Grape Growing in Virginia

EXTENSION DIVISION
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

PUBLICATION 5
REVISED NOVEMBER 1979
CONTENTS

Introduction and History ........................................... 1
Location of vineyard ............................................... 2
Site and soil ...................................................... 2
Variety selection .................................................. 2
American hybrids ............................................... 2
French-American hybrids ........................................ 3
Vinifera .......................................................... 3
Muscadine ......................................................... 3
Virginia introductions ............................................ 4
Propagation ........................................................ 4
Cuttings ........................................................... 4
Layering ........................................................... 5
Grafting ............................................................ 5
Establishing the vineyard ......................................... 6
Site preparation ................................................... 6
Planting ............................................................. 6
Trellis construction ................................................ 6
Training systems .................................................... 7
Four-arm Kniffin .................................................. 7
Umbrella Kniffin ................................................... 7
Single Curtain Cordon ........................................... 8
Geneva Double Curtain .......................................... 8
Training young vines ............................................... 8
Pruning mature vines .............................................. 9
Fruiting habits of grapes ......................................... 9
Time of pruning ................................................... 9
Severity of pruning ............................................... 9
Tying the vines ................................................... 10
Cluster thinning .................................................. 10
Soil management ................................................... 11
Cultivation ....................................................... 11
Fertilization ...................................................... 11
Pest control ....................................................... 11
Harvesting ........................................................ 12
Time of harvesting ............................................... 12
Yields ............................................................. 12
Method of harvesting ............................................ 12
Handling and storage ............................................. 12
Vineyard Establishment Costs ................................... 13

The research on which this publication is based was conducted by G. D. Oberle, Professor Emeritus of Horticulture, and R. C. Moore, Associate Professor Emeritus of Horticulture. Appreciation is given them for their original work on earlier versions of this publication.

The Alwood grape shown on the front cover was developed, selected, and named by R. C. Moore, Associate Professor Emeritus of Horticulture, and a member of the V.P.I. Horticulture Department for 42 years. Alwood was released in 1967.
GRAPE GROWING IN VIRGINIA

Revised by
E. L. Phillips, C. R. O'Dell, and C. L. McCombs

Department of Horticulture

Grape growing has received serious attention in Virginia since soon after the arrival of the first English colonists at Jamestown in 1607. Although native grapes were abundant, they failed to win the approval of the colonists due to the strong flavor and odor. In 1619 cuttings of the best wine grape varieties grown in France were brought to Virginia. The vines soon “sickened and died”.

This was repeated many times in Virginia and other eastern states with the same results. The European varieties lacked winter hardiness, were susceptible to fungus diseases endemic to this area, and were totally lacking in resistance to the grape root louse (Phylloxera vastatrix). Only in California and a few other areas having a similar mild and dry climate was a successful wine and table grape industry based on the European grape, Vitis vinifera, established in the United States.

Chance cross pollination of the imported European varieties with American bunch grape species, particularly Vitis labruscana, resulted in seedlings which combined many of the desirable characteristics of both parental types and fewer of the undesirable characteristics. From these chance seedlings came such varieties as Alexander, Catawba, Concord, Delaware, Isabella, Norton, and many others. This opened the door to the profitable commercial grape culture in the eastern United States. Intentional hybridization of European and American varieties and careful selection of the resulting seedlings has led to the improved varieties of American bunch grapes now available.

The grape root louse, carried abroad about 150 years ago on roots or cuttings of American species of grapes, spread rapidly across most of the grape growing regions of Europe. The existence of the industry was seriously threatened until it was found that the vinifera grape could be grafted easily on roots of the American species and thrive on them. In a very few years the European grape industry was converted almost entirely to vines grafted on American roots.

Hybridizers in France soon recognized that grafting the grapes involved additional expense in establishing vineyards and presented hazards in maintaining the vines. They, too, crossed European varieties with wild grapes from America and selected seedlings which escaped or resisted attacks by the phylloxera. These hybrids, often referred to as “direct producers” because they could be grown on their own roots, are known locally as French hybrids, or, more correctly, as French-American hybrids. Developed primarily for use in wine making, some of these hybrids are also good as table grapes. They are becoming increasingly popular in America and some varieties have performed quite satisfactorily in Virginia.

Although commercial production of the European, or vinifera, grape in North America is confined primarily to irrigated areas in California and adjoining states because of its requirement for a less humid climate and less severe winter temperatures, sufficient information has accumulated in recent years to indicate that selected varieties can be grown under some eastern conditions. Test plantings have been under way for a number of years in several of the eastern grape growing states, and more recently at various locations in Virginia. Successful production is expensive and time-consuming, however, as it involves special cultural care, careful selection of rootstocks, adjustments in pruning systems, fruit thinning, and additional sprays to protect fruit and foliage against insects and fungus diseases.

The muscadine grape, Vitis rotundifolia, is native to the southeastern states and adapted only to areas having relatively mild winters and long growing seasons. Some progress is being made toward developing new varieties that will mature their fruit in areas having shorter growing seasons and whose vines will withstand winters of lower temperatures. For the muscadine varieties now available, suitable growing conditions in Virginia are found only in the southeastern counties. Richmond and Petersburg probably are as far west as they can be expected to grow well, with Richmond and the York River being the northern limit.

Demand for grapes in Virginia far exceeds the supply in most local markets, and additional vineyards could prove profitable, if well managed. Commercial grape growing is a specialized business, however, and requires thorough knowledge and skill. Prospective growers should first determine whether or not their soils and locations are suitable for the type of grapes they desire to grow. Then, only the best available varieties should be chosen for planting.

Once the vineyard is planted, a carefully planned program of the best practices of pruning, fertilizing, weed control, and pest control should be followed in order to produce large crops of high quality grapes. Sufficient capital is needed to finance the cost of plants, posts, wire, fertilizer, spray materials, equipment, and labor for the first 4 years, until the vines reach full bear-
ing age. Vineyards may be expected to bear profitably for 20 to 30 years or longer, and such initial costs will be recovered over a period of years.

LOCATION OF VINEYARD

The first and most important step towards a successful vineyard is the careful selection of a good location. Commercial vineyards should be planted only where they are most likely to succeed. From 150 to 180 or more frost-free days are necessary for fruit and vine maturation of most varieties. Planting any type of grape in an area with less than 150 frost-free days involves risk.

Most American grapes and French-American hybrids can withstand humid summers and cold winters better than the vinifera varieties. Variations exist, however, with regard to climatic adaptation. Length of growing season for a given area of the state, winter hardiness, and susceptibility to such diseases as black rot and mildew should be considered in the selection of varieties of either type.

The European grape, Vitis vinifera, grows best under long, mild summers and cool winters. It is extremely susceptible to fungus diseases and insect pests that flourish under humid conditions. Neither does it withstand intense winter cold without protection. Few varieties are successful where temperatures frequently drop below 10°F. It requires a long growing season, with a minimum amount of rainfall during the blossoming and ripening season.

The muscadine grape, Vitis rotundifolia, cannot be successfully grown where temperatures fall below 10°F. It will thrive, however, in warm, humid areas where other types of grapes fail.

SITE AND SOIL

The vineyard should be planted on a site higher than the surrounding land in order to provide good air and water drainage, thereby reducing injury by late spring frosts. Gently sloping land is preferred to steep slopes. On sloping land, the grape rows should follow the contours of the land to lessen soil erosion. Cool temperatures on northern slopes often delay vine growth enough in the spring to avoid frost damage, whereas a southern slope may result in earlier growth and increased risk of frost injury. Avoid planting on a slope exposed to strong prevailing winds to reduce vine damage and trellising problems.

A good vineyard site allows maximum exposure of the foliage to sunlight. Where the slope permits, it may be of advantage to run the rows in an east-west direction. Not only will this permit better light exposure, but it also allows prevailing winds to help dry dew and rain more quickly, thus reducing disease problems.

Grapes are deep rooted plants, frequently penetrating to a depth of 6' to 8' under good soil conditions. Although they can be grown on a wide range of soil types, they do best on fertile sandy loam soils, high in organic matter. Deep sands or heavy clays may be used, however, if provisions are made for adequate fertilization, moisture, and soil drainage. Grapes are tolerant to a wide range of soil acidity, but prefer a pH of 5.5 to 6.5.1

VARIETY SELECTION

Proper selection of varieties is of major importance to the commercial grape grower. In addition to fruit and vine characteristics such as quality, vigor and productivity, season of ripening, hardiness, and resistance to common disease and insect pests, the market outlet and requirements of the processor or consumer must be considered. A market for the grapes should be determined before the vines are planted.

Tables 1-4 may be used as a guide in selecting varieties for use in commercial vineyards in Virginia. The indicated time of ripening of each type of grape is relative, approximate, and variable. With the exception of the muscadine varieties, the time of ripening has been indicated with reference to the average date Concord is ready for commercial harvest.

Seasonal conditions, particularly temperature, have a great influence on the time of ripening of all grape varieties. Development is slow in a cool season and rapid in a warm season. Varieties requiring a long season for maturation should not be planted where the growing season is short.

Vineyard management also influences time of ripening. Trellising systems that increase the amount of leaf exposure to full sunlight will usually hasten fruit maturation. Overcropping delays maturity, as does over stimulation of vegetative growth with excess nitrogen or excess moisture. Diseases and insect damage which reduce the foliage generally reduce the rate of fruit ripening and maturity of both fruit and wood.

American Hybrids

The older American bunch grape varieties were developed from selections from wild American species, primarily Vitis labruscana, and hybrids of two or more selected varieties. Many of the newer American hybrids involve crosses of V. labruscana with one or more grape species such as V. vinifera, V. riparia, or V. aestivalis. All varieties developed by these crosses exhibiting predominantly labruscana characteristics are generally referred to as American bunch grapes.

The varieties in Table 1 have been selected for their adaptability to Virginia growing conditions, and, except for the limitations noted, can be successfully grown commercially throughout the entire state.
these hybrids have potential for table use and all yield quite good jams and jellies. Their suitability for wine is due mainly to a flavor predominantly vinifera in character.

Of the many French-American hybrids available, those listed in Table 2 have been sufficiently tested to be suggested for planting anywhere in Virginia American bunch varieties can be grown.

Vinifera

Few varieties of Vitis vinifera have performed well enough to be recommended for commercial planting in Virginia. Varieties that have performed reasonably well in test plots and home plantings include Malaga Bleu, Lignan Blanc, Chasselas Golden, and Loenigen der Weingarten. In northern wine-growing areas, and in some small commercial vineyards in Virginia, there is some limited production of a few vinifera varieties for wine. Of these, Johannisberg (White) Reisling and Pinot Chardonnay have been the most successful.

The wine varieties of vinifera listed in Table 3 show sufficient promise to be suggested for trial plantings in Virginia, subject to the limitations noted.

French-American Hybrids

Most of the French-American hybrid grapes have been introduced since World War II. They were developed from crosses of the European grape, Vitis vinifera, with one of the American species, primarily V. rupestris and V. linceumii. Although developed as wine grapes, some

Table 1.—American Grape Varieties for Virginia

<table>
<thead>
<tr>
<th>Variety</th>
<th>Harvest Date in Weeks before or after (+)</th>
<th>Principal Use</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Himrod W</td>
<td>3</td>
<td>T</td>
<td>Good white wine.</td>
</tr>
<tr>
<td>Seneca W</td>
<td>3</td>
<td>T</td>
<td>Good table grape.</td>
</tr>
<tr>
<td>Price B</td>
<td>3</td>
<td>T, J</td>
<td>High quality, vigorous.</td>
</tr>
<tr>
<td>Buffalo* B</td>
<td>2½</td>
<td>T, J, W</td>
<td>High quality, hardy.</td>
</tr>
<tr>
<td>Fredonia B</td>
<td>2½</td>
<td>T, J</td>
<td>Good white wine.</td>
</tr>
<tr>
<td>Alden B</td>
<td>2</td>
<td>T, W</td>
<td>Non-slipskin, high quality.</td>
</tr>
<tr>
<td>Bath* B</td>
<td>1½</td>
<td>T, J</td>
<td>Concord type, hardy.</td>
</tr>
<tr>
<td>Monticello B</td>
<td>1½</td>
<td>T, J</td>
<td>Hardy, high quality, vigorous.</td>
</tr>
<tr>
<td>Delaware R</td>
<td>1</td>
<td>J, W</td>
<td>Good white wine.</td>
</tr>
<tr>
<td>Concord* B</td>
<td>0</td>
<td>T, J, W</td>
<td>Standard by which other varieties are rated.</td>
</tr>
<tr>
<td>Niagara* W</td>
<td>½</td>
<td>T, W</td>
<td>Good wine, sus. to black rot.</td>
</tr>
<tr>
<td>Steuben B</td>
<td>½</td>
<td>T, J</td>
<td>Concord type, recommended for E. Va.</td>
</tr>
<tr>
<td>Catawba* R</td>
<td>½</td>
<td>J, W</td>
<td>Popular wine variety.</td>
</tr>
</tbody>
</table>

* Not recommended for Eastern Virginia due to uneven ripening and susceptibility to black rot.

1 Fruit Color: W—white; B—black or blue; R—red.
2 Average Concord Ripening Date: Valley and Southwest Virginia—Sept. 10; Piedmont—Sept. 6; Southside and Tidewater—Sept. 1.
3 Principal Use: T—table or dessert; J—juice, jam, jelly; W—wine.

Table 2.—French-American Hybrids for Virginia

<table>
<thead>
<tr>
<th>Variety</th>
<th>Harvest Date in Weeks before or after (+)</th>
<th>Wine Color</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aurora (S-5279) W</td>
<td>2</td>
<td>W</td>
<td>Good table grape, hardy, vigorous, productive.</td>
</tr>
<tr>
<td>Cascade (S-13059) B</td>
<td>1½</td>
<td>R</td>
<td>Hardy, vigorous, productive.</td>
</tr>
<tr>
<td>Foch (Kuhlmann 188-2) B</td>
<td>1</td>
<td>R</td>
<td>Hardy, med. vigor, average production.</td>
</tr>
<tr>
<td>DeChaunac (S-95-9) B</td>
<td>½</td>
<td>R</td>
<td>Hardy, productive, average vigor.</td>
</tr>
<tr>
<td>Bacch Noir (Baco #21) B</td>
<td>½</td>
<td>R</td>
<td>Extremely vigorous, small clusters, hardy.</td>
</tr>
<tr>
<td>Leon Millot (Kuhlmann 194-2) B</td>
<td>½</td>
<td>R</td>
<td>Hardy, productive, disease tolerant.</td>
</tr>
<tr>
<td>Chancellor (S-7053) B</td>
<td>0</td>
<td>R</td>
<td>Very productive, hardy, vigorous.</td>
</tr>
<tr>
<td>Seyval (SV-5276) W</td>
<td>½</td>
<td>W</td>
<td>Very good wine, sus. to disease, medium vigor.</td>
</tr>
<tr>
<td>Vidal (V-356) W</td>
<td>½</td>
<td>W</td>
<td>Vigorous, productive, promising.</td>
</tr>
<tr>
<td>Villard Blanc (SV-12375) W</td>
<td>½</td>
<td>W</td>
<td>Good table grape, hardy, vigorous, productive.</td>
</tr>
</tbody>
</table>

1 Fruit Color: W—white; B—black or blue.
2 Average Concord Ripening Date: Valley and Southwest Virginia—Sept. 10; Piedmont—Sept. 6; Southside and Tidewater—Sept. 1.
3 Wine Color: W—white; R—red.

French-American Hybrids

Most of the French-American hybrid grapes have been introduced since World War II. They were developed from crosses of the European grape, Vitis vinifera, with one of the American species, primarily V. rupestris and V. linceumii. Although developed as wine grapes, some

Table 3.—Vinifera Varieties for Virginia

<table>
<thead>
<tr>
<th>Variety</th>
<th>Harvest Date in Weeks before or after (+)</th>
<th>Wine Color</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinot Noir B</td>
<td>1</td>
<td>R</td>
<td>Moderate in vigor, hardness, productivity.</td>
</tr>
<tr>
<td>Gewurztraminer W</td>
<td>½</td>
<td>W</td>
<td>Vigorous, productive, moderate in hardness.</td>
</tr>
<tr>
<td>Pinot Chardonnay W</td>
<td>½</td>
<td>W</td>
<td>Excellent wine; moderate in hardness, vigor, productivity.</td>
</tr>
<tr>
<td>White Reisling W</td>
<td>1</td>
<td>W</td>
<td>Best for most Virginia conditions. Vigorous, productive, moderately hardy.</td>
</tr>
<tr>
<td>Cabernet Sauvignon B</td>
<td>½</td>
<td>W</td>
<td>Excellent red wine. Moderate in vigor, hardness, productivity.</td>
</tr>
</tbody>
</table>

* Rigorous spray schedule required in humid areas because of susceptibility to fungal diseases. Subject to winter injury in areas of frequent low temperatures.

Muscadine

As the muscadine grape, Vitis rotundifolia, cannot be grown successfully where temperatures go lower than 10° F., production in Virginia is limited to the southeastern portion of the state. The selection in Table 4 from the numerous named varieties available has been made on the basis of adaptability to Virginia grow-
ing conditions, the vigor and productiveness of the vine, and the quality of the fruit for eating and for use in jams, jellies, juice, and wines.

Table 4.—Muscadine Grapes for Virginia

<table>
<thead>
<tr>
<th>Variety</th>
<th>Fruit Color</th>
<th>Approx. Ripening Date</th>
<th>Principal Use</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunt</td>
<td>Black</td>
<td>Sept. 20</td>
<td>J, W</td>
<td>Vigorous, productive, wine quality fair, sus. to bitter rot fungus. Excellent white wine, very productive, vigorous, moderately hardy.</td>
</tr>
<tr>
<td>Carlos *</td>
<td>Bronze</td>
<td>Sept. 20</td>
<td>W, J</td>
<td>Very good white wine; moderate in vigor, hardness and productivity. Excellent white wine, vigorous, relatively hardy, productive, subject to fungus diseases.</td>
</tr>
<tr>
<td>Scuppernong</td>
<td>Bronze</td>
<td>Sept. 20</td>
<td>J, W</td>
<td>Excellent burgundy type wine, very vigorous, moderately hardy, sus. to powdery mildew.</td>
</tr>
<tr>
<td>Magnolia *</td>
<td>Bronze</td>
<td>Sept. 20</td>
<td>W, J</td>
<td>Excellent burgundy type wine, very vigorous, moderately hardy, sus. to powdery mildew.</td>
</tr>
<tr>
<td>Tarheel *</td>
<td>Black</td>
<td>Sept. 20</td>
<td>W, J</td>
<td>Excellent burgundy type wine, very vigorous, moderately hardy, sus. to powdery mildew.</td>
</tr>
</tbody>
</table>

* Perfect flowered. Other varieties are pistillate and require pollinizers.  
1 Principal Use: J-juice, jam, jelly; W—wine.

Virginia Introductions

The following varieties resulted from the grape breeding program at VPI & SU. Two, Price and Monticello, have already found a place in commercial vineyards in the eastern grape growing region of the United States.

Alwood (VPI 5-2) — This variety ripens about 2 1/2 weeks before Concord. The vine is of medium vigor and productivity. The clusters are of medium size, and the medium-size berries are blue-black in color, with a heavy waxy bloom. The berries ripen uniformly and are not as subject to uneven ripening in the warmer areas of the state as those of Concord. The fruit and foliage is only moderately susceptible to the normal grape diseases — black rot, anthracnose, downy mildew, and powdery mildew.

Moored (VPI 26) — Moored has large compact clusters of medium-red berries, ripening about 3 weeks before Concord. The vine is much above average in vigor and productivity. The skin is of the slipskin type, medium in thickness and toughness. The fruit is above average in firmness and withstands normal picking and handling operations without damage. Flavor is somewhat “foxy” when allowed to become overripe. Susceptibility to black rot and mildew is only moderate.

Price (VPI 30) — A 1972 introduction, Price has already been accepted as a commercial variety of promise in eastern grape growing areas. Ripening about 3 weeks before Concord, it is a good variety for eating fresh and in jellies and jams. The red-orange wine is of only fair quality. It is less subject to black rot, mildew, and skin cracking than most varieties. The vines are of moderate vigor and productivity.

Monticello (VPI 31) — In grape areas north of Virginia, Monticello promises to be a replacement for Bath. Ripening about 10 days before Concord, it is of average vigor and much above average in productivity. It needs cluster thinning to prevent over-bearing. The berries are blue-black in color, of medium size, slipskin, and not subject to cracking. It runs high in sugars and is very good as a table grape as well as in jams and jellies. Its wine qualities are only fair.

Century I (VPI 32) — A variety of the non-slipskin type, the quality of Century I is rated at least equal to that of any California-grown grapes found in Virginia markets. The clusters are large, usually well-filled with large, ovate, reddish-black berries. It ripens with Concord, depending upon the load of fruit the vines carry. The crisp, mealy flesh has a flavor distinctly of the vinifera type, sweet and fruity. The vines are average in vigor and overly productive. They must have close pruning and cluster thinning to prevent overbearing, resulting in winter injury to the wood. The fruit and foliage are subject to black rot and powdery mildew, requiring disease control measures typical of vinifera grapes grown under eastern climatic conditions. The vine is medium hardy to winter cold unless allowed to overbear.

PROPAGATION

Most growers prefer to buy their plants from commercial sources, but grapes may be propagated easily and at little expense by the average grower with a “green thumb” and a little time.

Cuttings

Most varieties of American bunch grapes and French-American hybrids are grown on their own roots. These are usually propagated from hardwood cuttings of the previous year’s growth. The wood for cuttings can be taken from the vines any time after the leaves have been shed by the vines in the fall. Unless facilities are available for storing the wood under conditions that will protect it against drying out or severely low temperatures, it may be better to leave the wood on the vine until late winter or early spring. Wood of medium diameter and medium vigor, as shown by the length of the wood between the buds or nodes, usually roots more readily than wood of small or larger diameter. Wood of excessively long growth between the buds is more inconvenient to handle in the nursery or propagating beds.

Varieties of the Concord-type root readily from cuttings of three buds in length. Varieties with short growth between buds (like Delaware) will root equally well from three bud cuttings, but such short cuttings may be less convenient to handle than longer cuttings. If vines of new or scarce varieties are to be propagated and the supply of wood is limited, cuttings of two buds can be used, but special care and the use of greenhouse or cable-heated beds may be advisable to favor rooting of the cuttings.
The bottom or basal cut is usually made just below a bud with a “square” or right-angle cut. The upper cut of each cutting is usually made at an angle or slope so that when the cuttings are placed in the propagation bed or nursery, none will have the bottoms and tops reversed. Cuttings placed upside down usually do not grow well.

The cuttings are usually tied in bundles of 25 or 50, using a rot-resistant twine, if they are not to be planted at once. Each bundle should be carefully and accurately labeled to each variety, with the date when the cuttings were made. They can be stored, waiting for planting, in a well-drained trench on the shady side of a building or other structure, in a cool cellar, in a household refrigerator, or in refrigerated cold storage not being used for fruit storage. The bundles of cuttings should be covered with moist (but not wet) soil, sand, sawdust, shredded peat, or other material to prevent them from drying.

If the cuttings are to be rooted in a nursery, they should be planted in early spring about the time early vegetable gardens are planted. The soil should be well prepared to a depth of 8 to 10 inches before the cuttings are planted. They should be spaced 4 to 6 inches apart in rows spaced 3 to 3½ feet apart, depending upon the kind of tillage equipment that is to be used in the nursery. The cuttings should be pushed into the well-loosened soil to the uppermost bud or placed against the side of a narrow trench dug for each row. The soil should be packed or tamped firmly around the cuttings to ensure close contact with soil moisture. The young shoots that develop are quite brittle and subject to breakage by tillage or by the wind. Care must be exercised in working them. If fertile soil was selected for the nursery, the young vines should not need fertilizing the first season.

If the cuttings are to be rooted in a greenhouse or a cable-heated bed, they should be placed in a bench or bed which has been filled with a mixture of soil, sand, and peat or other such material to a depth of 8 to 10 inches. Since the cuttings will be transplanted after they have rooted, which usually takes 4 to 6 weeks, and held under protected conditions for a few weeks before being set in the nursery or vineyard, they can be started in late winter, February or March. Much closer spacing of the plants is recommended than for the nursery planting. The cuttings can be spaced 1 inch apart in rows 4 to 6 inches apart. The plants should be transplanted from such beds when the roots have grown to an inch in length, to avoid crowding of the plants. By that time, the top bud should have developed into a new shoot an inch or two in length. If danger of frost no longer exists, the rooted cuttings can be transplanted directly to the nursery. If the weather is still cool, the rooted cuttings can be transplanted into treated cardboard plant bands of 3- to 4-inch size, or to comparable-size peat pots for later transplanting to the nursery.

Layering

If a vine dies in the vineyard, it can be replaced by “layering” a new vine from an adjoining vine. This consists of bending a cane from an adjoining vine to contact the soil and covering several buds or leaf nodes with 3 or 4 inches of soil at the site where the new vine is to be located. This can be done in late winter or early spring with a cane of the preceding year’s growth or in midsummer with a cane of the current season’s growth. In either case, the buried shoot or cane will strike roots at the site of the buried buds or leaf nodes. New shoots will grow from the buried buds and by the end of the first season of growth a well-rooted plant should have developed from the layered (buried) cane. The following spring, the cane connecting the layered plant to the original vine should be cut and the newly layered plant allowed to develop independently. It should then be pruned and trained like a newly set plant.

Most muscadine varieties are difficult to root from cuttings. If only a few vines are needed, they can be propagated by layering.

Grafting

Most varieties of vinifera (European) grapes and some of the American and French-American hybrid varieties are so subject to attack by the phylloxera when grown on their own roots that grafting them on a resistant rootstock is necessary. Grapes can be grafted by the amateur, but special techniques and skill are necessary for success. Most growers prefer to buy grafted plants from commercial sources.

A number of rootstocks have been used successfully in the eastern states. Couderc 3309, C. 3306, Teleki 5A, 5BB, 504, and Rupestris St. George have performed well in Virginia, giving greater vigor, heavier production of fruit, and longer life to the vines. Rupestris St. George is
good on dry and stony soils; 5BB is tolerant to high lime conditions.

Although experienced grafters probably are equally efficient in making the cuts with a sharp knife, commercial nurserymen and large individual growers who make their own grafts use machines. In most cases, either the whip or bench graft, saddle graft, or tongue-and-groove graft is used (Figure 1). Grafting is done before the buds start developing on either rootstock or the scion variety.

ESTABLISHING THE VINEYARD

Site Preparation

Site preparation should begin the year before planting. Eradication of chronic weed problems, application of lime where necessary to raise the pH to a range of 5.5 to 6.5, and the establishment of a cover crop is more easily done before vines are planted and the trellis is constructed.

Row spacing depends upon the training and trellising system and the cultivation and harvesting equipment to be used in the vineyard. A 9- or 10-foot spacing between rows is commonly used in commercial vineyards, with the vines spaced 8 to 10 feet in the row. An 8- by 10-foot spacing requires 544 vines and a 10- by 10-foot spacing requires 435 vines to the acre. Slow-growing varieties such as Delaware may be planted 8 feet apart, while more vigorous vines such as Concord and the muscadine varieties usually need 10 feet.

Planting

Vigorous 1- or 2-year-old vines are best for planting and they should be set in late winter or early spring. Before planting, trim away broken or injured roots and prune the tops to leave one strong new cane. Dig holes large enough to spread the roots without crowding. Plant the vine about 1 inch deeper than it stood in the nursery. First, tamp topsoil around the roots and then fill the hole. After planting, cut back the cane to two buds (Figure 2).

During the first summer, two new shoots will grow from the two buds. Train the strongest shoot upward on a stake driven beside the plant and remove the other shoot after the danger of frost has passed. At this time, scatter about 2 ounces of nitrate of soda per vine in a circle around the plant. Be careful not to put fertilizer on the plant.

The young plants may be allowed to trail on the ground during the first summer; however, cultivation will be difficult and the vines will not reach bearing age as quickly as when staked. Cultivation should be shallow and only often enough to destroy competing weeds during the summer. Suckers that grow from the base of the plant tend to compete with the main shoot for plant food and soil moisture and usually are rubbed off while still small. If they become large, cut them off with a knife or shears; otherwise, the tender bark may be torn by rubbing. At the end of the first summer, the main shoot should be 4 or 5 feet high. Vigorous varieties planted in rich soil may grow much faster.

TRELLIS CONSTRUCTION

The trellis should be constructed during the first growing season or the following spring before growth begins. The most popular trellis consists of 2 wires stretched horizontally along a line of posts spaced 20 to 24 feet apart. The posts should be placed to include 2 or 3 vines, between consecutive posts, depending upon how far apart the vines are planted.

The No. 9 gauge top wire is usually placed 72 inches above the ground and the No. 10 gauge bottom wire 36 inches above the ground. Where a third wire is used for additional vine support, it is placed midway between the top and bottom wires.

End posts may be of locust or cedar about 8½ feet long, set 2½ feet deep and thoroughly braced (Figure 3). Inside posts may be smaller and set from 18 to 24 inches deep. Staple the wires to the posts loosely enough to permit restretching each winter. Fasten the wires on the sides of the posts toward the prevailing wind or on the outside of curves in contoured rows, in order to lessen the strain on the staples.
TRAINING SYSTEMS

Pruning can be done faster and by less experienced workers when a definite system of training is followed. Conventional training of eastern grapes has been to the Kniffin system. Three modifications of this system are in current use — the 4-arm Kniffin, 6-arm Kniffin, and the umbrella Kniffin. Two new systems of training, the single curtain cordon, and the Geneva double curtain, are worthy of consideration by the commercial grape grower in Virginia. They are adapted to mechanical harvesting and vines of high vigor. Better maturation and increased yield are possible by shoot and foliage positioning which exposes a greater proportion of the leaf area to sunlight.

Four-arm Kniffin

The single trunk, 4-arm Kniffin system consists of a permanent trunk of old wood reaching to the top trellis wire. There are 4 semi-permanent arms, 6 to 10 inches long, 2 extending in opposite directions on each trellis wire. New canes arise near the base of the arms each summer, one cane being left on each arm to bear fruit the following summer. Another cane on each arm is cut back to a short stub with 2 buds. This stub is called a "renewal spur".

Figure 4 illustrates the successive steps to be followed in training young vines to this system. The young vines will be weakened if they are permitted to bear heavy crops of fruit during the second and third summers. A partial crop is produced the third summer. The vine usually is fully grown after the fourth year from planting.

The six-arm Kniffin system permits more canes to remain on the vine by tying them to each of 3 trellis wires. Both systems standardize the training procedure for routine pruning and handling of the vine.

Umbrella Kniffin

The Umbrella Kniffin is somewhat like the 4-arm and 6-arm Kniffin systems except that all of the fruiting canes grow near the top wire. A single trunk is headed about 6 inches below the top wire and new canes are allowed to grow from this head. Two to six fruiting canes are bent over the top wire and tied to the bottom wire in the shape of an umbrella (Figure 5).

Figure 4.—Stages in training the young vine to the single trunk, 4-arm Kniffin system.

(1) After pruning the first winter. The single cane is cut back and tied to the lower wire. If the cane has grown less than 3 feet during the first summer, it should again be cut back to two buds.

(2) After pruning the second winter. Two new canes of four or five buds each are tied on the bottom wire. A third new cane is tied to the top wire and cut off.

(3) After pruning the third winter. Three of the arms (A) and the fruiting canes (B) have been formed. A cane (C) with four or five buds is left to establish the fourth arm.

(4) A fully formed vine after pruning the fourth winter. The arms (A) should be shorter than those shown. T—single permanent trunk; A—four semi-permanent fruiting arms; F—four annual fruiting canes; S—four renewal spurs with two buds on each.

Figure 5.—Grape vine trained to the Umbrella Kniffin System.
Leave enough buds on all canes so that each vine has a total of 40 to 50 buds, depending upon the vigor of the vine.

**Single Curtain Cordon**

The single curtain cordon training system is developed on a standard 2 or 3 wire trellis used for training to the Kniffin systems. It is suitable for vines of low to moderate vigor, gives the advantage of greater exposure of the foliage to sunlight, and is adapted to mechanical harvesting.

As shown in Figure 6, the single trunk is trained to the top trellis wire approximately 6 feet from the ground. Two horizontal cordons are developed along the top wire, extending 4 feet in each direction. Initially, cordons are secured to the wire by plastic ties or other similar material. As the cordons are actually extensions of the trunk, they are semi-permanent and by giving them 1 1/2 turns around the wire will remain in place without annual tying. Like the Geneva Double Curtain system, 5-bud fruiting canes and 1-bud renewal spurs are selected from each cordon. Shoots are later positioned downward for maximum exposure to sunlight and to facilitate harvesting.

**Geneva Double Curtain**

The Geneva Double Curtain system of training is recommended for vineyards with above average vigor — those producing 3 or more pounds of prunings per vine. Although developed for the Concord variety, it has been used effectively for other vigorous varieties of both the American and French-American hybrids and is recommended for the vigorous growing muscadine varieties. It has proven superior to other systems in use, increasing vine productivity and at the same time improving fruit and vine maturation.

As shown in Figure 7, two horizontal cordon wires are separated in the row by a distance of 4 feet and are at a height of 5 1/2 to 6 feet above the ground. The wires are held in position by wood or metal supports attached to each post spaced 24 feet in the row.

Two main trunks from each vine extend vertically 5 1/2 feet and then horizontally to the cordon wire, a distance of 2 feet. A wire strung down the row and secured near the middle of the posts will aid in supporting the trunks. A single trunk which separates at the cordon wire, as in the case of the Single Curtain Cordon shown in Figure 6, may be used instead of the double trunk if desired.

Cordon canes extending 6 to 8 feet along the cordon wire in each direction are secured to the wire by semi-permanent ties. Five-bud fruiting canes and one-bud renewal spurs are maintained on each cordon. The growing shoots are positioned by hand so that they will grow in a vertically downward direction to form a curtain of foliage suspended from each cordon wire. The final effect is a double curtain of foliage from each row of grapes.

**TRAINING YOUNG VINES**

Regardless of the training system to be followed, young grape plants are handled alike during the first season in the vineyard. Most growers cut back to 2 strong buds at planting. Some prefer to leave a longer cane of 8 or 10 buds and allow only the 2 uppermost buds to develop into shoots. This often permits the new shoot to grow to the top of the stake or trellis more quickly. A stake 4 or 5 feet high driven into the ground near each vine is used to train the vine during the first growing season.

Before pruning the second spring, a system of training should be decided upon. Primary consideration of all training systems is the establishment of a vigorous, straight trunk. Remove all but the best single cane during the second dormant pruning. Two trunks may be left for training to the Geneva double curtain system. Also, in the case of the tender *vinifera* varieties, a second trunk gives added insurance of vine survival under adverse weather conditions.

Tie the cane securely to the uppermost wire
that it will reach and more loosely to the lower wire, then cut it off just above the upper tie. If a cane is weak and does not reach the lower wire of the trellis, cut it back to 2 or 3 buds and treat as a newly planted vine.

**PRUNING MATURE VINES**

**Fruiting Habits of Grapes**

In order to prune properly, the fruiting habits of grapes must be understood. Grapes are borne on new fruiting shoots that grow in the spring from buds on 1-year-old canes. Each cane has a number of joints, or nodes, and at each node there is a bud. Fruiting shoots grow from these buds in April. These shoots usually bear two to four blossom clusters that open in late May and early June. Fruit forms on these clusters and is picked in August or September. If spring frosts kill the first fruiting shoots, then the compound buds develop secondary shoots which may produce a partial crop.

**Time of Pruning**

Pruning is best done in late winter. In large vineyards, it may start as soon as the vines become dormant in early winter and continue during mild weather until spring. There appears to be no danger of winter injury following early pruning. Pruning after the sap begins to flow does not injure the vines.

**Severity of Pruning**

Grapevines should be pruned rather heavily each year. Most pruners tend to remove too little wood, rather than too much. Proper pruning regulates the amount of vine growth and the number, size, and compactness of fruit clusters. It also provides for renewing the fruiting canes each year. Figure 9 shows a Concord vine of average vigor trained to the 4-arm Kniffin system before and after being pruned.

For vines trained to the 4-arm Kniffin system, follow 3 pruning steps:

1. Select four canes of wood, one on each arm, to bear fruit the following summer. These canes should be about 4 to 6 feet long and about the thickness of a lead pencil or slightly larger. Preferably, the canes should grow from the base of the arm near the trunk. If no cane is to be found on an arm, then select a cane that grows directly from the trunk near the arm, although it may not be as productive.

2. Shorten these four canes so that 8 to 15 buds remain on each. Leave the strong canes longer and shorten the weaker canes so that a total of 32 to 48 buds remain on all four canes. Leave
fewer buds on weak vines and more buds on vigorous vines. Leave fewer buds on Portland and Delaware and more buds on Fredonia, Buffalo, Concord, and Niagara. Heaviest production of fruit usually occurs at the fifth and sixth buds of Concord canes and relatively less fruit is borne toward the base and the tips of the canes.

The balanced pruning method is helpful in determining the number of buds to be left on the fruiting canes. It is based upon the amount of fruit usually occurs at the fifth and sixth buds of Concord canes and relatively less fruit is borne toward the base and the tips of the canes.

For Concord vines, leave 30 buds for the first pound of new wood removed and 10 buds for each additional pound. For example, if 2 pounds of new wood has been pruned off, leave 30 plus 10, or 40, buds on the four fruiting canes. Fredonia requires lighter pruning in which 40 buds are left for the first pound and 10 buds for each additional pound of new wood prunings. With a little experience, the pruner will be able to estimate the pounds of pruning rather than weigh them for each vine. (See Tables 5 and 6).

Table 5.—Relation of Number of Buds Remaining to the Weight of One-Year-Old Pruning Wood Removed from Concord Grape Vines

<table>
<thead>
<tr>
<th>Lbs. of 1-Year-Old Wood Removed</th>
<th>No. of Buds Left For Fruiting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1</td>
<td>Less than 30</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td>4 or more</td>
<td>60*</td>
</tr>
</tbody>
</table>

* It is recommended that not more than 60 buds be left on a pruned vine.

Table 6.—Number of Buds to Retain on Concord Vine Trained to Either Single Curtain Cordon or Geneva Double Curtain

<table>
<thead>
<tr>
<th>Lbs. of 1-Year-Old Wood Removed</th>
<th>No. of 5-Bud Canes</th>
<th>No. of 1-Bud Renewal Spurs</th>
<th>Total No. Buds Retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>10</td>
<td>60*</td>
</tr>
</tbody>
</table>

* It is recommended that not more than 60 buds be left on a pruned vine.

2. Select four other canes, one near the base of each arm if possible, or wherever they may be found on the trunk near the arm. Shorten them to leave one or two buds on each. These short stubs are the renewal spurs that provide new fruiting canes each year. A strong cane will grow from one of these buds and this cane is used for a fruiting cane for the next year.

3. Prune off all other new growths from the vine. Remove old tendrils that are twined around the vine, in order to avoid girdling.

The four arms should be renewed frequently. Very old long arms tend to cause overbearing and weakening of the vines. An arm is renewed by selecting a strong cane growing directly from the trunk and shortening this cane to two buds. As vines become older, it is difficult to maintain arms. It may then be best to select canes that grow directly from the trunk and cut them back to one or two buds for renewal spurs. When the main trunk becomes too old or weak to produce profitably, cut it off at the ground and replace it by starting a new shoot from the base of the vine. Train this new shoot as if it were a newly set vine.

In the case of old vines that have not been pruned regularly, the canes extend farther out each year. leaving the fruiting wood too far away from the trunk. Many short, weak shoots form dense shade, which causes the inside parts of the vine to die. These old vines may be rejuvenated by proper pruning and fertilizing to bear good crops within 2 years. The first step in pruning is to cut out all dead and extremely weak wood. Then shorten the long trunk and branches so as to leave eight to ten of the strongest new canes on the vine. Shorten about one-half of these new canes so as to leave six to eight buds on each; cut the others back to one or two buds each. This heavy pruning stimulates the development of strong new shoots nearer the main trunk and, at the same time, provides some fruit the next summer. Prune the second winter so as to thin the new canes and provide renewal spurs. Thereafter, pruning should follow one of the methods that have been discussed previously.

Tying the Vines

Tight wires and proper tying prevent sagging vines and curved trunks. After pruning, keep the vines free from the trellis until the wires have been tightened. Tie the trunk and fruiting canes to the wires with plastic ties, binder twine, or other suitable material. These ties should be strong enough to support the vines for one season but not so durable as to interfere with brush removal during pruning the following winter. Tie the trunk to both wires loosely enough to avoid girdling and tie each fruiting cane to the wire at a point near its tip. A tie about 12 inches long is looped over the wire, crossed between the wire and the cane, and then tied around the cane. Long canes should be tied in two places.

Cluster Thinning

Many varieties of grapes set more fruit clusters than they can carry to maturity with the highest quality. French-American hybrids frequently set 3 to 5 clusters from each fruitful bud. In varieties where the basal buds are fruitful, the vine can easily be overloaded even though pruned severely to short spurs.

Cluster thinning is the easiest and best means of reducing the crop on overloaded vines. Enough fruiting wood should be left at pruning time
to produce a good crop in years of poor set, then reduce the overload by thinning. Thinning, as soon as possible after fruit has set, to 1 or 2 clusters per shoot is recommended.

SOIL MANAGEMENT

Cultivation

Cultivation is necessary for young vines and also for most older vineyards. It should begin in the spring and continue until about 1 month before the fruit ripens. A winter cover crop of rye or other winter-hardy small grain may be planted between rows. Disking in the spring should be delayed until such time as the growing cover crop starts to compete with the vines for soil moisture and nutrients. The longer the cover crop is left, the more organic matter will be added to the soil.

If no cover crop is planted, a natural cover of fall weeds and grasses should be allowed to grow and cover the ground during the winter. Cultivation should be shallow and frequent enough to check the growth of competing weeds and grasses, but not so frequent or thorough as to leave the soil entirely bare. Clean cultivation will cause soil erosion and loss of organic matter.

Effective implements include a light disk harrow for use between rows; a garden tractor cultivator of suitable power to be used along the sides of the row; and a hand or tractor hoe for removing weeds between vines. Do not use turning plows in bearing vineyards because they injure too many roots. A convenient implement is the tractor hoe with an adjustable scraper blade to turn the soil alternately toward the rows during one cultivation and away from the rows the next. The tractor driver moves the blade in and out between vines, thus eliminating much hand hoeing.

Maintaining a permanent sod cover between vineyard rows may be desirable under certain conditions. It should be mowed frequently, leaving the clippings on the vineyard floor. Some reduction in yield due to competition for moisture may be experienced, particularly on lighter soils.

The use of chemicals for weed control in vineyards is very effective and frequently less expensive than cultivation. Herbicides must be used with caution, however. Grapes are very sensitive to misuse. Contact your local Extension agent for the latest recommendations.

Fertilization

Grapevines respond to commercial fertilizers according to the kind of soil and its natural fertility. Practically all vineyards should receive an annual application of nitrogen fertilizer such as nitrate of soda, sulphate of ammonia, or ammonium nitrate. These fertilizers stimulate plant growth and increase yields. Fertilize early in the spring before growth starts. If nitrate of soda is used, an average vine will need about 2 ounces for each year of age up to one-half pound for mature vines, or 250 to 300 pounds per acre. When sulphate of ammonia is substituted for nitrate of soda, only three-fourths as much will be needed. Only one-half as much ammonium nitrate is required since it contains twice as much nitrogen as nitrate of soda. The standard recommendations of 10-10-10 or 5-10-5 fertilizers, applied when the winter cover crops are planted, usually will add enough phosphorus and potash to the soil to provide for the needs of the grapevines. If 10-10-10 fertilizer is applied for the benefit of the cover crop, the spring application of nitrogen for the vines may be reduced by one-fourth to one-half. For young vines, scatter the fertilizer in a circle around the plant. For mature vines, spread the fertilizer evenly over the entire area since the grape roots occupy practically all of the space between the rows. Weeds are less troublesome if little or no fertilizer is placed directly under the trellis.

Skilful vineyardists vary the annual amounts of pruning and nitrogen fertilizer to balance the amount of vine growth and fruit yield. When vines have been weakened by overbearing, drouth, or loss of leaves, they need heavier pruning and more nitrogen fertilizer than usual. On the other hand, excessive vine growth resulting from a light crop or from highly favorable growing conditions during the preceding year, calls for less pruning and smaller amounts of fertilizer. Normally, a vine is considered weak when the new canes are less than 3 feet long. Canes 10 feet or more long usually indicate too much vine growth. These figures will vary considerably, and the grower's experience will be his most reliable guide.

PEST CONTROL

Black rot is the most destructive disease among grapes in Virginia. Carried over the winter on old canes, leaves, and dried grapes, this disease infects the leaves early in the spring. Unless controlled, infection quickly spreads to new shoots, other tender parts of the vine, and then to the developing fruit. The fruit rots, becoming black, hard, and shrivelled. Black rot is especially troublesome in wet seasons.

Downy mildew also thrives during wet, cloudy weather. The foliage of Delaware and the fruit of Fredonia are very susceptible to this disease. It first appears as yellowish spots on the upper surface of the leaves, followed by white cottony patches on the lower surface. These spots later turn brown. Severe infection results in premature loss of the foliage, withering of the fruit and stems, and weakening of the vines.

Anthracnose causes oval, sunken spots to appear on the surface of new shoots, stems, and leaves, with round gray and red spots on the developing fruit. While the infection is severe, heavy foliage and fruit loss may result. Anthracnose is more severe in hot climates than in cool areas.

Leaf hoppers and the grape berry moth are the major insect pests.
For current recommendations on the chemical control of insects and diseases of grapes, contact your local Extension agent.

HARVESTING

Time of Harvest
The proper time to harvest grapes depends upon the variety, growing season, and use to be made of the fruits. For table use, maturity is usually determined by taste or by the color of the seeds, which changes from green to brown. Skin color is not always a reliable test for ripeness, as some blue varieties color before they have developed their best flavor. Both blue and red grapes should be completely colored around the stems when they are ripe.

For juice or wine, the harvest date is determined on the basis of the percentage of soluble solids as measured by either a refractometer or a Balling hydrometer. Processors prefer grapes that contain at least 15% soluble solids. An increase in soluble solids above 15% is usually reflected in an increased price per ton.

As grapes do not improve in color or sugar content after removal from the vine, where possible, harvest should be delayed until most of the berries are fully ripe. For fresh use, the clusters are harvested selectively according to the degree of maturity. For commercial processing, the entire crop is harvested at one time.

Yields
Although a partial crop may be expected the third season after planting, full bearing capacity will not be reached until the fifth or sixth year. The productive life of a vineyard ranges from 20 to 30 years or longer, depending on the care given the planting and suitability of the site.

Under Eastern growing conditions yields are quite variable, being affected by variety, pruning and training systems, cultural practices, degree of pest control, and climate. American and French-American hybrids frequently yield as high as 8, 10, and even 12 tons per acre. The average is somewhere around 4 tons, however. *Vitis vinifera* have in some instances been reported to yield as high as 10 tons, with the range somewhat lower — between 2 and 5 tons. Some muscadine varieties have yielded 7 tons, with the average between 2 and 6 tons.

Method of Harvesting
Although most grapes are now hand harvested, mechanical harvesters have been developed and are being used in large commercial vineyards for harvesting processing grapes.

Vines trained to the single curtain cordon and the Geneva double curtain systems are particularly adapted for mechanical harvesting.

Grapes for fresh market use should be picked and handled carefully. It is usually necessary to pick at least twice to allow for full ripening of all clusters. Each cluster is cut from the vine with a knife or special sharp-pointed shears. They are frequently packed directly into containers as they are picked. Portable picking stands about 30 to 36 inches high on which to set the baskets are convenient.

Muscadine varieties bear the fruit in small clusters of 4 or 5 to a dozen berries. The fruit usually is not harvested by gathering clusters, but by placing a sheet or catching frame under the vine and shaking it vigorously to separate the ripe berries from the clusters. For processing, muscadines may also be harvested mechanically.

Handling and Storage
As soon as possible after harvest, grapes should be removed from the vineyard and placed in shade or storage. If the fruit cannot be moved directly to the consumer or processor, it may be held in storage. Ideal storage conditions for grapes are similar to those for apples — a temperature of 30° to 34°F. and a relative humidity of 85 to 95%.
# A Guide for Virginia

**Costs of Establishing Table Grape Vineyard at 1976 Prices**

<table>
<thead>
<tr>
<th>Variable Cost</th>
<th>Unit</th>
<th>Cost per Acre</th>
<th>Cost per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land Preparation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel Tractor, 57 H.P.</td>
<td>hour</td>
<td>1.82</td>
<td>.80</td>
</tr>
<tr>
<td>Plow, 2-16&quot;</td>
<td>hour</td>
<td>.60</td>
<td>.80</td>
</tr>
<tr>
<td>10-10-10 fertilizer</td>
<td>ton</td>
<td>140.00</td>
<td>.20</td>
</tr>
<tr>
<td>Agricultural lime</td>
<td>ton</td>
<td>12.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Operator labor</td>
<td>hour</td>
<td>3.50</td>
<td>.88</td>
</tr>
<tr>
<td><strong>Hole Digging</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel tractor, 57 H.P.</td>
<td>hour</td>
<td>1.82</td>
<td>43.52</td>
</tr>
<tr>
<td>Tree auger</td>
<td>hour</td>
<td>.20</td>
<td>43.52</td>
</tr>
<tr>
<td>Unskilled labor</td>
<td>hour</td>
<td>2.50</td>
<td>47.87</td>
</tr>
<tr>
<td>Operator labor</td>
<td>hour</td>
<td>3.50</td>
<td>47.87</td>
</tr>
<tr>
<td><strong>Planting</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas tractor, 57 H.P.</td>
<td>hour</td>
<td>2.19</td>
<td>27.20</td>
</tr>
<tr>
<td>Two wheel trailer</td>
<td>hour</td>
<td>.12</td>
<td>27.20</td>
</tr>
<tr>
<td>Table grape vines, 1 year</td>
<td>each</td>
<td>.60</td>
<td>544.00</td>
</tr>
<tr>
<td>Unskilled labor</td>
<td>hour</td>
<td>2.50</td>
<td>59.84</td>
</tr>
<tr>
<td>Operator labor</td>
<td>hour</td>
<td>3.50</td>
<td>29.92</td>
</tr>
<tr>
<td><strong>Watering</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank truck</td>
<td>hour</td>
<td>1.26</td>
<td>1.00</td>
</tr>
<tr>
<td>Operator labor</td>
<td>hour</td>
<td>3.50</td>
<td>1.10</td>
</tr>
<tr>
<td><strong>Post Setting</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas tractor, 57 H.P.</td>
<td>hour</td>
<td>2.19</td>
<td>21.76</td>
</tr>
<tr>
<td>Diesel tractor, 57 H.P.</td>
<td>hour</td>
<td>1.82</td>
<td>21.76</td>
</tr>
<tr>
<td>Two wheel trailer</td>
<td>hour</td>
<td>.12</td>
<td>21.76</td>
</tr>
<tr>
<td>Post driver</td>
<td>hour</td>
<td>.13</td>
<td>21.76</td>
</tr>
<tr>
<td>Posts, 3&quot; tip, treated</td>
<td>each</td>
<td>2.00</td>
<td>272.00</td>
</tr>
<tr>
<td>Unskilled labor</td>
<td>hour</td>
<td>2.50</td>
<td>47.87</td>
</tr>
<tr>
<td>Operator labor</td>
<td>hour</td>
<td>3.50</td>
<td>23.94</td>
</tr>
<tr>
<td><strong>Wire Installation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas tractor, 57 H.P.</td>
<td>hour</td>
<td>2.19</td>
<td>8.00</td>
</tr>
<tr>
<td>Portable Drill</td>
<td>hour</td>
<td>.065</td>
<td>8.00</td>
</tr>
<tr>
<td>Wire (no. 9)</td>
<td>foot</td>
<td>.0225</td>
<td>9,712.00</td>
</tr>
<tr>
<td>Unskilled labor</td>
<td>hour</td>
<td>2.50</td>
<td>17.60</td>
</tr>
<tr>
<td>Operator labor</td>
<td>hour</td>
<td>3.50</td>
<td>8.80</td>
</tr>
<tr>
<td>Interest on operating capital</td>
<td>dollars</td>
<td>.08</td>
<td>2,232.46</td>
</tr>
</tbody>
</table>

**Total of Vineyard Establishment** $2,409.82

---

*With permission of Dr. J. M. Johnson, Extension Specialist, Marketing, Department of Agricultural Economics, VPI&SU.*

1 Exclusive of growing operations including pest control chemical and spray equipment.

2 Figures may not be exact because of rounding errors.