue Eye | B | 2 | Late Season | 115 | W | Large compact clusters. |
| Sheridan | B | 2 | Late Season | 120 | T-H | Needs long season, Concord type. |
| CATAWBA | R | 1 | Late Season | 120 | W-J | Principal wine grape of Ohio. |

1 Fruit Color: W = white; B = black or blue; R = red.
2 Adaptability Rating: 1 = good; 4 = poor.
3 Based on data from Southern Branch, OARDC, Ripley, Ohio.
4 T = table or dessert quality; W = wine; J = juice; H = good for home plantings.

**TABLE 2: French Hybrid Grape Cultivars for Ohio**

| Cultivars | Color[1] | Climatic Adaptation[2] | Approx. Season | Approx. Days from Bloom to Harvest[3] | Principle Use[4] | Remarks |
|---|---|---|---|---|---|---|
| Foch | B | 1–2 | V. Early | ... | W | Extremely vigorous, not fully evaluated. |
| Seibel 5279 | W | 2 | V. Early | 80 | W | Holds promise as commercial wine grape. |
| Seyve Villard 5276 | W | 2 | Early | ... | W | Susceptible to black rot and mildew. |
| Seibel 9549 | B | 3 | Early | 90 | W | One of the best wine grapes. Excellent quality; not too hardy. |
| Couderc 17 | B | 2 | E. Mid. | 95 | W | Recovered well from spring frost. |
| Seibel 1000 | B | 1–2 | E. Mid. | ... | W | Vigorous, not fully tested in Ohio. |
| Seibel 7053 | B | 3 | E. Mid. | 100 | W | Very productive, good vigor, moderate hardy. |
| Baco #1 | B | 1 | Mid. Season | 110 | W | Extremely vigorous, productive, small berries, and clusters. |
| Seibel 8745 | B | 3 | Mid Season | 100 | W | Only moderate hardy, good wine grape. |
| Seibel 10878 | B | 2 | Mid. Season | 105 | W | Good vigor, commercial potential for wine. |
| S. V. 12375 | W | 1 | Late Mid. | 110 | W-T | Excellent vigor, productive, hardy. |
| Couderc 7120 | B | 1 | Late Season | 115 | W | Hardy, productive, good wine grape. |
| Vidal 256 | W | 1–2 | Late Season | ... | W | Insufficient testing, looks promising. |

1 Fruit Color: W = white; B = black or blue; R = red.
2 Adaptability Rating: 1 = good; 4 = poor.
3 Based on data from Southern Branch, OARDC, Ripley, Ohio.
4 T = table or dessert quality; W = wine; J = juice; H = good for home plantings.



Cutting with 2 buds ready for inserting in rooting medium. Cuttings for inserting in field usually made with 3 buds in length.

## PROPAGATION

Grape growers, in most instances, are well advised to purchase planting stock from nurserymen or commercial propagators. Occasions arise, however, where it is necessary or desirable for a grower to produce his own vines. Perhaps he might want to increase a new cultivar before a supply of plants is commercially available, or he may wish to produce his own replacements for missing vines in an established vineyard.

Cultivars of grapes, as other fruits, can only be reproduced through asexual methods. Grapes do not grow true from seed, that is, the seedlings will not have the same characteristics as the cultivar which produced the seeds. Most grape vines are reproduced by hardwood cuttings or by layering of canes. In some instances scions of healthy cultivars are grafted upon specific rootstocks. Cuttings or scions should always be taken from vines known to be true to name. Methods of asexual propagation are described in the following sections.

### Cuttings

The most common way to propagate grapes is by the use of hardwood cuttings. Make cuttings from well-matured, dormant canes of the preceding season's growth. The preferred cane size is one-fourth to three-eights-inch in diameter with 4 to 6-inch internodes.

Cuttings are usually made in late fall or early winter. Each cutting should contain three buds, although two-bud cuttings have been used satisfactorily. Make the basal cut just below the lower bud, and the upper cut 1 to 2 inches above the top bud. Cut in this manner, the upper and lower ends of cuttings can be easily identified. The cuttings may be sorted into uniform lengths and bundled for convenience in handling. Hold the bundled cuttings in cold storage (32°-35° F) or bury in a trench until spring. Place cuttings in a well-drained trench and cover with up to 3 inches of soil. Mulch with 8 to 12 inches of straw (strawy manure) for protection against severe cold.

In the spring as soon as the soil can be worked, remove cuttings from the storage or trench and line out in nursery rows. The rows should be located on a deep, well-drained, fertile soil that is in a good state of tilth. Space rows 3 to 4 feet apart and furrow to a depth of 6 to 7 inches. Set cuttings vertically in the furrow, about 5 inches apart, with the top bud just above the soil surface. As the trench is filled, tamp soil firmly around the cuttings.

As the season advances, shoots will develop from the above ground bud and roots will develop from the nodal regions below the ground. Maintain vines in the nursery row in a high state of vigor during the growing season. Give special attention to the control of diseases, insects and weeds. The new vines will be ready for planting in their permanent vineyard locations in late fall. In order to compensate for "poor take," start about twice as many cuttings as the number of vines required.

### Rooting Cuttings in the Greenhouse

To produce new vines for spring planting, hardwood cuttings of all American grape cultivars can be rooted during late winter under a mist system in the greenhouse. This method saves one year in the propagation of new vines over the conventional outdoor rooting of cuttings.

For greenhouse propagation, take cuttings from healthy vines of the desired cultivars in early December. Make cuttings in the manner described in the previous section. Then tie cuttings in bundles, wrap in damp burlap or place in polyethylene bags, and store at 32° to 33° for approximately 30 days.

In early January take cuttings from storage and insert in a suitable rooting media in the greenhouse. Before

Cutting rooted under mist; ready for transplanting in early spring.

insertion, the lower ends of cuttings may be dipped in a commercial growth regulator such as indolebutyric acid to improve rooting. Vermiculite is an excellent media for rooting because of its freedom from weed seeds and diseases. Sand or mixtures of sand and peat are also satisfactory. Fill flat or greenhouse bench with the media to a depth of 3 to 5 inches. Insert cuttings so the lower cut and node is pushed down to near the bottom of the flat with the upper bud extending just above the media surface. Space cuttings 1 to 2 inches apart in rows 2 to 3 inches apart.

As soon as the cuttings are in place, provide an intermittent mist to maintain a high and constant relative humidity around the cuttings during the rooting period. A mist system that operates automatically for approximately 6 seconds once every 6 minutes during the day is satisfactory. The mist can be turned off during the night.

Bottom heat provided by a heating cable under the flats or in the bottom of a bench hastens rooting. Rooting is most satisfactory if day temperatures in the greenhouse are maintained between 65° F and 70° F and night temperatures around 60° F.

Usually the cuttings root and develop a few small leaves within 4 to 6 weeks. At this time the rooted cuttings can be transplanted into 4-inch pots, preferably peat pots, for easy transplanting to the field later. A suitable mixture for filling the pots is ⅓ peat, ⅓ sand, and ⅓ soil. Steam sterilization of the soil mixture before filling the pots prevents weed growth and diseases. Methyl bromide treatment may be used as an alternate for steam sterilization.

After the rooted cuttings have been potted, place them back under the mist for another day or two to allow the roots to become established in the new medium. Once the cuttings are established, they should be moved to a conventional area in the greenhouse. Fairly high temperatures of 70° to 75° F will encourage growth of the new vines. Lower temperatures must be used to harden the vines before they are taken to the field. During the hardening off period, maintain night temperatures at 40° to 45° F and day temperatures at 65° to 70° F. The vines must be watered regularly and receive weekly applications of a dilute fertilizer solution to maintain growth.

By the time new shoots are about 10 inches long, they are ready for setting in the vineyard. In many cases this transplanting comes early to mid-April. With some cultivars, cuttings may not be sufficiently rooted for transplanting until late April. Regardless of the state of growth, new vines should not be set in the field until all hazard of frost is past. Greenhouse grown plants are extremely sensitive to frost.

Inspect cuttings in the greenhouse regularly for insects. White fly can be a troublesome pest. When the first flies are noticed, use an appropriate insecticide according to directions. One suitable material is Naled (Dibrom) which can be applied to the heating pipes. Another is endosulfan (Thiodan) which is applied to the vines either as a spray or as a 10 percent aerosol.

## Layering

All cultivars of grapes can be propagated by layering. This method is used primarily for replacing missing vines in established vineyards. It is too cumbersome for production of large numbers of plants.

Layering is done in late winter or early spring. Vigorous one-year canes are used. Lay the cane in a shallow trench dug in the desired location of the new vine. Place a 2 to 3 node section of the cane at the bottom of the trench. At least two distal buds should extend above the soil surface. Cover the part of the cane in the trench with 3 or 4 inches of soil and tamp firmly. Roots normally develop from the covered nodes in a few weeks and leaves and new shoots from exposed terminal buds. During the growing season any shoots developing between the layered area of the cane and the mother vine should be rubbed off.

New plants produced in a vacancy in the vineyard are left in place and the connecting cane cut off the following spring after the new vine is well established. If it is to be moved, dig the layered vine and transplant after one year's growth.

## Grafting

Grafting is used when a grower desires to propagate a grape cultivar on a special rootstock such as one resistant to certain root parasites. The European (vinifera) grape, for example, is highly susceptible to the phylloxera or root lice. Consequently, cultivars of this species cannot be successfully grown on their own root system in phylloxera infested soils. Thus, it becomes necessary to graft European cultivars on phylloxera resistant rootstocks in order to grow them successfully on many soils in this country and other parts of the world. Experiences indicate that those root stocks with high phylloxera resistance are also resistant to certain parasitic nematodes.

The need for using resistant rootstocks with American and French hybrid grapes has been considerably less than with European cultivars. Therefore, most of our vineyards have been established with self-rooted vines, especially Concord. The root systems of these cultivars apparently carry considerable resistance to phylloxera and other soil borne parasites. However, differences in resistance have been noted in American grape cultivars. Delaware and Ives, for example, have performed better than Concord on resistant rootstocks.

Where vigor of self-rooted vines is characteristically low, most favorable results can be expected in Ohio from the use of resistant rootstocks. Perennially poor vine vigor and productivity often occur on sites where old vineyards are renewed and new vines are established. It is in the replant vineyards of this nature that resistant rootstocks may prove a distinct advantage with American cultivars or with French hybrids.

Among the rootstocks carrying high resistance to grape phylloxera, nematodes, and possibly other soil borne parasites are Couderc 3309, Couderc 3306, Clinton, and Baco No. 1 cultivars. These rootstock cultivars are propagated by conventional means, that is, by cuttings or layering. Once rooted, the stocks can be used for grafting to any desired cultivar.

Whip or bench grafting is commonly used in propagating grape cultivars on special rootstocks. Either 1-year-old rooted plants or unrooted cuttings are used for the rootstocks. The unrooted cutting is preferred. Grafting is done early in the spring before growth starts.

Although top working is not a normal mode of propagation, it is possible to top work a grape vine or vineyard by using cleft grafting techniques. Such grafting is more successful when done in early spring just before growth begins, although fair success is attained just after the beginning of growth. Dormant scions must be used in all instances. Remember, such procedures are of value only in special instances.

## ESTABLISHING THE VINEYARD

### Site Preparation

Preparation of the proposed vineyard site is very important. Begin this job the year before planting. Special emphasis during the preparation period should be on the eradication of chronic weed problems such as thistle, quackgrass, and dock. Herbicides can be used safely and effectively to control such troublesome weeds in the preparation period but cannot be used once the vines are planted. Whenever possible, avoid sites severely infested with such weeds until they have been eradicated.

If the area to be used is in sod, it is best to plow the sod under the fall prior to planting the vineyard and seed it to a suitable winter cover crop. Ordinary rye is a satisfactory cover. Seed in September at the rate of 2 to 3 bushels of rye per acre or 2 to 3 pounds per 1000 square feet. For best results, grow a cultivated crop on the site the season prior to vine planting. When the crop is removed the winter rye cover should be established.

Apply animal manures, when available, in the fall before spring planting of the vines. A suitable application is 10 to 12 tons of horse or cow manure per acre, or 50 to 75 pounds per 100 square feet.

A soil test, made during the season prior to planting, can be a valuable guide to soil pH status and liming requirements. If the test shows the pH below 5.5, apply agricultural ground limestone to raise the pH to a more desirable range, 5.5-6.5. Such applications should be made well in advance of planting time. The soil test will also give some general indication as to the fertility level of the soil and the fertilizer needs during the vineyard's first year. Contact county Cooperative Extension Service offiices for additional information on Ohio's soil testing service procedures and usage.

Final site preparation should be done as early in the spring as the soil can be worked, preferably in late March or early April. After plowing, the required fertilizer may be applied and disced in before setting the vines. In the absence of a soil test, make a general application of a complete fertilizer. On most sites, an application of 350 pounds per acre of an 8-16-16 analysis fertilizer or a similar one is suitable. The rate is 8 to 10 pounds per 1000 square feet on small plots.

Even though early spring preparation is advisable, it should not be done until the soil is dry enough to work properly. The advantages of early preparation will be lost since soil may become "puddled" if worked wet. The effects of a "puddled" soil, particularly one with very high clay content, may result in poor vine growth for a number of years.

### Laying Out the Planting Design

In most cases, vineyard rows are laid out in straight rows for ease of trellising and vineyard management. On sloping land, however, the rows are best laid out to follow drainage grade or contour. Soil Conservation Service technicians are available to assist growers in layout design. Contour plantings on the steeper slopes aid in prevention of soil erosion and in more efficient vineyard management.

Row spacing depends in part upon the proposed training and trellising system, and in part on the equipment to be used in the vineyard, including the possible use of a mechanical harvester. A nine-foot spacing between rows is common and generally ample, but 10 to 12 feet between rows may be needed to accommodate large equipment. An eight-foot row spacing is satisfactory for small plantings but is considered too restrictive for most commercial operations.

Spacing vines in the row at eight foot intervals has proven most satisfactory. However, closer spacings have produced somewhat higher yields under specific conditions. Cultivars that produce less vigorous growth such as Delaware or Catawba, may be set closer together than Concord or others of similar vigor. Highest yields on an acre basis have generally been obtained from vineyards containing 600 or more vines per acre.

Several different methods are in use for laying out the new vineyard. If a contour planting is to be made, rows can be laid out at the same time the contours are established. Where conventional, straight rows are desired, a base line must first be established along one edge of the field. Drive a stake at each end of the proposed line. Generally, these stakes are located by measuring a desired distance in from the edge of the field. By sighting from one stake to the other additional stakes are placed on the base line to mark it. A careful tractor operator can then mark off the base line with a plowed furrow. This base line also serves as the first row of grapes.

There are several ways to establish rows parallel to the base line or first row. A simple way is to establish a line at each end of the row that is perpendicular to it. First, set a stake on the base line 30 feet from the end. Then place a stake 40 feet from the end of the base line of the assumed perpendicular line. Measure the angular distance between the 30 and 40 foot stakes. If the distance is 50 feet, the assumed line is correct and can be extended by sighting. If it is not, move it, still maintaining the 40-foot interval, until there are 50 feet between the two stakes. Stakes can be driven on these lines at the proper intervals to indicate the row ends. The procedure used in marking the base line is then repeated until the required number of rows have been marked out. A pole the length of the desired interval between vines can be used to quickly space vines in the row as they are planted.

It is important to leave enough space at the ends of rows for machinery to turn. A 25-foot headland at each end of the vineyard should be adequate. Similarly it is important to leave sufficient space on the sides of the vineyard to allow easy movement of equipment. If rows are long, 20-foot-wide cross alleys established at about 500-foot intervals will prove most convenient in vineyard operations.

### Vine preparation and Planting

Handle young vines carefully to prevent drying out or other damage once they have been dug or received from the nursery. If vines are not planted immediately, place them in cold storage, 32° F with a high relative humidity, until planting time. Storage areas used for holding fruit are not satisfactory. If proper facilities are not available, carefully heel vines in a sheltered location. Dig a shallow trench and place individual vines in the trench so the tops are exposed. Cover roots with soil and firm. Water newly set vines to prevent the roots from drying out. The sooner the young vines can be planted in their permanent location, the better the chance of their survival.

Early spring is the most suitable time for planting grapevines in Ohio. Generally, fall planting is not recommended but may be done on the lighter, well-drained soils. If set in the fall, plow up a four to six-inch mound of soil around the base of the young vines or mulch them

with straw to protect against heaving and severe winter temperatures.

Before setting vines, prune off broken or dead portions of roots. Long roots may be shortened somewhat for convenience in planting. Additional root pruning is not necessary or desirable. At the same time, reduce the top growth to a single cane.

If a deep furrow, 10 to 12 inches deep, has been plowed for the row, it will accommodate a rather large root system without packing a mass of roots into a small hole. Spread roots well, then cover with a few inches of top soil and tamp firmly. A plow or disk may be used to finish filling the furrow. In small plantings, the entire operation is done by hand. When the planting is completed, the node from which the lowest cane will arise should be at or just above the soil level. If vines grafted on special rootstocks are used, care should be exercised to be sure the union is well above the soil level.

Prune the single cane remaining after planting. Prune it back so that only 2 or 3 buds remain. Some growers prefer to leave a longer cane, 8 or 10 buds. As the new shoots develop, all but the two upper most ones are broken off when about an inch long. This leaves the two topmost shoots to develop into vigorous new canes the first year and may result in increasing vine length or height the first season.

### Polyethylene Mulch

Black polyethylene mulch has been used with very satisfactory results in establishing new vineyards. With this mulching method, the planting procedure begins with a thorough tillage of the row areas. A rotary type tiller is an excellent tool for soil preparation. Fertilizer can be incorporated with the soil during the tillage operation, but the rate should not exceed 100 pounds per acre of ammonium nitrate or 200 pounds per acre of a mixed analysis fertilizer. When the row is finished and the fertilizer thoroughly tilled in, roll black plastic over the row, pull tight and hold edges down with a small ridge of soil. The laying of plastic mulch is easily done with modern equipment, requiring little or no hand labor. In small plantings, lay the plastic by hand in a similar manner. Three-foot-wide, 1.5 mil thick ordinary black plastic performs most effectively.

Setting vine through small slit in black plastic mulch.

Once the mulch is in place, mark off the plant spacings and set vines through the plastic. A common procedure is to force the long narrow blade of a tiling spade through the plastic into the soil to a depth of 10 or 12 inches. The opening is widened by a back and forth motion, leaving an open hole. Insert the vine and tamp soil firmly around the new plant. Some growers have found an ordinary hand type post hole digger a useful tool in planting vines through the plastic.

## TRELLIS CONSTRUCTION

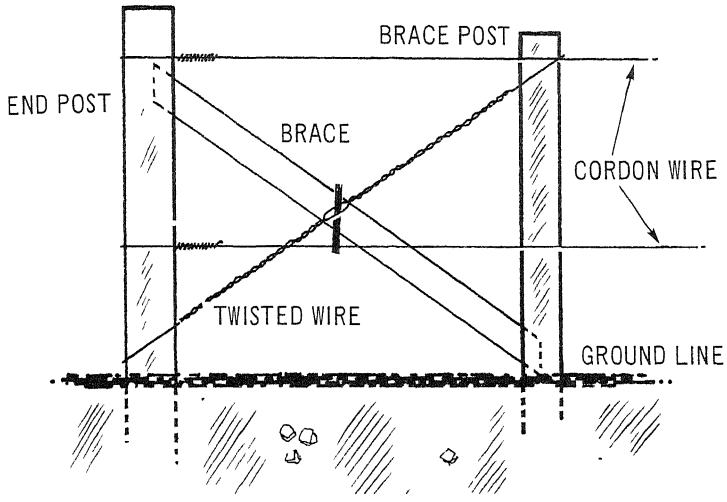
Construction of a conventional grape trellis is similar to constructing a farm fence. The trellis structure must be substantial enough to carry the heavy loads of vines plus fruit, and to withstand strong winds when fully loaded.

The best time to construct a trellis is during the first growing season or the following spring before growth begins. If delayed beyond this time, harvesting of profitable crops will also be delayed.

Trellis construction is quite similar for all conventional grape training systems. In essence, the trellis consists of two or three wires, one above the other, stretched tightly and secured to firmly set posts. Two wires are most common, but some growers find three make the

Conventional trellis system; well-braced end posts; line posts between every 2 vines and wires stretched tightly.

End post braced with guy wire and dead-man buried in ground.




**End post braced to line post; avoids use of wires beyond end post.**

trellis more rigid and wind resistant. In general, the higher the trellis the more effectively the foliage may be exposed to sunlight and hence the more productive the vineyard.

End posts should be larger than line posts, since they must serve as anchor points as well as wire supports. Creosote or pentachlorophenol treated locust, white pine or other suitable posts are commonly used, but sound railroad ties of 8½ to 9½ feet in length can serve as end posts. Set end posts about three feet or more in the ground and at a slight angle with the top leaning away from the direction of the vine row. The top should extend at least six feet above ground level after setting in order to support the top trellis wire at the desired height.

End posts may be braced in several ways. A common and preferred method is to set an extra line post within a few feet of the end post on the row side. A heavy piece of wood, 3x4 inches or larger, makes a good brace between the two posts. Cut so that the upper end rests in a notch half way or two thirds up on the end post and the lower end against the base of the extra line post. The angle should be greater than 34 degrees between the brace and the end post to prevent lifting the end post out of the ground when wires are tightend.

Another bracing method, but somewhat less desirable, utilizes a brace wire from the top of the end post to a "dead man" or other anchor on the side opposite the row. The anchor is buried some 36 to 48 inches from the post. A double wire brace extends around the post near the top and to the anchor. The brace is tightened against the anchor by twisting the wires together. Other types of bracing with the guy wire are available. Use of the guy wire brace requires additional headlands. Perhaps a greater disadvantage of the end brace wire is the difficulty it presents in turning equipment at the end of the row.

Line posts are generally cut 8 to 9 feet long with a minimum of three inches diameter at the top. They are set 24 to 30 inches deep and spaced 20 to 24 feet apart in the row. The exact spacing will depend upon vine spacing. In most cases, three vines are set between each two posts. Thus, if the distance between vines is eight feet, posts will be spaced 24 feet apart.

Galvanized wire, while more expensive initially, is more durable and may be the least costly over a long period. Galvanized wire is especially recommended for the lower wires as it tends to reduce serious wire chafing of the young vines.

Three wire sizes are commonly used in trellising: number 9, the largest, is used for the top wire and either number 10 or 11 for the lower wires. The amount of wire needed per acre can be calculated from row spacings and the weight of a given wire size. With a row spacing of nine feet, the total length per wire will be 4,840 feet per acre. If two wires are used, the trellis will require 9,680 feet of wire per acre. Wire in large quantities is generally sold by weight. Table 3 gives the approximate number of feet per ton for different wire sizes.

**TABLE 3: Feet per ton of wire on three wire sizes**

| Size of Wire | Feet Per Ton |
|---|---|
| Number 9 | 34,483 |
| Number 10 | 41,408 |
| Number 11 | 52,352 |

Wires may be secured to end posts in various ways. A common method is to wind the wire around the post once or twice, and then twist the end several times around the wire as it is stretched to the next post. Some vineyardists use special devices to attach the wires to the end posts because they simplify tightening of the wires. These devices employ cranks or a "cinch," that eliminate removal of wires from end posts when tightening.

Wires are fastened to line posts with ordinary staples. When installing, drive staples far enough to hold the wires close to the post but with enough play that the wire will slip through when tightening is needed. With steel posts, use regular fence wire fasteners. If wires are hung on the windward side or on the uphill side of posts, the staples are less likely to pull out.

Space wires vertically according to the method of training to be followed and height of the finished trellis. The top wire for most trellis systems should be 5½ to 6 feet above the ground. The higher the top wire, the greater the percentage of foliage exposed to sunlight. Generally, the lower wire is fastened 30 to 36 inches from the ground. If a third wire is used, it is situated about half way between the upper and lower wires.

Trellis wires should be slack in the fall. If taut, contraction of the wires during cold periods will put severe strain on the trellis and may damage it. Generally, the wires will have stretched sufficiently so that loosening is not necessary, but it may be desirable. The trellis wires should be tightened each spring. The best time to do this is after pruning but before the canes are tied to the wires.

## COMMON TRAINING SYSTEMS

Conventional training of eastern grape vines has been to the Kniffen system. Three modifications of this system are in use—the 4-arm Kniffen, 6-arm Kniffen and Umbrella Kniffen.

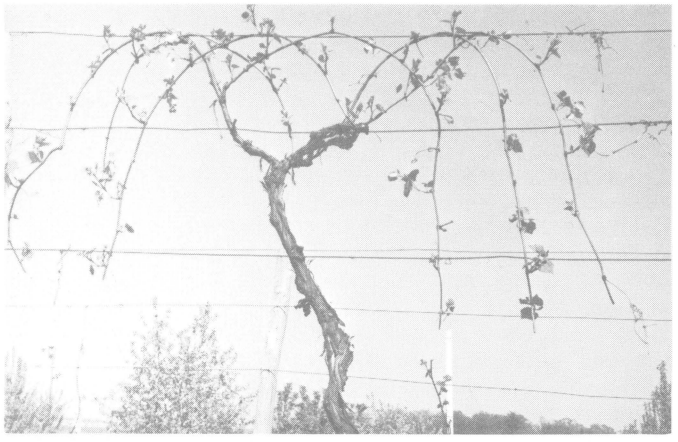
### Four-Arm Kniffen

This system is characterized by the 4 short arms from which the fruiting shoots arise. The arms two on each side of the trunk are developed from just below the point where the wires and trunk meet. Two bud renewal spurs

are left on each arm of the trunk near the base of the fruiting cane. Growth from the renewal spurs will provide fruiting wood for the following year. All surplus wood is pruned away each year. If the vine can support more than 4 canes, they should be left on the top wires since they will be more productive than those arising lower on the trunk.

### Six-Arm Kniffen

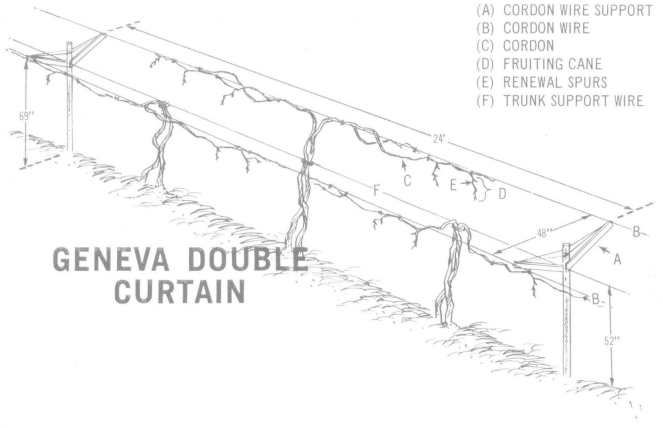
This system differs only slightly from the previous one. It permits more canes to remain on the vine by tying them to each of the 3 trellis wires. (See picture page 13.) In general, both of these systems tend to standardize the training procedure for routine pruning and handling of the vine.



**Grape vine trained to the umbrella Kniffen system, after pruning. Head of vine between second and top wires.**

### Umbrella Kniffen

Presently, this system is the predominant one used in Ohio vineyards. The mature vine trained according to this system, consists of a single trunk trained to the top trellis wire then headed out at this point, or from 4 to 6 inches below the wire. All the canes utilized in training thus originate near the head of the vine near the top wire. The canes growing on each side of the trunk at this point are extended over the top wire allowed to droop down and are tied to the lower wire or wires. With care, the canes are bent rather sharply, just enough so the outer bark cracks. The purpose of cracking the bark is to induce more vigorous growth from the buds behind the bend rather than allowing it to develop at the cane tip. Overall fruitfullness is presumably increased. The number of canes will vary from 4 to 6, depending upon the vigor of the vine.




### Geneva Double Curtain

This system, developed at the Geneva, New York Agricultural Experiment Station, represents the latest and most up-to-date method of training Concord vines and perhaps those of other cultivars. It is especially adapted to mechanical harvesting and the utilization of high vine vigor. Grower trials, started in Ohio vineyards in 1964, show this system can increase vine productive capacity and at the same time maintain or even improve fruit and vine maturation. Better maturation and increased yield are made possible by shoot and leaf positioning which exposes a greater proportion of the leaf area to sunlight. Vine vigor and the principles involved in balanced pruning are also fundamental concepts of this system. Cane and cordon positioning plus trellis construction make mechanical harvesting more feasible.

As illustrated in accompanying diagram, two horizontal cordon wires are separated in the row by a distance of 4 feet and at a height of 5½ to 6 feet above the ground. These wires are held in position by wood or metal supports attached to each post set at the normal spacing of 24 feet apart in the row.

Two main trunks from each vine should extend vertically 5½ feet and then horizontally to the cordon wire (maximum distance 2 feet). One trunk which divides near the cordon wires can be used when converting from a standard trellis system. A single wire strung down the row and secured somewhat above the middle of the posts will aid in supporting the trunks. This principle is important in establishing the Geneva Double Curtain system as trunks should not angle up to the cordon wire, but extend up and out. In mechanical harvesting, the shaker arm moves this cordon wire up and down about 5 inches. Thus, curvature of the trunk allows for the necessary flexibility. This procedure also facilitates movement of spray and other equipment down the row. For vines spaced 8 feet apart in the row, double trunks are recommended.

Cordon canes extending 6 to 8 feet along the cordon wire in each direction are secured to the wire by semi-permanent ties. Originators of the system suggest that, "the first year the cordon components be wrapped around the cordon wire several times in order to provide support and the canes tied securely at the ends with wire. In the second or third year, the cordon should be unwrapped from the wire and the desired number of cordons tied with semi-permanent ties along the cordon wire."

The Geneva Double Curtain system is recommended for vineyards with above average vigor—those producing 3 or more pounds of prunings per vine. Conversion of low vigor vineyards has tended to weaken cane growth, thus reducing productivity over a period of several years.

**TABLE 4: Number of buds to retain on each Geneva Double Curtain trained Concord vine during second and each succeeding year**

| Pounds of cane prunings | Number buds (including renewal spurs) per vine | Number of 5-bud canes | Number of 1-bud renewal spurs |
|---|---|---|---|
| 1 | 30 | 4 | 10 |
| 2 | 40 | 6 | 10 |
| 3 | 50 | 8 | 10 |
| 4 | 60 | 10 | 10 |
| 5 and more | 70 | 12 | 10 |

## TRAINING YOUNG VINES

### First Year

Regardless of the training system to be followed, it is recommended that after planting the strongest cane be cut back to 2 strong buds and any others completely removed. Some growers prefer to leave a longer cane, 8 or 10 buds, and allow only the 2 uppermost buds to develop into shoots. This added length of the old cane often permits the new shoot to grow to the top of the stake or trellis more quickly. A stake 4 to 5 feet high is driven in near each vine and the new growth trained to it during the first growing season. Tie the shoots loosely to avoid the possibility of girdling.

### Second Year

Before pruning the second spring, decide which training system is to be followed. The more common systems include the four-arm Kniffen, six-arm Kniffen, umbrella Kniffen and the newer Geneva Double Curtain. All have several aspects in common. Primary among these is the establishment of a vigorous, straight trunk. To accomplish this, all but the best single cane is removed during the second year dormant pruning. Two canes may be left for training to the Geneva Double Curtain system. If the trellis has been completed, tie this cane securely to the uppermost wire that it will reach and more loosely to the lower wires. Less danger of girdling the vine is likely with plastic ties than with string or wire. Cut the cane off just above the upper tie. If the trellis is not in place, continue to use the 4 to 6 foot stake to support the cane.

If cane growth is weak and will not reach the lower wire of the trellis (30 to 36 inches above the soil), treat it the same as a newly planted vine.

## PRUNING MATURE VINE

### Three years and older

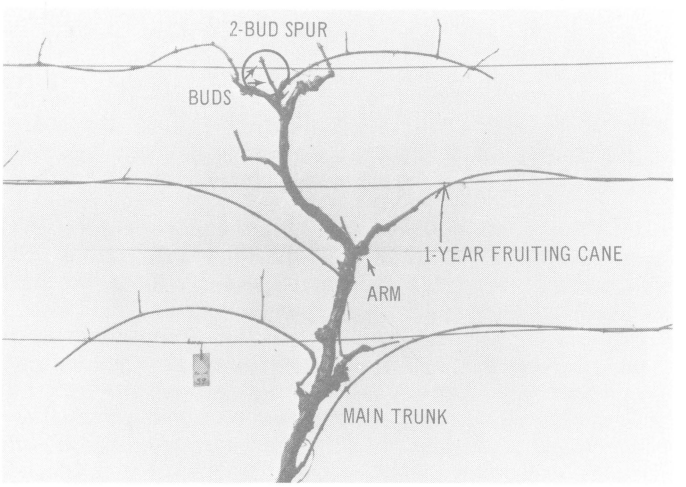
Pruning, to the uninformed, appears in opposition to the normal growth processes of nature. On the contrary, pruning modifies the size and form of the vine rendering it more productive of high quality and good sized fruit. At the same time, pruning aids in maintaining adequate vegetative vigor for high yields in future crops. A deficiency or excess of good fruiting wood affects crop production more than any other single factor. The following example emphasizes the importance of this concept.

By today's standards, a good Concord vineyard should be capable of producing 6 tons or more of grapes per acre. If the vines are planted 8 feet apart in the row and 9 feet between rows, there will be 604 vines per acre. This means the average yield must be at least 20 pounds of grapes per vine. An average cluster of grapes usually weighs 3 to 4 ounces. Therefore, 80 to 100 clusters per vine are needed to produce 20 pounds of fruit. Since each fruit bearing shoot produces 1 to 3 clusters, 40 to 50 shoots per vine can produce the crop. A single shoot arises from a bud, but not all shoots flower and set fruit.

An excess of 50 buds per vine are necessary to produce the 6-ton crop. The mature grape vine will have several hundred buds before pruning with more than half of these capable of producing fruiting shoots. If all buds were to remain, the vine would over-bear, resulting in delayed fruit maturity and small berries. Of even

**Left, young shoots are supported by stake at each vine; right, vine pruned after first season's growth.**

**Vine trained to the 6-arm Kniffen system, before pruning.**




**Same vine as above after pruning. Note, bulk of cane growth produced previous season was removed.**

Left and right is vine pruned to Geneva Double Curtain system before and after pruning.

Balanced pruning—prunings from one vine, about 5 pounds. Weighed to determine number of buds to leave.

greater significance, the vine would not produce enough good fruiting wood for the next year's crop. On the other hand, if the vine were over-pruned, the current season's crop would be reduced and new growth would be over-vigorous. Such over-vigorous growth produces poor fruiting wood for the following season.

### Time of Pruning

Grape vines can be pruned anytime during the dormant season. However, fall pruned vines are subject to more winter injury during extremely cold weather than those left unpruned. Since some cultivars are much more prone to winter injury than others, it is advisable to wait until late winter or early spring to prune so that uninjured canes can be selected for fruiting.

Delaying pruning until later in the dormant season also tends to hold back growth which may be injured by untimely frosts. "Bleeding," the flow of sap from wounds, may occur when vines are pruned late. Evidence indicates this does little or no harm to the vines.

Summer pruning is not recommended. Vines can usually be pulled or tied out of the way. For most training systems, even this is not, necessary. Shoots do not need to be pruned or positioned so that the grape clusters can get sunlight. Leaves utilize the sunlight in manufacturing food material, so removing them will only tend to weaken the vine and delay fruit maturity. Positioning of foliage will be discussed later.

## BALANCED PRUNING

Although 50 buds or more can easily be left on a grape vine, as shown in the previous example, a crop of 6 tons per acre cannot be expected unless the vine has sufficient vigor to support such a fruit load. To determine the potential fruit capacity of a vine at pruning time, the concept of balanced pruning has been developed. The principal is valid for grapes in general, but will vary in magnitude from one cultivar to another. Procedures presented in this section have been developed for Concord. Modifications of the principle as it applies to other cultivars will be presented as each is discussed.

### Pruning Considerations

A. Characteristics of productive fruiting wood:
   1. Grown the previous season (1-year-old).
   2. Canes are approximately ¼ inch in diameter (pencil size) at about the 5th and 6th buds and nearly the same thickness at the 10th bud.
   3. Canes originate from arms near the main trunk.
   4. Cane bark has a bright reddish-brown color.
   5. Distance between the buds (nodes) is from 5 to 8 inches.

B. Evaluation of the previous year's yield, fruit size, maturity, and quality:

Each vine is an individual and must be pruned according to its own capacity. If the crop was large last year, the vine may not have produced enough growth this year to mature a similar amount of fruit. If berry clusters during the current season are large in number but small in size, the vine may have been over loaded. Nutrition and moisture may have been limiting factors. If the yield was less than desired, examine the canes of the previous season to see if they were more or less vigorous than characterized under item A as to size color, and internode length.

C. Position and quality of the canes:

Better yields and quality will result when the trellis is fully occupied with vines and a large percentage of the leaves are exposed to sunlight. Excessive vigor generally produces a greater percentage of shaded leaves, a condition often associated with low fruit quality, low soluble solids and high acid content. Low soluble solids on low vigor vines may also occur due to an inadequate leaf to fruit ratio. Studies at the Ohio Agricultural Research and Development Center show that positioning the vines and leaves for maximum exposure to sunlight can aid materially in producing maximum yields of high quality fruit and ample fruiting wood for the next year. Regardless of how the canes are positioned for light exposure, only those with sound, healthy wood will be most productive.

### Pruning Procedures

1. Size up the vine and estimate the amount of 1-year-old wood; select the fruiting canes to be

retained; remove all other 1-year wood and weigh. After pruning a few vines, one estimates more accurately. Then, only periodic weighings are necessary.

2 Using Table 5 as a guide, determine the total number of buds to leave. The best results with Concord are obtained by using the 30 plus 10 formula: 30 buds left for the first pound of prunings and 10 additional buds for each additional pound of wood removed. If your estimate is 3 pounds of wood, then prune so that 50 to 60 buds remain on the vine With conventional training systems, this means leaving 5 or 6 canes, each with 10 good buds, plus some renewal spurs.

3. Select fruiting canes from those on the upper portion of the vine as close to the trunk as possible Selection of canes will vary slightly, depending upon the specific training system followed. Leave several (5 to 7) renewal spurs of 2 buds each as near the trunk as possible to develop the fruiting canes for next year. Renewal spurs are especially important in this area to keep the vine from extending further and competing with adjacent vines on the trellis

4. Weigh the initial 1-year-old prunings from the vine if too many buds remain, adjust to the final number needed by additional pruning If the prunings weigh 1 pound, leave 30 buds; if 2 pounds, leave 40 buds; if 2½ pounds, leave 45 buds, etc.

TABLE 5: **Relation of number of buds remaining to the weight of 1-year pruning wood removed from Concord grape vines**

| Pounds of 1-year-old wood removed | Number of buds to be left on vine for fruiting |
|---|---|
| Less than 1 | Less than 30 |
| 1 | 30 |
| 2 | 40 |
| 3 | 50 |
| 4 or more | 60 |

1 Under conventional trellising systems, it is recommended that not more than 60 buds be left on a pruned vine

### Disposal of Prunings

Once the pruning of a vine or section of the vineyard is finished, the prunings are placed between the rows. Prunings should be removed carefully from the trellis to avoid breaking those canes retained for producing the crop. The prunings may be removed from the vineyard or chopped between the rows with a heavy duty rotary mower or similar machine. Most commercial vineyards chop the prunings, thus reducing labor for this operation and adding a small amount of organic matter to the soil.

## SOIL MANAGEMENT

Design management practices within the vineyard to produce the optimum growth, yield, and maintenance of the vineyard site. Two soil management systems are now in general use in Ohio vineyards. Many growers follow the system of cultivation between the rows during the growing season and a cover crop over winter. Another, and more recent system, is the maintenance of a permanent sod cover between the rows. In either case, weed growth is controlled beneath the trellis by chemical or tillage methods.

### Cultivation Plus Cover Crop

Vineyards planted on the lighter soils in the lake plains areas or on shallow soils, usually respond best over a period of years to the cultivation plus cover crop system Those planted on the heavier soils, and those on the more sloping sites subject to soil erosion, may respond more favorably to the system of permanent sod cover between the rows with maintenance of weed and grass-free rows. However, with care these vineyards may also be maintained under the cultivation plus cover crop system, at least during the first few years or for short periods in an established vineyard.

The kind of winter cover crop selected seems of minor importance. The most common ones are rye and ryegrass. Both are satisfactory. Seedings are made in August or early September. Satisfactory seeding rates are 2 bushels per acre for rye seeded in early August, or 20 pounds per acre of ryegrass seeded in July. A light application of fertilizer such as 3-12-12 at the rate of 200 to 250 pounds per acre may be made at seeding time. In making the seeding, use care to avoid scattering seed in the vine rows.

Disk the overwintering cover crop down in early spring before it competes with the grape vines. For rye, competition with vines begins when rye reaches a height of one to two feet and for ryegrass, when seed heads just begin to appear. In no case, however, should disking be done when the soil is wet enough to puddle. Disk only enough to "knock down" the cover. Excessive disking is not only a waste of labor but also may be deleterious to the vineyard.

Cultivate between vine rows during the summer only when necessary to control weed growth. Cultivate as shallow as possible but deep enough to accomplish the purpose. Deep cultivation or plowing between rows will do more damage than weed growth, due to the root pruning effects of these practices.

Keep cultivation in the vine row after the planting year to a minimum to avoid injury to shallow roots. If cultivation becomes necessary, cultivate shallow and only enough to destroy weed or grass beneath the trellis Preservation of the shallow roots near the vine is essential to obtaining the highest yields of fruit. Chemical weed control under the trellis is recommended and is discussed in a separate section.

In some seasons, demonstrations have shown that a cover crop in the vineyard during spring and early summer can reduce yields significantly over cultivation. The extent of yield reduction has apparently been in proportion to the degree of competition between the cover crop and the vines for soil moisture and nutrient elements. Since nutrient elements can be applied through the application of fertilizers, the primary competition most likely is for water.

### Permanent Sod Management

Maintaining a permanent sod cover between vineyard rows is a desirable soil management practice in Ohio. It is the recommended practice in vineyards where soil erosion is likely to be severe under summer cultivation.

Bluegrass is considered best for this purpose. Not only is it suited to our environmental conditions, but it competes less severely with the grapes than do deeply rooted cover crops. Avoid growing deep rooted crops such as tall fescue, timothy and other vigorously growing types of plants.

A fall seeding of bluegrass is more successful than one in early spring. The ideal time is early September. If the vineyard has been under summer cultivation, bluegrass may be seeded following the last cultivation at the rate of 2 pounds per acre. If the vineyard has not been under cultivation, bluegrass seed may be broadcast following a light disking which does not destroy existing sod. Avoid broadcasting seed under the trellis.

Mow the grass cover as needed, leaving the clippings on the vineyard floor. Usually vineyard fertilization is adequate for maintenance of a good sod cover. However, if poor sod results, a soil test should be taken and the recommended fertilizer practice followed. Control vegetation under the vineyard trellis as indicated in recommendations for the cultivated vineyard.

Greater reduction in crop yields have been experienced with the permanent cover crop system on the lighter, sandy or gravelly soils than on clay or silty clay loam soils. This is probably due to the greater amount of available moisture in the latter soil types.

## Mulching

Mulching has been used as a soil management practice for grapes, although it has not become a generally accepted practice. Some of the advantages of mulching over cultivation plus cover crops are:

1. Suppression in weed growth, hence less competition for soil moisture and nutrients.
2. Conservation of soil moisture and increased infiltration of rainfall.
3. Less nitrogen required in annual applications for equivalent yields.
4. Vigor and productivity of vines in many instances, maintained or increased without addition of other nutrient elements, these being derived from the decaying mulch.

In vineyards where vine vigor is low, mulching in conjunction with other good soil management practices can be a very economical and effective way to boost vigor. Under this situation, the most favorable results of mulching may be achieved.

The mulch may have some disadvantages in certain situations. Vines high in vigor may require a longer season to mature fruits with optimum soluble solids (sugar) content than vines of less vigor. The problem arises when attempting to reduce the vigor or amount of growth on over-vigorous vines under continuous mulch. It often requires a longer period of time, from 2 to 3 years, to reduce annual vine growth to a more desirable amount, even when balanced pruning is followed.

Heavy mulching of poor to fairly well-drained soils should be avoided. Such a practice could actually increase the problem of excess soil moisture in the root zone of the vines. Mulching may also increase fire and rodent hazards.

Most organic materials such as straw, hay, corn cobs, sawdust or fine wood chips will serve satisfactorily in the vineyard. The mulch may be applied to the entire vineyard floor or confined to a 4 or 5 foot wide band beneath the trellis. The depth of the mulch applied may vary from 2 to 10 inches. Depth of the mulch needed will depend upon the quantity available, the density of the material used and the cost involved. Generally, 6 to 8 inches of loose straw or 2 or 3 inches of sawdust are adequate.

**Excellent season-long weed control achieved by using appropriate and approved herbicides.**

Once the initial mulch has been established, annual additions are necessary to maintain the desired depth. In general, a ton of straw is required to make an inch of mulch over one acre. Other materials may take more or less than this amount to make an inch of mulch, depending upon their density and bulk.

## Weed Control

Control weed growth in vineyards to reduce competition for moisture and nutrients. Weeds interfere with cultural operations and reduce yields. The most difficult weed control problem occurs directly under the trellis, but effective chemical or mechanical control methods can be used here.

The trellis wires and the location of vines and posts limit the equipment which can be used. The grape hoe, generally hydraulically operated, has been used in commercial vineyards to work the area under the trellis, and hand hoeing in smaller plantings. Effective weed control is achieved only by repeated operations during the season. These means of control are difficult, laborious, and are accompanied with the risk of injury to trunks and root systems of the vines. Although such weed control methods are followed in some vineyards, greater attention has been turned to chemical means.

Safe and effective chemical weed control measures have been developed in recent years and are widely used by commercial growers. Such controls under the trellis are more efficient than mechanical means and their use is encouraged. These same procedures could be used to control weed growth between the rows, but this has not been encouraged since weeds between the rows can be effectively and efficiently controlled by power equipment. Further, the total elimination of weed growth in these areas may, in time, create other cultural problems.

A number of approved herbicides are available for control of the weed species frequently found in vineyards. However, no herbicide should be applied in vineyards unless it is specifically recommended for this use. Use of other than recommended or approved herbicides may result in injury to the vines and undesirable residues in the grapes. Also, use of approved herbicides must be restricted to the limitations listed on the label. Improper use of even the recommended herbicides can result in damage to the crop or lack of weed control.

Apply recommended herbicides at low pressures, 40-50 psi, in 50 to 100 gallons of water per acre of sprayed area. To apply herbicides, a special tractor-mounted sprayer with agitator in the tank and a boom equipped with nozzles that permit directed spraying under the trellis is preferred. Make every effort to min-

imize herbicide contact with the vines. A swath 3 to 4 feet wide under the trellis is most satisfactory.

Successful chemical weed control depends upon the application of the proper amount of the recommended herbicide at the proper time. Careful calibration of the spray rig is essential. Growers are advised to become familiar with such procedures in a small portion of their vineyard before making extensive applications.

The following herbicides have been recommended in the past based upon former label approval by the Food and Drug Administration. However, before any herbicide is applied in a vineyard, the user should first check current recommendations to see if the chemical carries approval for such use. The current recommendations are available through each county Cooperative Extension Service office.

Suggested application rates are in terms of the commercial product applied per acre of sprayed area. The use of herbicides is not recommended during the first season of planting a new vineyard.

**Simazine** [2-chloro-4, 6-bis (ethylamino)-S-triazine] 80 WP is applied on average soils at a rate of 4 pounds per acre in 50 to 100 gallons of water. Apply in early spring prior to the establishment of weed growth as a directed spray under the trellis. On light soils reduce the rate to 3 pounds, while on heavy soils the rate may be increased to 6 pounds. Simazine has little contact action but good residual value. A single application should give season-long control of annual weeds.

**Diuron** [3-(3,4-dichlorophenyl)-1, 1-dimethl urea] is sold commercially as Karmex diuron. Apply on average soils at the rate of 4 pounds per acre in 50 to 100 gallons of water. Apply in very early spring prior to beginning of growth as a directed spray under the vineyard trellis. On light soils, reduce the rate to 3 pounds; on heavier soils, the rate may be increased to 6 pounds. This material has little contact value but good residual effect. A single application should give season-long control of germinating weed seeds.

**DNBP** (Dinitro ortho secondary butyl phenol) is sold commercially as Dow General or Sinox. Apply with diesel fuel oil at the rate of 2 pints of 55% DNBP plus 10 gallons of oil and enough water to make a total volume of 100 gallons of spray. Where weed growth is dense, rates can be increased to 3 pints of DNBP and 20 gallons of fuel oil. Apply as directed at the rate of 50 to 100 gallons per acre of sprayed area, according to the amount of weed growth. Make 3 applications and apply the first one when weeds have reached the height of 6 to 8 inches. Follow-up sprays can be spaced at 3 to 4 week intervals when weeds again reach heights of 6 to 8 inches. This mixture has value as a contact or chemical mowing action but little residual value. Avoid contact with vegetative parts of the grape vine.

**Combination—DNBP plus OIL plus DIURON or SIMAZINE.** Add the suggested amount of either diuron or simazine to the DNBP mixture. This mixture offers both contact and residual action. It has special value in the first year of establishing the weed control program, or where application of weed sprays has been delayed. Make no more than one such application per season.

These spray treatments are primarily effective against germinating annual weeds and grasses. They will not control deep rooted perennial weeds or well established annual weeds. Such weeds are best controlled by conventional means prior to treatment.

**Paraquat** has 2 approved formulations of which both are effective in vineyard weed control. These are Paraquat CL [Paraquat dichloride 1,1′-dimethyl-4,4′-bipyridinium dichloride] and Dual Paraquat [Paraquat bis (methylsulfate) 1,1′-dimethyl-4,4′-bipyridinium bis (methylsulfate)].

This herbicide kills weeds and grasses by contact and has no residual effects since the chemical is inactivated upon contact with the soil. It is effective in controlling existing annual weeds and killing top growth of many perennials.

Apply at the rate of 1 to 2 quarts per acre in 50 to 200 gallons of water as a directed spray under the trellis. Add a non-ionic surfactant (spreader) to insure thorough wetting of weed foliage. Use sufficient spray solution to thoroughly wet the weed foliage, application being most effective when weeds and grasses are succulent and new growth is from 1 to 6 inches high. Retreatment or spot treatment may be necessary, especially for perennials and late germinating weed seeds.

Avoid contact of the spray with vine trunks, fruit or foliage as injury may result. Paraquat is rapidly absorbed by green plant tissue where its killing effects take place.

Handle Paraquat carefully. Avoid inhalation of fumes and bodily contact with the material, either in concentrated or dilute forms.

**Dichlobenil (Casoron)** is applied in the granular form at the rate of 6 pounds active per acre treated. It has proven effective for the control of quackgrass and other difficult weed species. Apply in early or late winter. The effectiveness of dichlobenil diminishes as the growing season progresses.

Due to the changing ecology encountered through the continued use of a single herbicide, rotation or alternation of herbicides under the trellis is encouraged. Herbicides should be thought of as chemical tools. Like other tools, the one to use will depend upon the problem to overcome.

**Special Weed Problems:** Frequently quackgrass, thistle, dock, poison ivy, and wild brambles become troublesome under the vineyard trellis. Many of the difficult weed problems can and should be avoided by destroying such troublesome weeds prior to the establishment of the planting. Quackgrass can be controlled on the proposed planting site by treating it with Dalapon (2,2-dichloropropionic acid) at 10 to 20 pounds per acre, or Amitrole (3-amino-1,2,4-triazole) (50%) at 5 to 7½ pounds per acre or Amitrole T at 1 gallon per acre. Amitrole and Amitrole T are also effective at the rates indicated for the control of dock, thistle, poison ivy and some other troublesome broad leafed weeds. Such treatments should be applied when the weeds are vigorously growing. These treatments may be repeated if needed. **All such treatments should be completed the season prior to planting.**

## LIMING AND SOIL REACTION

Grapes can be grown successfully over a wide range of soil pH conditions. They perform best where soil pH is between 5.0 and 6.0. Under many circumstances, vineyard fertilization has fewer problems and may be less expensive where the soil pH is maintained between 5.0 and 5.5. Periodic soil testing must be used to determine the soil pH and liming requirements. Lime

applications should be made only when a soil analysis shows the need.

Research results show that potassium deficiency can be intensified by the application of only one ton per acre of dolomitic limestone (high in magnesium) on a silty clay loam of pH 5.4. Excessive applications of calcium limestone can result in manganese deficiency. This is due to soil manganese becoming more insoluble and less available to vine roots when the pH is raised to near 7.0 or above.

Where magnesium deficiency is present in a vineyard, the application of one ton per acre of dolomitic limestone, providing the pH is below 5.5, can correct this problem. It may also be useful in lowering the available potassium level in a soil if the latter is exceptionally high.

## FERTILIZATION

Grapes, like other crops, require adequate supplies of all essential plant nutrient elements for optimum growth and yield. Most soils can supply adequate or near adequate quantities of all nutrient elements.

Under Ohio conditions, the plant nutrient elements most likely to limit grape production are nitrogen, potassium, and magnesium. There is some evidence to indicate that phosphorus and manganese may be limiting in specific vineyards. Fertilizer practices in the vineyard are designed to supplement the supply of available nutrients in the soil to that level required for optimum growth and fruit production.

Accurate determination of the nutrient status of the vineyard is basic to proper fertilizer practices. Vineyard sites or sections of the same site may vary in the levels of nutrients available to the grape vines. Several means of determining the nutrient status of the vineyard are available to the grower. Weak growth, poor leaf color, and early defoliation indicate a low nutritional status. Delayed vine and fruit maturity and excessive vigor suggest too much nitrogen. Soil tests are of some assistance in determining the availability of plant nutrient elements. The most recent and most useful means available is through plant analysis. No one means, however, is completely accurate or reliable in itself. The efficient grower utilizes all means available to him in determining vineyard fertilizer programs.

In plant analysis of grapes, leaf petioles are the parts sampled. Chemical analysis of the petioles gives a good representation of the level of nutrient elements in the entire vine. Samples are collected between July 1 and August 15 and mailed to the Ohio Agricultural Research and Development Center Plant Analysis Laboratory for determinations and recommendations. County Cooperative Extension Service offices have detailed information on procedures of this grower service.

Petiole analysis, to be of greatest value, should be developed as part of the management program over a period of years. A single analysis can be useful in diagnosing a nutrient problem or in determining the nutrient status of the vine at the time sampled. It does not, however, indicate what the nutrient status may be a year later. Petiole analysis continued over a period of 3 to 5 years in a given vineyard will help to establish trends and changes in nutrient element levels. The direction and nature of such trends are then interpreted and used in determining annual fertilizer and cultural programs. Such direction can greatly aid in maintaining the vineyard at its peak of production year after year.

**Nitrogen** is the nutrient element most often needed in the vineyard fertilizer program. In fact, the vineyard is rare that does not need nitrogen applied on an annual basis.

Nitrogen deficient vines generally exhibit a light green to yellowish-green color of foliage over the entire vine, with the most intense discoloration occurring in older leaves. Cane growth is shorter and leaves smaller than on vines adequately supplied with nitrogen. The greater the nitrogen deficiency, the greater the reduction in vine and crop production.

The rate of application varies with vine vigor and other factors. In general, most vineyards should receive between 40 and 60 pounds actual nitrogen per acre per year. If ammonium nitrate (33⅓% N) is used, this amounts to 120 to 180 pounds of the material broadcast per acre over the entire vineyard area. Less vigorous vines would receive the higher rates. In small vineyards, nitrogen fertilizer may be applied annually at the rate of ¼ pound of a 33⅓% nitrogen carrier, or its equivalent, around each vine.

Most forms of nitrogen can be used equally well in vineyards. The choice depends largely upon the cost per pound of nitrogen applied. There is one possible exception. On soils with a high pH where grape leaves may show manganese or iron deficiency symptoms, sulfate of ammonia would be preferred. This form of nitrogen tends to increase soil acidity and thus renders more manganese available to the vine roots.

Nitrogen applications, to be of greatest benefit, must be applied at least 30 days before new growth begins in the spring. Where losses of nitrogen are likely to be small due to erosion or leaching, late fall or winter applications may be satisfactory.

High rates of nitrogen application can stimulate excessive growth. Under such circumstances, this may result in the appearance of deficiency symptoms of certain elements. For example, if the available supply of potassium, magnesium or another nutrient element is low in a given vineyard soil, high rates of nitrogen application could result in appearance of deficiency symptoms of one or more of these elements.

**Potassium,** next to nitrogen, is the plant nutrient element most often found limiting in Ohio vineyards. One of the first symptoms to be noticed in potassium deficient vines is a dull, somewhat darker green color of leaves. Accompanying this is usually the development of very dark spots or blotches often nearly covering the affected leaves of a vine. This symptom has often been characterized as "black leaf" of grapes. As the deficiency becomes more severe, marginal chlorosis, browning and dying may occur. It may also be accompanied by brown, dead spots or areas throughout the leaf. In severe cases, half or more of the leaves of a vine may show these extreme symptoms. Severe potassium deficiency greatly reduces vine vigor, berry size, and crop yields.

Symptoms of potassium deficiency generally develop first and become most severe on mid-shoot leaves. Older, basal leaves are usually next to show the symptoms. The younger terminal leaves develop symptoms last and often show none.

The major potassium carriers are potassium sulfate, containing about 50 percent $K_2O$ (potassium oxide or potash), potassium chloride (muriate of potash) containing about 60 percent $K_2O$, and potassium nitrate with 46 percent $K_2O$. There is some evidence indicating

the grape may respond better to potassium sulfate than to potassium chloride. Studies in Ohio have shown no significant differences between them. Thus, any of the carriers may be used to supply needed potassium. Foliar sprays of potassium sulfate or potassium nitrate can be effective in temporarily alleviating severe potassium deficiency.

Potassium compounds tend to be fixed in the soil surface, although to a lesser extent than phosphates. This fixation, which renders potassium unavailable to plant roots, is generally greater in a clay soil with pH near 7.0 than in a sandy soil whose pH may be near 5.0. Thus, rates of potash application may need to be greater and more frequent on clay than on sandy loam soils, especially if the pH is above 6.5. Response to potash fertilizers is greatest when the application is made in a band about two feet wide beneath the trellis. Broadcasting over the entire vineyard is considered a less efficient and economical method of applying potash.

Where limited potassium is known, either soil or foliar applications of sulfate or nitrate of potash should be made. Base the rate of soil application upon the results of either soil or foliar analysis. In general, from 100 to 400 pounds per acre have been adequate in Ohio vineyards. If foliar sprays are indicated, the vineyard should be sprayed with a solution containing 6 to 10 pounds of either carrier per 100 gallons. Apply it at the rate of 300 gallons per acre of mature vineyard. Such foliage applications are of primary value although temporary for the rapid reduction of the potassium problem. Soil applications have a more lasting effect. Make applications as soon as the need is determined.

Avoid excessive rates of potash. Such a practice can develop magnesium deficiency in a vineyard.

**Magnesium** is most likely to be deficient in vineyards with very acid soil conditions, or where excessive amounts of potash have been applied. Deficiency symptoms of this element have been observed in some northern and eastern Ohio vineyards where soils are characteristically acid.

Magnesium deficiency symptoms develop first and most severely on the older, basal leaves of the canes. The most typical symptom is chlorosis or yellowing of tissues between the veins of the leaves while the veins remain green. As a vine becomes more severely affected, the interveinal chlorosis becomes more intense in older leaves and progresses to younger leaves towards the terminals of canes. The younger terminal leaves may not exhibit symptoms until the entire vine is extremely deficient.

Where the soil pH is below 5.5, an application of dolomitic limestone (high in magnesium) at the rate of one or two tons per acre will usually correct magnesium deficiency. Complete correction may not be achieved for one or two years after the application, or it may occur within a few months. If the soil pH is above 5.5 and no liming is needed, then correction is best achieved through foliage applications of magnesium sulfate (epsom salts). Even where dolomitic limestone may have been applied and the magnesium deficiency symptoms are severe, the foliage application would be desirable for quick correction of the problem.

For foliage sprays, magnesium sulfate is mixed at the rate of 16 pounds per 100 gallons of water. Generally, two applications are adequate. Apply the first shortly after bloom and the second two weeks later. Each spray requires about 300 gallons of the mixture per acre to thoroughly wet the vines.

Magnesium sulfate may be applied to the soil where longer lasting effects are desired. This could be the case on high pH soils where magnesium deficiency is due to excessive potash applications. Under these circumstances, it would be applied either alone or mixed with other fertilizer materials at the rate of 100 to 500 pounds per acre broadcast over the entire vineyard floor. The rate depends upon the results of a soil test or foliar analysis. In small vineyards the magnesium sulfate would be applied at ¼ to ¾ of a pound around each vine showing deficient symptoms. Magnesium sulfate or dolomitic limestone may be applied any time of year.

**Other nutrient elements** such as phosphorus, manganese, calcium, and iron have seldom been found deficient in Ohio vineyards. Thus, supplemental applications of these nutrient elements have rarely produced increased growth or yields. Manganese deficiency is most likely to occur in vineyards on soils with pH near 7.0 or above. Few vineyards in Ohio have been planted on such soils.

Manganese deficiency symptoms first appear as interveinal chlorosis or yellowing of the younger terminal leaves. The veins remain green, thus causing symptoms similar to magnesium deficiency. The two symptoms are often confused and in some leaves they cannot be separated except on the basis of a petiole analysis. However, the magnesium deficiency symptoms normally develop first in older leaves while those of manganese are first noticed in young leaves.

In most cases, any manganese deficiency that may occur in Ohio vineyards can be corrected by applying fertilizer grade manganese sulfate. The application rate varies from ½ to 1 pound per vine, depending upon vine size and severity of the deficiency. A manganese chelate (EDTA) or Raplex may be used in place of manganese sulfate. These materials should be applied according to the product label.

All of these manganese materials can be applied as foliage sprays for quick correction of a deficiency. Mix manganese sulfate at the rate of 4 pounds plus 2 pounds of hydrated lime per 100 gallons of water. Manganese chelate is mixed at the rate of 1 pound per 100 gallons of water, and Raplex at 2 pounds per 100 gallons. The spray is applied at the rate of 200 to 300 gallons per acre. Two applications, the first just after bloom or when symptoms first appear and the second two weeks later, will usually give season-long control of manganese deficiency symptoms.

Phosphorus, when a need is indicated by soil or petiole analysis, is generally applied as super phosphate or as phosphate in a mixed analysis fertilizer. If calcium is ever needed, it can be applied as finely ground limestone, hydrated lime or in fertilizer mixtures. Iron, if deficiency symptoms ever develop or a petiole analysis indicates a need for its application, is best applied in the form of iron chelates.

When applying manganese, iron, boron or any other micro nutrient element, be careful to avoid over application. Too great a concentration of these elements in soils can cause severe toxic symptoms in vineyards.

It is generally more economical to improve soil fertility than to compensate for poor air and soil drainage of the site. Thus, in site selection, the drainage considerations are usually more significant than soil fertility.

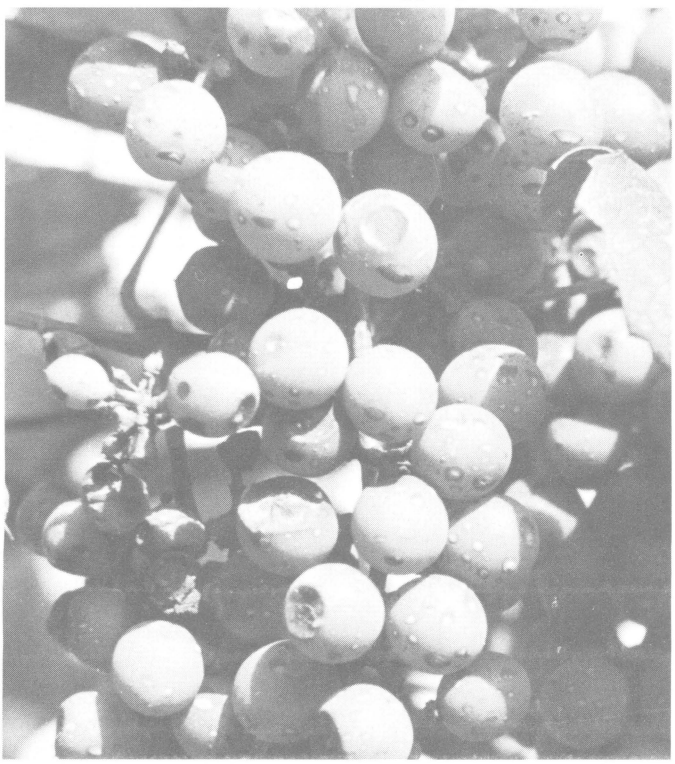
Modern equipment for disease and insect control is more efficient.

## DISEASES AND INSECTS AND THEIR CONTROL

Two major problems encountered in grape growing are diseases and insects. Damage from the these pests is often of greater concern with grapes than other fruits because of the difficulty of sorting injured berries from good ones on the cluster. The grower must adjust his practices throughout the life of the vineyard in order to avoid or to minimize these problems and to reduce losses.

The most important single practice which must be followed is a regular spray program designed to prevent a build-up of diseases and insects within the vineyard. Annually, a revised spray program is made available through county Cooperative Extension Service offices. This incorporates the latest advances in disease and insect control measures. It is most important that only the correct and current season's program be followed.

Success in disease and insect control depends on the use of correct pesticides at the appropriate time and in the proper amounts. Also just as important to the total program as the use of pesticide sprays is the intimate knowledge that the grower has of his vineyard, including all phases of culture. There are a number of comprehensive sources of information available concerning diseases and insects, their descriptions, types of damage, and control measures.



Black rot of grapes in early stages. Dark, sunken spots are points of infestation.

**Black Rot:** The fungus causing black rot may attack the leaves, young canes, tendrils, and fruit. Only the youngest tissues are susceptible, although the fruit may become infected at any time until it is fully grown. Rotting of fruit after it begins to color is generally caused by other organisms.

About 2 weeks elapse between the actual time of infection and the appearance of typical spot symptoms. Although spotting occurs on the leaves and vines early in the spring, the disease does not attract much attention until mid-summer when the nearly half-grown berries begin to rot. The disease on the fruit first appears as light-brownish, soft, circular spots, which enlarge rapidly, and within 2 or 3 days the entire berry is discolored. By the next day, small black specks begin to appear on the discolored berry. Very soon the decaying berries begin to shrivel, and within a week or 10 days they are transformed into black, hard, shriveled mummies, which may remain attached to the bunch for several weeks. Some shattering of the berries may occur, depending on the cultivar, during the period of rapid decay and before they shrivel. After being mumified, berries are not readily dislodged. The attached dried fruit is covered with very small pimple like structures which produce infective spores.

The fungus remains dormant through the winter, but during the warm, moist weather in the spring, new spores are produced and they infect the young leaves and shoots. Thus, the rot organism is perpetuated from one season to the next. The abundance of the disease from season to season depends on weather conditions during the spring and the early summer and on the amount of diseased material carried over on the vines, fallen leaves, and fruit from the previous season.

Control measures must begin early in the season and continue on a regular schedule if black rot is to be effectively controlled. If this is not done, the fungus may attack young shoots and foliage, thus building up a source of spores capable of infecting the fruit later in the season.

**Downy Mildew:** Downy Mildew tends to be more severe and more difficult to control in southern than in northen areas of the state, even though it is favored by cool, moist weather.

The older leaves in the center of the vine are the first to become infected. The disease spreads toward the foliage at the end of the shoots as the leaves mature, and by autumn on highly susceptible cultivars, even the newest leaves may be affected. The disease may cause complete defoliation. If the season has been unfavorable for rapid development of the fungus, or if the grape cultivar is resistant, only a few of the oldest leaves may show symptoms.

The fungus overwinters in old diseased leaves on the ground. Weathering and decomposition liberate the spores during the spring. Splashing rain or wind causes some spores to reach the new shoots, tendrils, leaves or the fruit, where infection starts. Only minor damage is done to the foliage before late summer. The greatest damage occurs during August and September.

The first evidence of downy mildew infection in the leaves appears as light-yellow spots on the upper leaf surface. Later, a white moldy growth of fungus threads and spores forms on the undersurface of the leaves. The spots may be few or numerous. When they merge, they may affect most of the leaf surface. Invasion of the fungus kills the leaf tissues, then affected parts turn brown. Such leaves finally become dry and crumpled. When these leaves fall, the clusters of fruit may be scalded by the sun. Vines losing their leaves before the ripening season cannot mature the fruit normally. Consequently, fruit is of inferior quality. Early season infections on the shoots, tendrils, and developing fruit appear as water-soaked depressions without any other diagnostic characters, unless a white moldy growth develops similar to that on undersides of leaves.

When the fruit is attacked by downy mildew, there may be two infection periods. The first is in June when the grape berries are about the size of small peas. Berries infected at this period are soft, covered with the white snowy growth of the causative fungus, and shatter easily. During the hot summer months little fruit infection occurs. When nights become cooler a second infection period may occur. The fruit infected at this time does not soften or show the downy growth. Instead it becomes brownish, withers, and shatters easily. In severe cases the entire cluster may be destroyed.

The severe injury produced by the herbicide 2,4-D, to which grapes are extremely susceptible, may be confused with the injury caused by downy mildew. However, with 2,4-D, the white moldy growth of the fungus is not present.

**Powdery Mildew:** The economic importance of this fungus disease is generally much less than that of downy mildew or black rot. In Ohio and surrounding states, it is primarily a disease of the foliage and berry cluster stems.

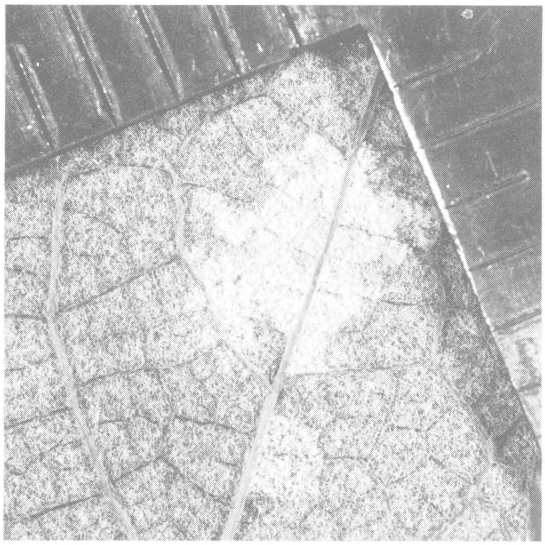
The infected area appears as a white, powdery, superficial growth on the upper side of grape leaves and on other green parts of the vine. Severely affected leaves turn brown and fall. If the berries are infected, the surface appears russeted or scurfy. They fail to mature properly, but no rot is associated with this injury. Infection of the cluster stem may cause shelling if the harvested fruit is not used immediately.

Powdery mildew is usually not troublesome in vineyards sprayed to combat black rot and downy mildew.

**Dead Arm:** This fungus disease is normally not a problem in Ohio vineyards, but if left uncontrolled, dead arm can cause severe damage. Considerable vine weakening, reduction in yield, and even loss of vines may result.

Dead arm is primarily a disease of the trunk and main arms. The fungus frequently enters through wounds or damaged tissue. After entering the damaged tissues, it lives there year after year as a perennial parasite. It causes a canker to form which enlarges each year and finally girdles the arm or trunk. Those parts of the vine above the canker then die. Often, a new shoot develops near the canker. Generally, it will be weak, its foliage dwarfed and curled, and usually it dies the following winter.

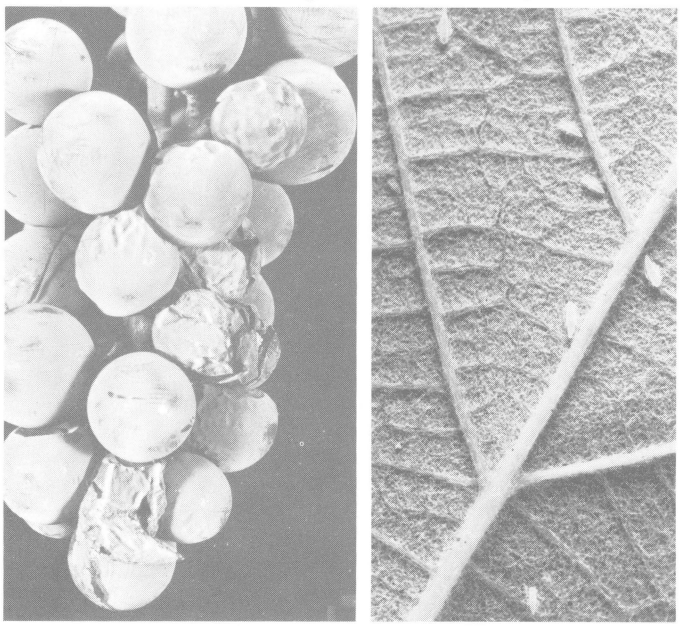
As soon as the canker is first noticed, remove it from the vine well below the margins of the canker and destroy by burning. This may mean complete removal of an infected vine. In vineyards where dead arm has been found, a delayed dormant spray of bordeaux



**Downy mildew infestation on underside of leaf. In severe cases may cover most of underside of leaf.**

mixture (8-8-100) or Captan at 2 pounds per 100 gallons of water should be applied. This spray protects vines against entrance of the fungus.

**Grape Berry Moth:** The larva of this moth is an active, greenish caterpillar about three-eighths inch long when full grown. Larvae (worms) of the first brood of this pest feed on the blossoms or very young fruit clusters and in the newly formed berries. Those appearing later injure the green and ripening berries. These wormy berries are unsaleable. One larva may enter and injure several berries. Another symptom of activity of grape berry moth in the vineyard is the characteristic cocoons found in the fold of the leaves made after the larvae have left the berries. Caterpillars of the first brood usually construct their cocoons on the grape leaves on the vine during June or July. Those of the second brood usually drop to the ground and form their cocoons on small pieces of leaves under the grape trellis. The leaf folds containing the cocoons may remain at-



**Left, feeding damage of grape berry moth (small worms). Right, leafhoppers feeding on underside of leaf.**

tached to the leaves or they may break off and fall to the ground.

The insect overwinters on the ground in the cocoon. Late in the spring or early in the summer, inconspicuous brownish moths emerge and lay their eggs on the grape stems or berries.

**Grape Leafhoppers:** Grape leafhoppers are small, agile, white or pale-yellow insects with red or yellow markings and occur wherever grapes are grown. Abundant on the lower surface, they feed by sucking juice from the leaves causing them to become blotched with white which may later turn to brown and fall from the vines prematurely. Leafhopper feeding may interfere with normal vine growth and proper ripening of the fruit.

The insects overwinter in the adult stage in protected places, usually in trash on the ground in or close to vineyards. With the first warm days of spring, leafhoppers become active and feed on any green vegetation they can find, but they concentrate on the new leaves. Eggs are laid in the leaf tissue. There may be two or three generations of this insect each season.

**Japanese Beetle:** This insect has been more abundant in Northern and Eastern Ohio than in other areas of the state. The adult is a shiny, metallic green beetle with coppery-brown wing covers and slightly less than one-half inch long.

Adult beetles appear in vineyards during early summer, usually by mid-June. They have a ravenous appetite feeding upon foliage, especially the parts exposed to direct sunlight. They are frequently seen clustered together feeding on the tender vegetative parts. Affected leaves may have a lacelike appearance and those badly injured soon drop.

**Rose Chafer:** In a few localities, the rose chafer causes severe injury early in the season by feeding on grape foliage, blossoms, and newly set berries. Adult beetles feed on many kinds of plants and sometimes fly into a vineyard in large numbers. Here they consume most of the foliage, leaving only the larger vines. The feeding period rarely lasts longer than 3 to 4 weeks. Breeding of this insect occurs largely in the lighter, sandy soils where the small white grubs (larval stage) may be found.

**Grape Rootworm:** Limited vigor and, in some cases, wilting of grape vines may be due to attacks of the grape rootworm. These small white worms or grubs feed on the small roots and rootlets, and may tunnel throughout the outer part of larger roots.

Left, injury from herbicide, 2,4-D. Right is normal leaf.

Another indication of the grape rootworm presence is the appearance of adult beetles during the bloom period. These small, hairy, chestnut-brown beetles feed on the upper surface of grape leaves. Evidence of their feeding is a series of patches or holes eaten through the upper surface to the lower surface. Such injury is often of little concern and is of much less economic importance than the root feeding of the larvae. However, such feeding marks may indicate the presence of grape rootworms in a vineyard and the need for special control measures.

## INJURY FROM 2,4-D

Effects of 2,4-D on grape vines is frequently confused with disease and insect injuries. Most cultivated grape vines are highly susceptible to the injurious effects of this herbicide and related compounds. These herbicides are now available and used in a wide variety of forms.

Due to the extreme volatility of many 2,4-D compounds, injury to the grape may be observed at great distances from the point of application. In some areas use of such compounds in crop production has seriously limited the potential for grape production. It goes without saying that these compounds should not be used in or near the vines, unless one is willing to hazard the risks involved.

If a 2,4-D type of herbicide must be applied in the vicinity of grapes, use the least volatile forms. There are several of these available in commercial formulations. The effects of the highly volatile forms of 2,4-D and related compounds have been observed in vineyards at least 5 miles from the place of application. If at all possible, avoid the use of 2,4-D products in the immediate vicinity of grapes.

Symptoms of 2,4-D injury are quite characteristic on grape vines. The youngest terminal growth is most easily and severely affected. Terminal growth may cease for a time following the initial effects and will be retarded for several weeks if severe. Affected terminal leaves are small, narrow, misshaped and have closely packed, thick veins. The latter symptom is the most prominent. Vines showing these symptoms seldom produce new growth of normal features for the remainder of the season. If the effects were not too severe, normal growth will be resumed the following year. Severely injured vines may not recover for two years or more.

Vines injured by 2,4-D may also have delayed fruit ripening. When vines are severely affected, fruits may never mature regardless of length of season. These delayed maturity effects may exist in a vine for one to three years before normal ripening returns. Slight 2,4-D injury may have little or no effect upon fruit maturity.

Cultivars vary somewhat in their tolerance of 2,4-D. Concord is one of the most susceptible while some vinifera cultivars possess a fair degree of tolerance to 2,4-D.

## HARVESTING

The proper time to harvest grapes depends upon the cultivars, nature of the growing season and the particular use to be made of the fruits. The best way to tell the exact time to pick is by the degree of maturity.

The rate at which grape fruits mature, as well as the time of their ripening, is governed by several factors, of which some may be altered by the grower. Chief among these factors are:

Small cart used to hold container while hand picking grapes. Picker clips clusters from vine.

1. **Selection of cultivars that inherently mature their fruits within a specified growing season in Ohio:** Cultivars that bloom before June 15 generally mature their fruits in most seasons, especially if the first killing frost does not occur before late October.
2. **Growing season temperatures:** An average temperature of 70° F for the growing season is necessary for proper function of the natural processes that bring fruits and vines to maturity.
3. **Crop load:** Vines carrying normal to less than normal crops mature fruits earlier than those with heavy crops.
4. **Light exposure:** Vines trained to expose the highest percentage of leaves to light, especially those near the base of canes, mature fruits earlier than vines with less light exposure.
5. **Healthy foliage:** Leaves free from insect, disease or herbicide injury or nutrient deficiencies are conducive to normal maturity.
6. **Vine vigor:** Over vigorous vine growth tends to delay maturity of fruit and wood, while vines in low vigor generally mature wood and fruit somewhat earlier than normal vines.

Fruits normally reach maturity somewhat earlier on vines of moderate vigor than on those of high vigor. They also mature somewhat earlier on well exposed than on shaded shoots. The same is true of the wood of shoots that will mature into canes. Thus, in the case of over vigorous vines, neither fruit nor wood in the densely shaded portions may reach proper maturity before leaves and tender shoot terminals are killed by Autumn frosts.

There are several indices that must be considered together in determining the level of grape berry maturity. The size, color, and taste of the berry as well as its soluble solids content or refractometer value are the major considerations. Most grape cultivars change color long before they are mature enough for harvesting. Thus, grapes picked by their color alone may be harvested prior to their peak by flavor, size, and soluble solids content.

Grapes do not improve in color and sugar content after removal from the vine. On the other hand, if the grapes are left too long on the vine, the berries may shatter off and reduce yields. For table use, grapes are picked when both color and flavor have reached their peak. The average length of time between bloom and optimum harvest date for a cultivar can be helpful in determining the time of harvest but may vary considerably from year to year. The section, GRAPE CULTIVARS, contains information on length of growing season.

Grapes for commercial processing are generally harvested at the stage of maturity desired by the processor. The primary index of maturity for this purpose is the soluble solids (sugar) content, or the ratio of soluble solids to acid in the fruits. The percentage of soluble solids can be determined by placing a few drops of freshly pressed juice in a refractometer and reading directly on the scale. A Balling hydrometer can also be used for this purpose.

Processors prefer grapes that contain 15 percent or more soluble solids (sugars). Acceptable total acid content may range from slightly less than one percent to as high as two percent at harvest maturity. The importance of soluble solids content of the grape berry is shown by the price differential paid by processors. As the soluble solids content increases above 15 percent, there is a corresponding increase in price paid per ton of fresh grapes. Thus, growers must carefully evaluate their cultural practices as to effects upon soiuble solids content of the fruits, as well as upon yield, if they are to gain maximum returns from their enterprise.

Even though the quality of the fruit may be highest by harvesting only fully ripened clusters, it is sometimes necessary to harvest the crop before all the fruit is fully mature. There is always danger of loss if harvesting is delayed until all fruit matures on the vines. Some varieties tend to crack after maturity, and rain increases this tendency. On susceptible varieties, ripe fruit rots spread rapidly during rainy weather.

Where the growing season is short, a freeze or frost may damage the crop. In some locations birds do an enormous amount of damage, and mature fruits cannot be left on the vines unprotected without serious loss. In home plantings clusters on a few vines can be protected by bagging with Kraft bags, or by covering the vines with netting.

For fresh market and home use, the clusters are harvested selectively according to the degree of maturity. For commercial processing, the entire crop of a vine or cultivar is harvested at once.

Most grapes are picked by hand. The picker places his hand under the cluster, then uses a small pair of shears to clip the cluster from the vine before placing it carefully in a container. Grapes for fresh market are most frequently placed into 8 or 12 quart baskets. Those going to the processor are placed in lugs or boxes of various sizes. The most common ones hold from 15 to 20 pounds. Specially made, light-weight nesting plastic lugs are now widely used in commercial vineyards. A small light-weight portable picking stand is a convenient way to hold the picking containers and for moving along the row. An experienced picker in good grapes can pick between 40 and 50 lugs per day.

Although most grapes are now hand harvested, mechanical harvesters are being developed and are coming into use in large commercial vineyards for harvesting processing grapes. Most of the harvesters operate on the principle of high frequency vibration arms moving along the vines that shake the grapes from the clusters.

Grapes for fresh market or table use should be picked and handled carefully. It is often desirable to harvest a vine more than once. The first picking gets

**Since most grapes are used in processing, mechanical harvesting is gaining rapidly. Harvester straddles row and shakes berries from vines onto conveyor system.**

exposed clusters that are most mature and which are usually of the highest grade and quality. A second picking in one or two weeks is usually needed for completing the harvest of the remaining fruit.

Although migrant labor is frequently used, neighborhood families supply large numbers of excellent, skilled grape pickers in Ohio.

### Yields

A partial crop may be expected the third season after planting. Full bearing capacity will be reached about the sixth year. Vineyards have been known to be productive for nearly 100 years. However, the commercially profitable life of a vineyard is probably limited to 30 to 50 years. The profitable life will depend largely upon the suitability of the site and the care given a specific vineyard.

The yield of grapes per vine and per acre varies considerably from vineyard to vineyard. Factors influencing yield per vine include productive nature of the cultivar, pruning and training system, vine size, cultural practices applied to the vineyard, and the presence or absence of diseases, insects, frost or other injuries to vines or fruits. Yield per acre is influenced by the productiveness per vine and by the vines per acre.

Improved cultural practices, pest control, and vine training technique now make possible much higher grape yields than a few years ago. Yields of 8, 10 and even 12 tons of grapes per acre are not uncommon. Unfortunately the state average yield for Ohio is only about 4 tons per acre. A vineyard in a good productive state under good management can average at least 6 tons per acre over a period of years. Considering 600 vines per acre, this means a per vine yield of 20 pounds. If the clusters average one-half pound each, then a vine will require about 40 clusters to produce the 20 pounds or the 6 tons per acre yield.

### Handling

Use care to minimize the exposure of harvested grapes to the sun in order to maintain high fruit quality. As soon as practical after harvest, remove the fruit from the vineyard and place it in the shade or other cool area. In large commercial plantings, a fork lift mounted on the front or back of a tractor is used to efficiently move and assemble filled containers. Careful handling during this movement keeps bruising of fruit to a minimum.

The fruit should be moved as rapidly and as directly as possible to the consumer or to the processor. If, for some reason, the fruit must be held for a period of time before sold or used, it is best to keep it in refrigerated storage.

Holding Ohio grown grapes for extended periods of time is generally not practiced. Growers desiring to hold grapes for a special purpose or to extend the marketing period will find that some varieties can be held for as long as two months. Red cultivars, generally, store longer than blue-black or white ones. Among the cultivars that can be stored the longest are: Delaware (R), Naples (R), Yates (R), Catawba (R), Buffalo (B), Steuben (B), and Sheridan (B). Two white seedless grapes with fairly good keeping qualities are Himrod and Romulus.

Ideal storage conditions for keeping grapes the longest period are similar to those for apples, namely temperatures of 30° to 33° F and a relative humidity of 85 to 90 percent. For storage periods of only a few days, temperatures between 35° and 45° F may be satisfactory.

## MARKETING

The first step in successful marketing is taken prior to establishing the vineyard. It consists of a thorough consideration of the potential market for the grapes that may be produced. The successful grower produces grapes for a specific market or markets, rather than growing the crop and then attempting to find a market. Even in the selection of cultivars, the potential market must be considered. When planting grapes for commercial processing, the grower should first establish an agreement with the processor.

Ohio produced grapes are marketed in three ways. The primary channel has been processing into unfermented juice, wines, and other products. A modest volume of fresh grapes has moved through wholesale channels and retail stores. In recent years, an increasing volume has been sold retail on the farm and in farm markets. This latter method of marketing offers greater possibilities for the future with the introduction of a greater number of improved cultivars adapted to fresh market and table use.

Various types of containers have been used in the marketing of fresh grapes, both in retail stores and farm markets. Among the more popular ones is the cardboard carton with wooden handle which hold 2 or 4 quarts. Filled with red, white, and blue grapes, this type of basket arranged in a mass display can create eye appeal and sales demand. Of increasing importance are boats or trays filled with grapes, then over-wrapped with a transparent film. This type of container protects the grapes from drying out and helps to maintain their fresh appearance. If grapes on display in stores or farm markets can be kept refrigerated, their fresh, attractive appearance can be maintained much longer than if held at room temperature.