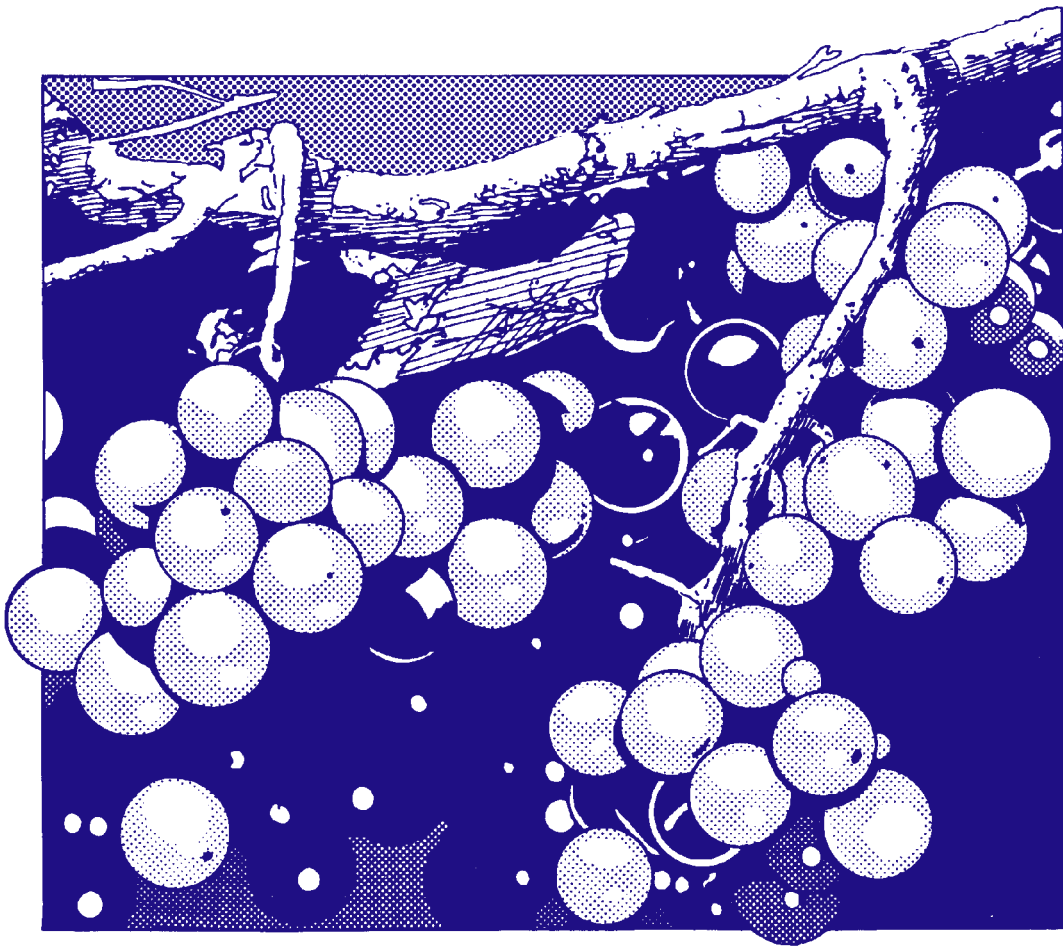


Muscadine Grape Production Guide

For North Carolina



*North Carolina Cooperative Extension Service
NC State University*

Recommendations for the use of agricultural chemicals are included in this publication as a convenience to the reader. The use of brand names and any mention or listing of commercial products or services in this publication does not imply endorsement by the North Carolina Cooperative Extension Service or discrimination against similar products or services not mentioned. Individuals who use agricultural chemicals are responsible for ensuring that the intended use complies with current regulations and conforms to the product label. Be sure to obtain current information about usage regulations and examine a current product label before applying any chemical. For assistance, contact your county Cooperative Extension agent.

Contents

Introduction	5
Production Costs and Returns for Processing	6
Site Selection	6
Varieties	7
Propagation	7
Commercial Nurseries	8
Trellising	8
Trellis Arrangements	9
Planting the Vineyard	10
Irrigation	12
Weed Control	12
Post-Plant Fertility and Liming	12
Insect and Disease Pests	13
Establishment	13
Mature Vines	14
Training	16
Harvesting	18
Conclusion	19
References	19

Muscadine Grape Production Guide

For North Carolina

Introduction

This muscadine grape production guide will help the increasing number of North Carolina farmers who are considering growing and marketing this fruit as a farm diversification option. Important changes have occurred in the North Carolina muscadine industry since this bulletin last appeared in 1987, most notably the wine industry's recent turnaround. North Carolina muscadine wines are becoming more widely appreciated for their distinctive fruity bouquet and are gaining considerable regional interest due, in part, to potential positive health effects afforded by moderate, responsible consumption. The state's commercial muscadine acreage rose to approximately 400 acres in 2002 from 265 acres in 1996. Prices for processed muscadine grapes for wine have been rising, and in 2002 reached in the range of \$500 per ton. This price is up sharply from those paid by wineries in the 1990s. Prices paid for Noble, North Carolina's second most important muscadine winegrape variety, were as high as \$750 per ton in 2002.

Adaptation. Muscadine grapes (*Vitis rotundifolia* Michx.), indigenous to the southeastern United States, are well adapted to a hot,

humid climate. They do not tolerate temperatures below 10° F (Figure 1). For this reason, they are not recommended for commercial production in the mountains, foothills, and areas of the upper piedmont where there is a high probability of winter temperatures below 10° F. Even in traditional muscadine production areas, cold injury may occur if less cold-hardy varieties are grown. The variety Ison, for example, is a variety bred in Georgia that was severely injured by a late spring freeze in 2001. Noble, a North Carolina-bred variety, escaped with little or no cold injury. Varieties with good cold hardiness may be prone to spring frost/freeze injury if they tend to break bud early in the spring. Unfortunately, North Carolina's main bronze muscadine

variety, Carlos, is prone to early bud-break in some years.

Muscadine products, markets, and challenges. Consumers' interest in healthier diets and changing lifestyles have led to an increase in eating fresh fruit, including muscadine grapes. Direct marketing of fresh muscadines is quite popular in North Carolina (pick-your-own, roadside stands, and farmers' markets). Commercial growers who produce muscadines primarily for processing into wine often also have limited plantings of specialty varieties for direct marketing, such as Nesbitt, Triumph, Summit, and Supreme. Increasing supplies of Georgia's larger-fruited muscadines have depressed wholesale market prices for fresh, smaller-fruited varieties like Carlos, which

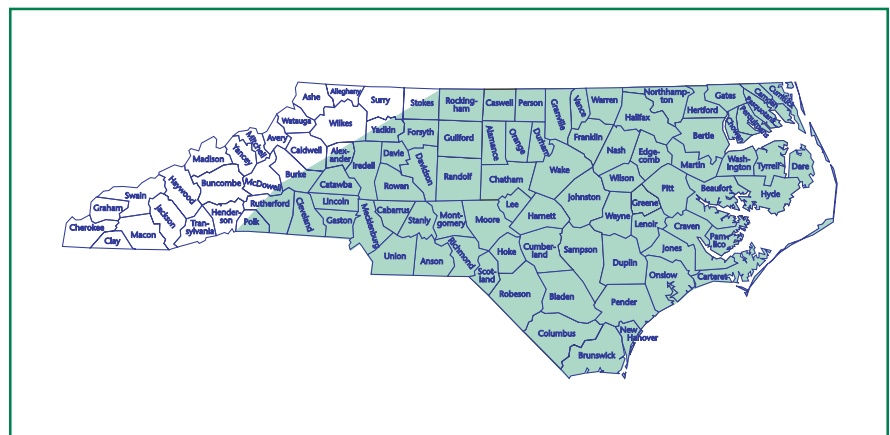


Figure 1. Muscadine grape production area in North Carolina.

is North Carolina's most widely planted bronze muscadine (grown mainly for processing). Better varieties for the fresh wholesale markets include larger-fruited muscadines, such as the black grape Nesbitt, or bronze types, such as Summit and possibly Triumph. A number of the larger-fruited muscadine varieties developed in Georgia, such as Supreme, are not appropriate in North Carolina because of their sensitivity to winter cold injury.

The juice yield (for use in wine) from a ton of muscadine grapes is only 135 to 140 gallons. Bunch grapes yield 165 gallons or more per ton. The North Carolina muscadine industry is supporting research on uses of the portion of the crop that is not used for winemaking or juice, called "pomace" (skin, seeds, and pulp). Potential uses include muscadine syrups, purees, and a variety of value-added "niche" products. Research in Arkansas is also proving that competitive products can be made by blending muscadine juice with neutral and less expensive grape and other juices while still maintaining the unique fruity flavors of the muscadine.

Yields and vineyard life. Muscadines are generally very productive. Yields average 1 ton per acre in the second year, 3 tons per acre in the third year, and 8 tons per acre by the fourth and in subsequent years. It is not unusual for a muscadine planting to produce for more than 30 years with good pruning, spraying, and a well-constructed trellis.

Production Costs and Returns for Processing

It costs approximately \$2,620 for materials to establish an acre of muscadine grapes in North Carolina (see Table 1), excluding labor, equip-

ment, land costs, and irrigation equipment. Computations are based on a spacing of 10 feet between rows, 20 feet between vines, and a single wire trellising system. At this spacing there are 218 vines per acre. This number is arrived at by first multiplying 10 feet between rows by 20 feet between vines (in-the-row) and then dividing 43,560 square feet per acre by the product. The configuration of this hypothetical acre is a square (approximately 209 by 209 feet).

When labor, equipment, and land costs are taken into account, the total establishment costs may easily be more than \$5,200 per acre. A drip irrigation system adds another \$1,200 per acre. In mature vineyards, annual operating costs are approximately \$1,700 per acre. The cost for custom mechanical harvesting is about \$90 per ton. Thus, an 8-ton per acre crop would cost about \$720 per acre to harvest.

Figuring average quality grapes and a winery price of \$450 per ton, an 8 ton per acre crop could generate \$3,600 in gross revenue per acre. With annual operating costs of \$1,700 per acre (mainly for pruning and spraying) and a custom harvest cost of \$720 per acre (8 tons multiplied by \$90), the crop might provide a return of

about \$1,180 per acre for an 8-ton per acre crop (before vineyard costs are subtracted). A winery price of \$500 per ton would provide a return of \$1,580 per acre.

If the yield is 5 tons per acre, which is closer to the state average, a muscadine vineyard will barely break even at \$450 per ton:

$$\text{Gross revenue} - (\text{Operating costs} + \text{Custom harvest costs}) = \text{Net return to grower}$$

$$\text{Or, in this example: } \$2,250 - (\$1,700 + \$450 \text{ harvest}) = \$100/\text{acre}$$

Site Selection

The most critical consideration in choosing a planting site for muscadines is internal soil drainage. Although wild muscadines survive on a wide variety of soils, commercial producers must select a well-drained soil. Water should not stand on the site after a normal rain, and the subsoil should not restrict drainage. Ideally there should be no gray mottling in the subsoil above a depth of 48 inches. Generally speaking, if tobacco has done well on the site, muscadine grapes should also do well. In the piedmont, plant on a site elevated above the surrounding area and at least 50 feet away from woods or other obstructions. Unobstructed

Table 1. Cost Per Acre for Materials

<i>Materials Needed</i>	<i>Number Needed (Per Acre)</i>	<i>Cost (\$ Per Item)</i>	<i>Cost (\$ Per Acre)</i>
Treated 4" x 8" Posts	218 posts	4.14	902.52
Treated 6" x 8' Posts	84* posts	7.80	655.20
Treated 4" x 4" x 8' Timbers	42** timbers	10.67	448.14
Wire, 100-pound rolls of #9 galvanized	3 rolls***	60.00	180.00
Grape Vines	218 vines	2.00	436.00
<i>Total Cost Per Acre</i>			<i>2,621.86</i>

* 4 bracing posts per row multiplied by (209 feet per acre divided by 10 feet between rows) equal 21 rows per acre, which is 84 bracing posts per acre

** 2 timbers multiplied by 21 rows equal 42 timbers per acre

*** 1,705 feet in length

locations allow air to drain away from the vineyard on cold nights. Preferred row orientation is north to south; however, topography of the vineyard site may dictate a different row orientation.

Varieties

Of the numerous muscadine grape varieties, only a few account for most of the commercial production acreage. The leading variety, Carlos, represents most of the acres of muscadine grapes in North Carolina. Carlos has excellent production potential and is a dual-use variety; it is the standard processing variety in the state and it is also acceptable for fresh local marketing, but it is not recommended for wholesale markets because of its small berry size. The second most important winegrape is Noble. Noble is outstanding for its high yields, but it is strictly a processing grape due to its small berry size.

The fresh market demands larger fruit size, and Nesbitt is quickly becoming the most important new black muscadine variety for both direct marketing (U-pick, ready-pick, satellite stands, farm markets) and fresh wholesale marketing to chain stores.

Carlos, Magnolia, and Sterling are three of the most consistently cold-hardy varieties. Noble and Nesbitt are also more cold hardy than varieties bred in Georgia. Although the new Georgia black grape Supreme has exceptional size and very good eating quality,

Table 3. Characteristics of Muscadine Cultivars

Cultivar	Type	Fruit Color	Fruit Size	Ripening
Black Fry	Female	Black	Large	Mid-late
Carlos	Self-fertile	Bronze	Medium	Mid
Cowart	Self-fertile	Black	Medium	Mid
Doreen	Self-fertile	Bronze	Medium	Late
Early Fry	Female	Bronze	Large	Very Early
Fry	Self-fertile	Bronze	Very Large	Very Late
Nesbitt	Self-fertile	Black	Large	Mid-late
Noble	Self-fertile	Black	Medium	Mid
Scarlett	Female	Red	Large	Mid
Sterling	Self-fertile	Bronze	Medium	Mid
Summit	Female	Pinkish	Large	Mid
Supreme	Female	Black	Very Large	Mid-late
Triumph	Self-fertile	Bronze	Medium Large	Early

it is not likely to adapted well to areas outside the coastal plain.

The above list of muscadine varieties is not exhaustive. If wine is not the primary use, other varieties, such as Supreme, Black Fry, Summit, Scarlett, Fry, Early Fry, Pam, and Late Fry, may be used in the coastal plain. Growers should plant limited numbers of these cultivars and evaluate them for specific markets.

Muscadine cultivars may be either female or perfect-flowered. If a female cultivar is used, a perfect-flowered variety must also be planted in order to assure proper pollination.

Some home gardeners grow muscadines in areas that are marginal due to cold winter temperatures. Five of the most consistently cold-hardy cultivars are Carlos, Magnolia, Nesbitt, Noble, and Sterling.

At this stage, there are still no commercially acceptable seedless muscadines for fresh market sales.

Propagation

Layering

Muscadine grapes can be propagated by layering vines in late June or July. To obtain new plants by layering, simply cover a portion of a new shoot with soil, leaving the growing end exposed. Roots will form where the branch is covered. The following winter or spring, cut the rooted portion from the old vine and transplant. To propagate a large number of plants by layering, take the entire fruiting arm, lay the arm in a shallow trench, and cover it with 4 to 5 inches in soil, leaving the tips of the shoots above ground. Each shoot will root and form a new plant.

Softwood Cuttings

It is easier and quicker to propagate large quantities of plants with softwood cuttings taken during and immediately after bloom in June. Using the current season's shoots, cut off and discard the tender tip, and make the cutting from the rest of the shoot. Leave

Table 2. Frequently Recommended Muscadine Cultivars for North Carolina

Use	Black Cultivars	Bronze Cultivars
Wine	Noble	Carlos, Magnolia
Fresh Market, Pick-Your-Own	Nesbitt	Carlos, Doreen, Triumph, Summit
Home Garden	Noble, Nesbitt	Carlos, Triumph

four nodes on each 4- to 6-inch cutting, and remove the bottom two leaves. Keep the cuttings moist to avoid wilting and space them out on a 3-by-4-inch spacing in a propagation bed containing a mixture of 1 part coarse sand and 1 part peat. Use shade cloth or lath to block out about 50 percent of the direct sunlight. Maintain humidity close to 100 percent by using mist nozzles that deliver about 2 gallons per hour at 30 to 50 pounds pressure. No misting is needed at night or on very humid days.

When the cuttings have rooted (after 4 to 6 weeks), remove the shade. Gradually reduce misting, and fertilize once a week until mid-September with a solution of 1 tablespoon of 20-20-20 soluble fertilizer per gallon of water. Use 1 gallon per 25 square feet of plant bed. Allow the plants to harden by watering only when needed.

Before freezing weather occurs, remove the rooted cuttings from the bed. Gently shake the rooting mixture from the roots, and remove any leaves that are on the plants. Store the rooted cuttings at 38° to 40° F in sealed plastic or in a protected cold frame until late March or early April, then plant them in the field in their permanent location. Small plants with poor root systems should be grown in a nursery row a year before planting them in the vineyard.

Commercial Nurseries

The names and addresses of muscadine grape nurseries can be found on the Web at <http://www.smallfruits.org/nurserycommdatabase.xls>.

Trellising

New information. In the past, the Geneva Double Curtain (GDC)

system has been the predominant trellising system in North Carolina. Observation and research have shown that muscadine yield is 20 to 25 percent higher with a GDC system than with a single wire system, but the single wire system has several advantages:

- Installation costs are less since crossarms are unnecessary.
- Pruning takes less time and is easier.
- Blueberry mechanical harvesters may be used to harvest grapes.
- Row spacing may be decreased.

The GDC system requires 12- by 20-foot spacing. As long as the grower's equipment will negotiate the width, the single wire system can be reduced to 10- by 20-foot spacing. This increases the total number of vines per acre. Table 4 shows how row spacing effects the number of vines per acre.

Table 4. Number of Vines Per Acre at Various Spacings

<i>Distance Between Rows (feet)</i>	<i>Distance Between Vines (feet)</i>	<i>Number of Vines Per Acre</i>
10	20	218
11	20	207
12	20	181
13	20	167

Posts

Posts should be long-lasting. Wood posts should be treated with a preservative for in-ground use and should last up to 20 years. "Preservative" means any chemical used in treating wood to retard or prevent deterioration or destruction caused by insects, fungi, bacteria, or other wood-destroying organisms. Most wood preservatives are highly toxic.

The wood preservative CCA (chromated copper arsenate) has been widely used in the past for

treatment of vineyard posts, but On February 12, 2002, EPA announced a voluntary decision by industry to move away from consumer use of CCA treated lumber by December 31, 2003, in favor of new alternative wood preservatives. A number of preservatives have been registered by EPA, and wood treated with these preservatives are expected to be available in the marketplace. In addition, untreated wood (e.g., cedar and locust) and nonwood alternatives, such as metal posts are available. Posts of durable natural woods may be less expensive, but are usually harder to obtain and cost more than treated pine posts. Be sure the amount of heartwood in each post is sufficient to support the trellis. Sapwood rots quickly and does not offer durable support.

Take the following precautions when using chemically treated posts:

- Make sure the wood is treated adequately with a proven material.
- Do not allow vines to make direct contact with freshly treated wood.
- Plant vines at least 1 foot away from posts treated with a preservative (CCA, creosote, or pentachlorophenol).

Recently, the bunch grape industry has been turning to steel posts, which offer the following advantages:

- Easier to install than wood posts.
- Easier to use than wood posts.
- Ready to use once they are driven into the ground; just string your wires.
- Wire slots provide more built-in options for placement of wires, making them more versatile than wood posts.
- Better for grounding lightning strikes than wood posts.

- Wire clips, staples, etc., are not needed.
- More fruit harvested with less beater power of a harvester and less damage to costly vines, making harvesting more efficient.
- Quality is more consistent than wood posts.

Trellis Arrangements

Vertical One-Wire Trellis

Bracing and supporting posts (interior) should be at least 8 feet in length. Posts no smaller than 5 to 6 inches in diameter should be used for bracing and with posts no less than 3 to 4 inches in diameter used for interior positions. Two and one-half feet of the line post is placed below ground level, establishing the wire and vine height at 5 1/2 feet. Use tractor-powered posthole augers and post drivers to install posts. Set line posts 20 feet apart in the row. Brace end posts according to Figure 2 using Number 9 galvanized wire. A ratchet strainer at the end of each row may be used to help establish and maintain wire tension. There are several methods for bracing end posts, and new growers should visit several established vineyards before making a final decision on bracing procedure. Most bracing techniques set the end posts deeper than interior posts with braces at a 15- to 30-degree angle to the ground. Research has indicated a slight yield advantage in orienting vineyard rows in a north-south direction, but other factors, such as slope and ability to move equipment, may be overriding factors. A vertical one-wire trellis with 10-by-20-foot vine spacing costs about \$2,600 per acre for materials (see section on Production Costs and Returns).

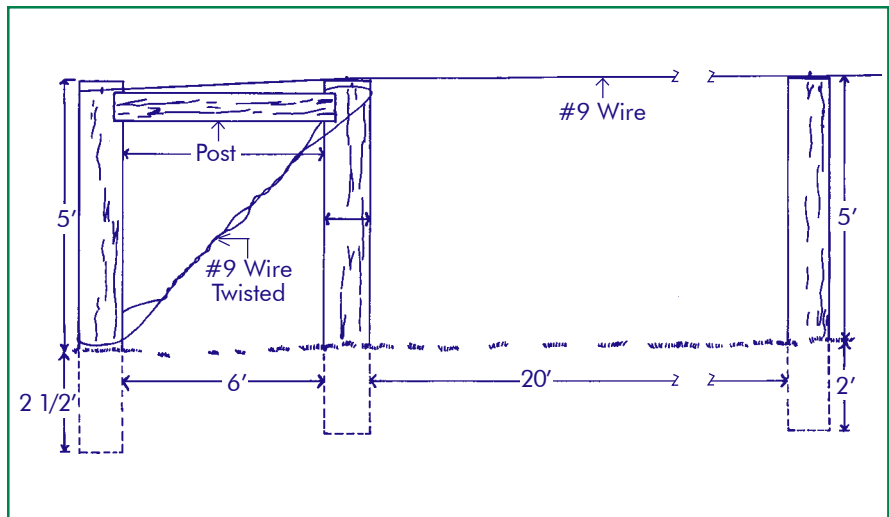


Figure 2. The Vertical One-Wire Trellis for Muscadine Grapes.

Geneva Double Curtain Trellis

Line posts 8 feet long are placed 2 1/2 feet in the ground and 20 feet apart (Figure 3). The end brace post is 8 1/2 feet long, at least

5 inches in diameter, and placed 4 feet in the ground at a slightly outward angle. A 6 1/2-foot post is used as an inside brace post. Place it 6 feet from the outside brace post

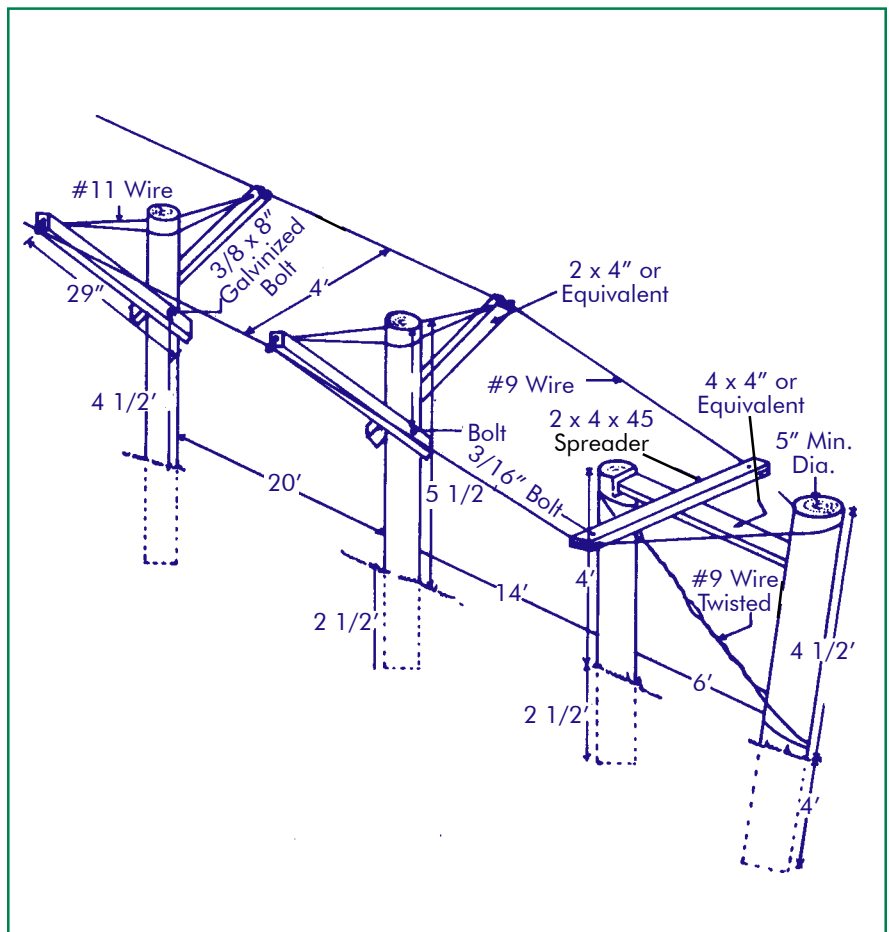


Figure 3. Construction details of the Geneva Double Curtain.

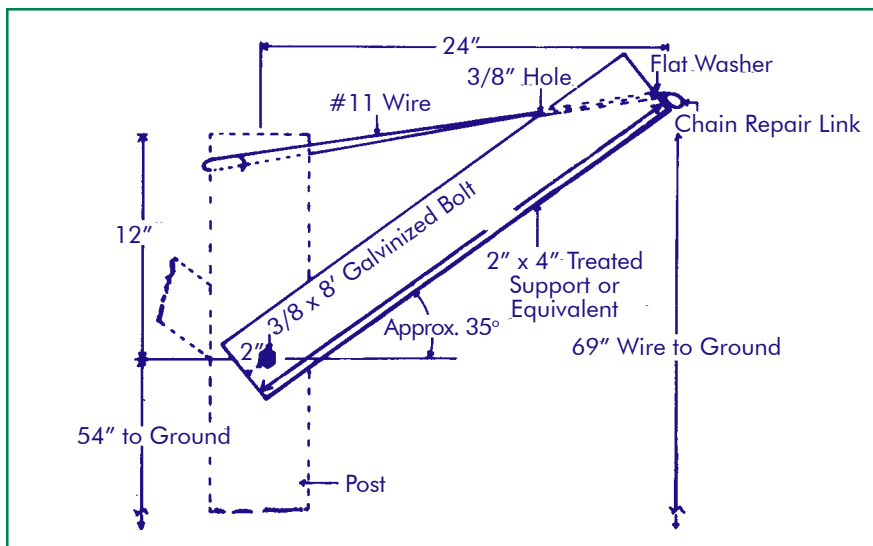


Figure 4. The support system for the GDC.

and position a 4 x 4 or equivalent piece of lumber between the top of the two posts as a brace. Run a double Number 9-gauge wire from the top of the inside brace post to the bottom of the outside brace post, and twist to tighten the entire brace system.

Metal cross arms (supports), commercially fabricated from galvanized steel, are generally used with new plantings. These arms are very durable and easy to install on the posts. Wire to support the plantings can be quickly attached to the cross arm with a hairpin-type clip.

Wooden cross arms also can be used. These cross arms are made from Number 2 grade 2-by-4's or the equivalent. The supports are 29 inches long and predrilled 2 inches from the end to accommodate 3/8-by-8-inch galvanized bolts. An additional hole is predrilled from the other end of the support parallel to the ground to allow the Number 11-gauge brace wire to pass through. After passing the loop end of the doubled wire through the support, place a 3/4 inch washer over the loop and attach a chain repair link to the loop (Figure 4). The brace wires are

now fastened around the top of the post so that supports form a "Y". Both should have angles approximately 35 degrees with the ground and measure 4 feet from tip to tip. Space between rows (post to post) should be no less than 10 feet.

Use Number 9-gauge wire for the main wires. Both main wires are fastened to the top of the outside brace post, threaded through a 45-inch spreader, and then run down either side of the trellis through chain repair links. The opposite end of the trellis is braced in the same way, and the two wires are tightened around the top of the outside brace post.

Planting the Vineyard

Key Factors to Consider Before Planting

Land preparation should begin the year before planting. Plan on an early spring planting after danger of hard freeze is past, usually mid-March to mid-April. After selecting the best site, test the soil and till in any needed lime and fertilizer, deal with internal water drainage problems, eliminate perennial weeds, and establish the trellis.

Here are 8 key factors to consider in selecting a vineyard site and in preparing it for planting:

1. *Field shape.* Choose a row direction that maximizes row length for important equipment-efficiency gains and reduced end-structure investment and maintenance costs.
2. *Row spacing and equipment.* Do not crowd your vineyard, especially if land is available and relatively inexpensive. Row width on slopes and especially on contours must be wider than on level land. On both vertical one-wire and the GDC trellis, space both plants and posts 20 feet apart in the row. Space needed by harvesters, tractors, mowers, and other equipment is the major factor determining row width. The most popular row width spacing for the vertical one-wire trellis is 10 feet. A row width of 12 feet is recommended for the Geneva double curtain.
3. *Row orientation.* The slope of the land and the shape of the field are the major determinants of row direction. If the land has more than a 2 percent slope, it may be advisable to align rows at right angles to the slope (cross-slope planting) to minimize soil erosion. North-south row orientation results in a slightly more productive vineyard than east-west row orientation when standard vertical one-wire training is used. However, there was very little difference with Geneva double curtain-trained vines.
4. *Soil pH and fertility.* The first step in good vineyard fertility management is a soil test. Collect soil samples about 8 to 10 inches deep no later than the fall before planting. For addi-

tional information, contact your county Cooperative Extension agent. Lime is usually necessary to raise the pH to 6.5. After problem weeds have been removed from the site (see below) and the land has been adequately tilled, apply lime according to soil test recommendations. Dolomitic lime is preferred because it contains magnesium, which often becomes deficient in muscadine plants. Incorporate the lime and any recommended phosphate also based on the soil test recommendations 6 months before planting, and plow it thoroughly to a depth of 8 to 10 inches.

5. *Weeds.* Perennial weeds and grasses, such as bermudagrass, johnsongrass, honeysuckle, and brambles, are relatively easy to kill before the vineyard is planted. Control becomes much more difficult after planting. For recommendations on weed control in muscadines see the *North Carolina Agricultural Chemicals Manual*, which is also available on the Web at <http://ipm.ncsu.edu/agchem.html>.
6. *Fescue sod middles to control erosion in the piedmont.* If the row middles are to be planted to a fescue sod cover in the pied-

mont, seed in the late summer or early fall of the year before planting. Keep clean strips where the vineyard row is located.

7. *Bedding up rows in coastal plain.* Bed up so that they are 4 to 6 inches higher than the sod middles in coastal plain growing areas.
8. *Construct trellises by early March.* Prepare the soil as thoroughly as for planting corn or tobacco, then lay off the rows and set the posts before planting. This operation should be completed by early March of the planting year (Figure 5).

Plants and Planting

Plants. Rooted cuttings survive as well as or better than layered plants. One-year-old, properly grown plants are as good as and usually better than older plants.

Planting. If plants arrive from the nursery prior to suitable planting weather, moisten (but do not wet) the roots, seal the plants in plastic bags, and store them in a refrigerated area (38 to 40° F). If this is not possible, heel them in along the north side of a building, and protect them well with a covering of at least a foot of loose straw or similar material. To avoid freeze damage to tender growth,

postpone planting until there is little chance of a hard freeze. However, the longer planting is delayed the more likely plants will suffer from high temperatures and drought. In North Carolina the ideal planting window for dormant plants occurs between April 7 and May 7. In most years, it is better to plant early rather than late. Fall planting is possible but increased winter injury may occur.

Planting holes and alignment.

The planting holes can be dug by hand or tractor auger and should be several times larger than the root ball of the grapevine. Plant the vines 1 to 2 inches deeper than they were growing in the nursery. During planting, vine roots should be temporarily submerged in a pail of water or wrapped in wet burlap. After planting, water the vines. Pack the soil firmly after the hole is filled and irrigate or hand water the soil surface immediately. Vines should be planted 12 to 18 inches from the posts. Setting vines against the posts may result in plant injury from the toxic wood preservatives. Planting on the north side of posts may help to minimize winter injury. After planting, the young vines are vulnerable to freeze and drought damage. Never place fertilizer directly in the planting hole. Be sure to set vines directly under the trellis; vines out of line are more likely to be injured by cultivation, mowing, and harvesting.

Grow tubes. Grow tubes, plastic cylinders 24 to 36 inches tall and 3 to 4 inches in diameter, allow earlier spring planting and increase the rate of growth. At the Castle Hayne Research Station, first-year plant growth in the 36-inch tubes was nearly twice as much as those grown without tubes. These tubes also allowed wide-spectrum systemic herbicides



Figure 5. Bracing and interior posts should be set before vineyard is planted.

to be applied close to young plants with little possibility of injury. You must, however, weigh the added costs of these tubes against the benefits. Several companies carry them, and they range in quality, size, and price. In the Castle Hayne study, 36-inch tubes produced the greatest total growth per season. Remove grow tubes before early winter to avoid any cold damage. The tubes are reusable.

Irrigation

Irrigation has only been recommended recently only in the deep South (e.g. Mississippi) and is not common in North Carolina. Irrigation on wine muscadines is normally not necessary after the first three years. Since grapes are usually nonbearing during these years, overhead irrigation is acceptable and preferable. If overhead irrigation is not available, then hand watering of newly planted vines can be accomplished with a water trailer, but this is a time-consuming method. Drip irrigation, moving guns, and soak hoses have also been used. Whatever type of irrigation is used, avoid overwatering the vines. Water thoroughly and allow the soil to dry out before irrigating again. During periods in which little or no rainfall occurs, 1 inch of water per week is usually adequate. For many years North Carolina growers were able to grow grow muscadines successfully without any irrigation. However, during the past decade droughts have been common during the growing season. If growers have a clean water source and are willing to invest the capital, a drip irrigation system makes the most efficient use of water.

Drip irrigation is the most efficient method, but it requires a sand filter for water from ponds and lakes. Water from most wells can be filtered inexpensively unless it has high iron content. It is highly recommended that you ask an authorized irrigation dealer in your area to evaluate your vineyard site and to properly design the drip irrigation system.

Overhead irrigation can be used in a drought, especially for the non-bearing years, but it has the following disadvantages:

- 1) high initial investment,
- 2) wetting of foliage, which can increase disease,
- 3) inefficient use of water, and
- 4) reduction of fruit set if used during the pollinating period.

Weed Control

During the first three years of a new vineyard, weed management is extremely important. As stated in the planting section, elimination of weeds should be part of site preparation. Here is where an ounce of prevention is worth a pound of cure. Prevention is especially critical with perennial weeds, such as bermudagrass and johnsongrass. Proper tilling techniques and systemic herbicides can minimize or eradicate many problem weeds before planting. When the vines begin growing, control of these weeds is much more problematic. Before weed seeds germinate, treat the soil with a preemergence herbicide. To maintain control throughout the growing season, at least two applications of these herbicides are required. The second spray should also be made before weeds emerge. Any emerged weeds should be hoed or sprayed with a systemic or contact herbicide

before the soil is treated with the preemergence. If applications of preemergence herbicides are not followed within a few days by irrigation or substantial rainfall, their activity is often greatly reduced.

Once the grapes begin to grow, take great care to prevent any contact with systemic or contact herbicides. Any contact of these herbicides with green leaves or stems may injure the plant. If used properly, grow tubes and homemade or commercial shields for sprayers or vines can sufficiently protect vines from herbicide contact. Avoid spraying herbicides on windy days. Consult your *North Carolina Agricultural Chemicals Manual* or local Extension agent for a list of herbicides labeled for grapes.

In recent years some growers have experimented with mulches in young muscadines to control weeds and reduce drought stress. It is probably best to use a durable mulch, such as chipped hardwood.

Post-Plant Fertility and Liming

Generally apply 1/4 pound of 10-10-10 in a 18-inch circle around each vine beginning 2 weeks after planting, and repeat every 6 weeks up through the first week in July. During the second year, double the application rate to 1/2 pound per vine applied at the same time intervals. In the third year use a rate of 1/2 pound per vine at the same intervals. It is sometimes desirable to adjust fertilizer rates to compensate for the effects of rain or drought. Overfertilizing during an extreme drought may damage vines. Never fertilize after the first week in July since this may lead to winter damage and

possibly crown gall. Apply any mulch or compost during the previous fall, winter, or very early spring to minimize winter injury due to nitrogen being released into the soil late in the season.

Accurate determination of fertilizer needs is essential. Annual soil tests may be used, but plant foliar analysis has been proven to be the most accurate way to determine the nutritional status of the vine. This service is not free, but the cost is minimal.

Foliar analysis determines the actual nutritional status of the plants during critical periods of growth. Take leaf samples in June and early July. Collect a double fist full of mature leaves located opposite fruit clusters on fruiting shoots. Place the leaves in a paper bag and allow them to dry. Send samples to the Agronomic Division, North Carolina Department of Agriculture. To be most effective, continue the practice from year to year to help establish trends and change in nutrient levels. Unfortunately, no single method is completely accurate. Consequently, the alert grower uses all means available to develop the fertilizer program for a particular vineyard. Appropriate levels based on whole-leaf nutrient concentration are shown in Table 5.

Table 5. Appropriate Levels of Nutrients Based on Foliar Analysis

<i>Element (Unit)</i>	<i>Optimal Range</i>
Nitrogen (%)	1.65 to 2.15
Phosphorus (%)	0.12 to 0.18
Potassium (%)	0.80 to 1.20
Calcium (%)	0.70 to 1.10
Magnesium (%)	0.15 to 0.25
Boron (ppm)	15 to 25
Copper (ppm)	5 to 10
Iron (ppm)	60 to 120
Manganese (ppm)	60 to 150
Molybdenum (ppm)	0.14 to 0.35
Zinc (ppm)	18 to 35

Fertilizer Deficiency Symptoms

In North Carolina the elements most likely to limit grape production are nitrogen, phosphorus, potassium, magnesium, and boron. It is important to maintain soil pH at 6.0 with dolomitic lime throughout the life of the vineyard.

Nitrogen: Foliage of vines deficient in nitrogen are green to yellowish over the entire vine. The oldest leaves are the least green. Shoot growth is short and leaves are smaller than on vines with adequate nitrogen. On the other hand, too much nitrogen will result in excessive growth, causing late ripening of the crop and possibly deficiencies in other elements. Ideally, each shoot should grow 30 to 36 inches each growing season.

Magnesium: Deficiency symptoms develop first on basal leaves and shoots. Unless the deficiency is severe, it does not become evident until late summer. Chlorosis, or yellowing of the leaves between the veins while the veins remain green, gives a “Christmas tree” effect. As a vine becomes more deficient in magnesium, chlorosis becomes more intense in older leaves and progresses to younger leaves. Young terminal leaves may never show symptoms unless the entire vine is extremely deficient.

Boron: Boron deficiency may result in poor fruit set. Leaf symptoms are similar to those of magnesium deficiency; however, newer terminal leaves are affected rather than older leaves. Probably the most noticeable are the die-back of terminal shoots and the prolific growth of lateral shoots, often several from each node. Boron deficiency is more common on sandy soils with a high pH.

Visible symptoms generally do not appear until the vine is critically deficient in this micronutrient, so foliar analysis is important in monitoring boron status. For mature vineyards, a common recommendation has been to apply 5 pounds per acre of Borax (10 percent) every 2 years or spray annually with 1 pound per 100 gallons of water of Solubor (20 percent) just before bloom. Excessive boron causes plant injury; do not exceed boron recommendations.

Insect and Disease Pests

Establishment

During the 2 to 3 years required for establishment, few insects or diseases are usually encountered. However, Japanese beetles can be a fairly severe problem. They do not persist over the entire growing season but normally feed over a 4- to 6-week period; spray as needed. Japanese beetles feed on grass roots and may emerge in large numbers on land that was previously a well-established pasture. If the vineyard is to be established in an old pasture, make an extra effort to kill grass during the growing season preceding planting. Sprays and/or cultivation are effective methods for eliminating grass. Consult the *North Carolina Agricultural Chemicals Manual* or your local Cooperative Extension agent for specific recommendations.

Growers inclined toward sustainable agriculture may be willing to accept a greater level of damage. They may also try interplanting companion plants or borders to repel or attract the beetles. Although no research has clearly proved its effectiveness, milky spore disease is frequently used in an attempt to control the grub stage.

Grape root borer is not a threat during the first 3 years. Apparently the borer requires some degree of shade for successful establishment in a vineyard.

Symptoms of black rot may appear on the leaves of muscadines during the establishment period, but since no fruit is usually present and infections are not usually severe, sprays are not usually necessary.

A good sprayer for disease and insect control is essential for profitable production. To cover the leaf and fruit surface for disease control requires high pressure and many nozzles or a high-speed air blast to break the material into small particles.

Mature Vines

Symptoms of Major Diseases

Angular leaf spot is an important leaf disease. Faint, light yellow spots first appear on the leaves. As the yellow spots become more noticeable, irregular brown flecks develop in the center of the spots. As the growing season progresses, the disease often increases and causes extensive defoliation by harvest. If heavy defoliation occurs, the yield and quality of the grapes are reduced.

Bitter rot can be a very destructive fruit disease. Infection occurs shortly after bloom. Just before harvest, infected grapes turn black with spore-bearing structures (acervuli) erupting through the skin of the fruit. Rotted grapes may or may not fall to the ground before harvest. The fungus infects fruit stems, leaves, and young shoots.

Powdery mildew attacks berry clusters and young grapes just after flowering. Infected grapes are covered with a white fungus growth. As the grapes enlarge, the

fungus growth disappears, but the grapes become rough-skinned (russeted) and may crack. Grape drop and reduced size of grapes occur.

Ripe rot also causes a grape rot near harvest. In recent years it has become the most damaging fruit rot disease. Rotted grapes turn dark brown over part or all of the grape and have pink or orange spore masses on the surface. Ripe rot infections can occur at any stage of fruit development, but fruit infected in the green (unripe) stages do not rot until they begin to ripen. Once infected grapes begin to rot and produce spores in the vineyard, the disease can spread rapidly to other ripe fruit. The most devastating losses to this disease occur on susceptible cultivars during rainy harvest seasons. Generally speaking, dark-skinned cultivars (Noble, Pride) are more resistant, while bronze cultivars (Carlos, Scuppernong, Magnolia) are more susceptible.

Macrophoma rot causes small, sunken, black fruit spots that are round with distinct edges in the early part of the season. As harvest approaches, these spots may develop a greasy-looking soft rot around the initial lesion. A halo develops around the black spot, and the entire fruit may rot just before harvest. Infections are sometimes not visible until the soft rot stage occurs.

Black rot causes a circular brown leaf spot and a black scab on grapes. Occasionally, lesions occur on the young stems and tendrils. Black rot seldom causes much damage in sprayed vineyards.

Pierce's disease is a bacterial pathogen of little importance on most muscadine grapes, occasionally causing a marginal leaf burn

on susceptible cultivars such as Carlos. The cultivar Pride is highly susceptible and may be killed by the bacterium. Growers should avoid propagating from symptomatic vines. Chemical control is not available.

Crown gall is caused by a bacterium frequently associated with gall formation on grape vines. Galls are fleshy, irregularly shaped growths. The disease usually occurs in association with freeze injury, and galls may form all along the length of the trunk and cordons. Fall planting exposes new vines to freeze injury and should be avoided.

Controlling Major Diseases

Resistance. Plant disease-resistant cultivars. For instance, among large-fruited bronze cultivars, Fry is very susceptible to ripe rot, while Triumph is not. As mentioned earlier, dark-skinned cultivars tend to have less ripe rot.

Cultural Practices. Reduce diseases through cultural practices. Mowing or otherwise reducing undergrowth near vines will improve air movement through the vineyard. Timely harvesting and removal of leftover fruit at the end of the season help reduce fruit rots. Avoid excessive late-season fertilizing to reduce disease and the likelihood of winter injury to cordons and trunks of vines.

Fungicides. A regular spray program with an effective fungicide plus an insecticide is highly beneficial and profitable. An effective disease control program is essential to produce the high yields of quality grapes that are possible with the newer varieties. In new vineyards, begin the disease control program in the second or third season after planting. Repeated early season

Table 6. Fungicide Effectiveness in Control of Grape Diseases*

Fungicide (Rate/Acre)	Angular Leaf Spot	Bitter Rot	Powdery Mildew	Ripe Rot	Macro- phoma Rot	Black Rot	Plant Safety
Captan 50WP (4.0 lb/acre)	XXXX	XXXX	0	XXX	XXX	XXXXX	XXXXX
Wettable Sulfur (4.0 lb/acre)	0	0	XXXXX	0	0	0	XXXX
Nova 40WP (5.0 oz/acre)	0	XXXX	XXXX	0	X	XXXX	XXXXX

* (0 = ineffective or injurious; xxxxx = very effective or very safe)

applications of fungicides (May-June-July) are the most effective.

Grape Root Borer

The grape root borer is a native species belonging to a family of insects known as clear-winged moths. The larva or borer, once finding a root, eats through the outer bark and then begins to excavate an irregular burrow. This burrow may encircle the root several times or run with the grain of wood. In larger roots this excavation is most likely to be found along the underside of the root. Severe pruning and girdling of roots lessens the feeding area of the vine, weakening the plant. Large numbers of borers cause discoloration, loss of vigor and production, and eventual death of the vine. The effect of borer feeding may not be immediately apparent.

Detection. Grape root borer injury first appears as discolored leaves. Wilting, loss of production, and eventual death follows over a period of years. Examine weakened, wilting, and dead vines for previous damage by borers or actual feeding. Full-grown borers are whitish with brown heads, sparsely covered with stiff hairs, 1 ¾ inches long. Pupal skins shed near the base of vines in August are also signs of infestation. Adults

fly only by day and bear a striking resemblance to wasps. However, grape root borer adults are more sluggish than wasps. Also, their hind pair of wings are clear and in flight have less rapid wing vibrations. They are dark brown with two orange and yellow bands on the abdomen and have orange-colored tufts on the tips of the abdomen.

Life Cycle. The grape root borer overwinters in the larval stage, and pupation occurs near the soil surface in June and July. The pupal stage requires about 39 days. Adults emerge from the pupal case at the soil line during July and August. After mating, female moths lay some 500 eggs indiscriminately on weeds, leaves, and bases of grape vines during their 7-day life. Flight occurs during the day, especially from noon to 4 p.m. Eggs hatch in about 15 days, and larvae enter the soil in search of roots. The cycle is repeated in 2 years.

The grape root borer has been reported on bunch grapes in Rutherford, Cleveland, Mecklenburg, Johnston, Henderson, Stokes, and Onslow counties. Reports on muscadine grapes have been verified in Onslow, Anson, Richmond, Moore, Robeson, Lenoir, Jones, Pender, and Bladen counties. Additional

counties will be verified as growers and Extension personnel closely examine vineyards.

Control. Natural enemies include barn swallows, mockingbirds, crested fly catchers, larvae of fireflies, a number of fungi, and a species of nematodes. Other parasites and predators undoubtedly exist. However, when weather conditions are unfavorable, they fail to control the grape root borer.

Resistant root stocks show some promise, but will not be available commercially for many years.

A periodic and constant surveillance of vineyards during July and August could reduce infestation through elimination of adult females. Females, once engaged in egg laying, can very readily be approached and killed. The female releases a strong sex attractant that attracts males for mating. Studies are in progress using a mass trapping and mating confusion technique. Identification and commercial availability of the pheromone are under investigation.

Grape root borers can be controlled with chemicals. Apply Lorsban 4E at the rate of 4 1/2 pints in 100 gallons of water. Apply a quart dilute mixture of spray to the soil at the base of the vine. Make a single application with a herbicide low-pressure sprayer 35 days before harvest. Do not let spray contact the fruit or foliage.

Tests in North Carolina indicate that plastic or ridges of soil placed around the base of vines provide a physical barrier that prevents adult emergence. It also helps control weeds around young vines. Proper timing (about August 1) is critical with this procedure and needs to be determined for areas and individual vineyards.

Cultural methods like weed control, fertilization, irrigation, clean cultivation, and weekly cultivation (disturbance of top 1 inch of soil) help reduce injury. Hence, the condition of the vine, whether it is a healthy, good producer or a weakened, poor producer because of the lack of good cultural practices, is a deciding factor in the decline of a vine as a result of injury by borers.

Training

During the first two or three years, vines need regular training (Figure 6), which means working on each vine once a week throughout the growing season. Training establishes the optimal shape and position of the vine for vineyard management and maximum productivity. Proper training is accomplished by selecting a single shoot and training it up a bamboo stake or string. Various materials are used for attaching vines to the stake. The current standard material is a plastic tape sold by most vineyard supply companies. The tape seems to decay, so girdling is not common.

Train the young vines up the stake or string to the wire. When the vine reaches the wire, pinch it back to approximately 4 inches below the wire. This will encourage a V-shaped branching. Choose two of these lateral branches and begin training them along the wire as future cordons. Continually remove lateral suckers along the trunk in order to direct all the plant's growth into the growing tips of the cordons. Until the cordons reach full length, cut back side shoots to approximately 4 to 6 inches during the growing season. Likewise, remove all fruit at the earliest possible stage in order to direct growth to the desired shoots.

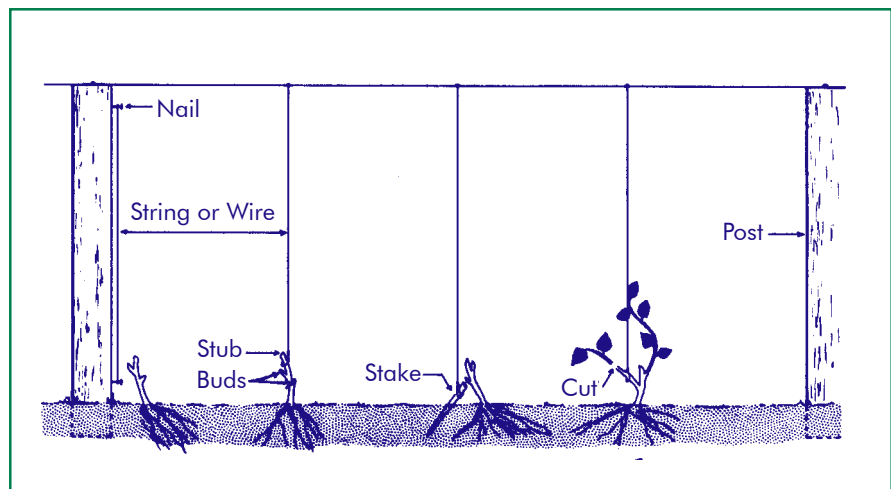


Figure 6. Methods of training a young vine.

Pruning Mature Vines

Unpruned vines become a tangled mass of unproductive and often diseased wood. Figure 7 shows the vine structure of a properly pruned muscadine. If you have "inherited" a poorly managed muscadine vine, use the steps in "Pruning Neglected Vines" to renew the fruitfulness of vines where annual pruning has been neglected.

Pruning is a key to maintaining healthy fruit-bearing wood. Fruit is borne on current season shoots; however, these shoots must arise

from buds set on the previous year's growth (Figure 8). Shoots arising from older wood usually are unfruitful. Pruning principles are the same whether you are training your muscadine vines to a vertical wire (VW) trellis or a Geneva Double Curtain (GDC). Most important is to leave an appropriate amount of last year's wood on the vine. One-year-old wood is the only source of fruitful shoots on the plant. The only difference in the VW and GDC is the arrangement and number of fruiting arms. The VW system has two permanent fruiting arms or

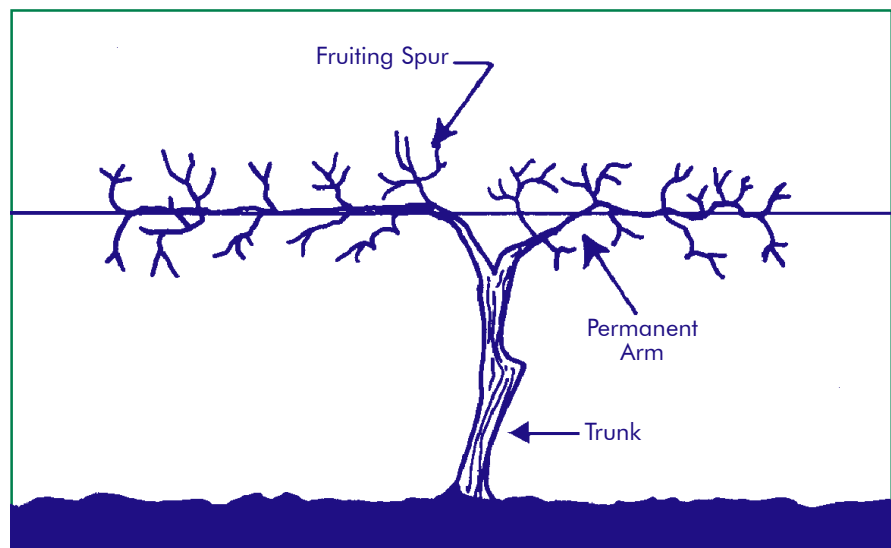


Figure 7. Framework of vine.

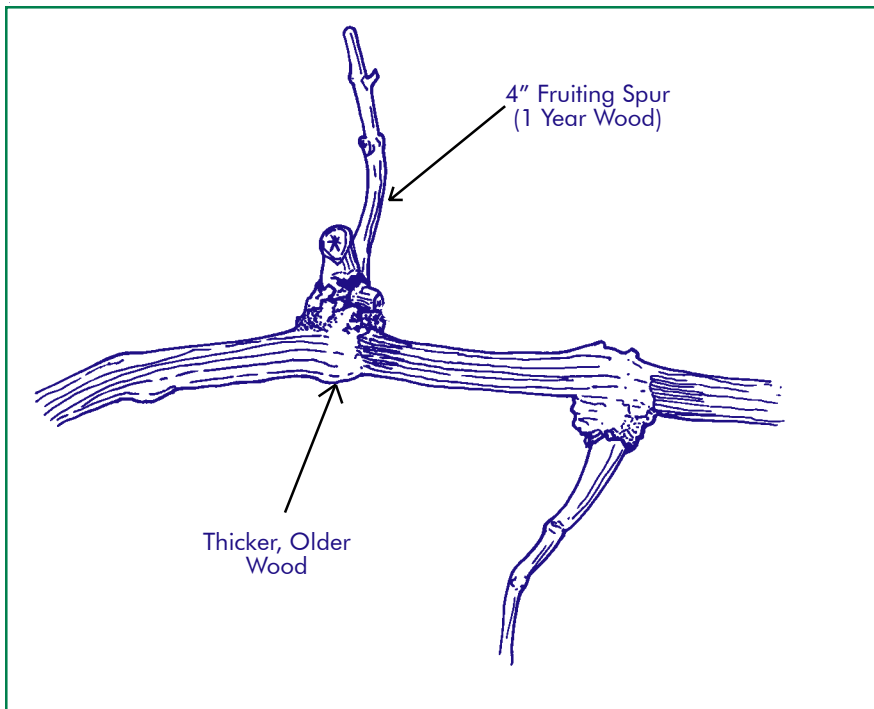


Figure 8. One-year wood and spurs.

cordons; the GDC has four permanent arms or cordons (Figure 9).

Step-by-step pruning:

1. In the dormant season, prune back all 3-inch-long wood (called "canes") that grew the previous year to fruiting spurs. No scientific evidence suggests that yields or fruit quality in muscadines will be improved by more time-consuming "balanced pruning" methods or more complex formulas used in bunch grape pruning. Muscadine pruning is quite simple and can be accomplished with a mechanical hedger or hand pruners. However, use great caution when pruning with any mechanical hedging equipment.
2. On young vines, leave the 1-year-old "shortened canes," or "spurs," about 6 inches apart. As the vine grows older, it will develop clusters of spurs at each of these locations on the fruiting arm. These clusters are called

- "bearers" (approximately 6 inches apart).
3. After the 4th or 5th year of fruiting, begin to thin out some of these bearers. This thinning will force new spur growth to replace these older bearers. It is critical to keep fruiting spurs

(of 1-year-old wood) close to the original fruiting arm.

4. Experience has shown that it is better to gradually thin out the older bearers starting in the third fruiting season (5- to 6-year-old vine), than to wait until the fourth or fifth fruiting season (7- to 8-year-old vine).
 5. Each year, remove wood that has grown at the top of the trunk. This helps to maintain vigorous growth and good yields along the lengths of the fruiting arms. If an arm becomes cold-injured, or broken, REMOVE IT ENTIRELY BACK TO THE HEAD OF THE VINE, AND TRAIN A NEW CANE TO REPLACE IT.
 6. Grapevines grow tendrils that bind to the trellis or whatever is nearby. They are especially bothersome when they encircle the trunk or fruiting arms. To prevent girdling damage, remove all tendrils attached to the trunk or fruiting arm of the vine.
 7. Vines pruned in late winter will
- Harvesting of muscadine grapes

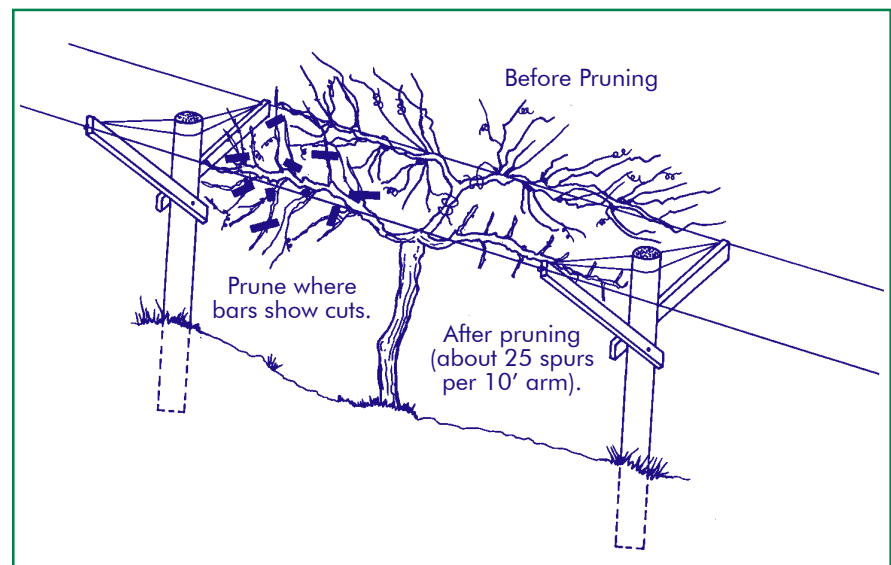


Figure 9. Pruning a mature vine.

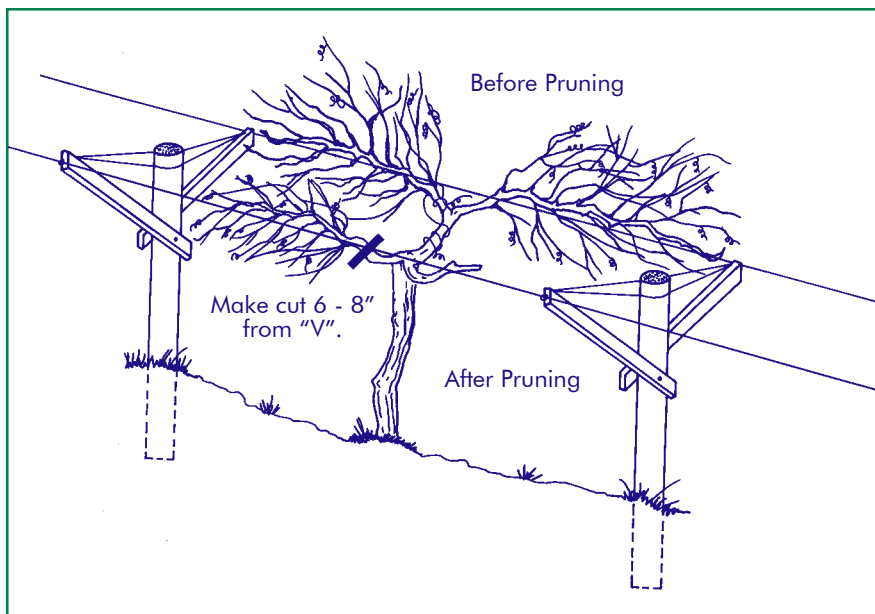


Figure 10. Pruning a neglected vine.

begins in early September and continues through October, depending on location and variety. Generally, the fruit is picked over several harvests for fresh marketing and in one harvest for processing.

Pruning Neglected Vines

Unless a vine is pruned in each dormant season, fruit-bearing wood develops farther and farther away from the permanent fruiting arms each year. Eventually, there is only a thin layer of new growth over a mass of tangled, nonbearing wood. If this occurs, the procedure described below is necessary, but it is never required if annual pruning is practiced, and if the older bearers are gradually thinned out, starting in the vine's third fruiting season.

Step-by-step renewal:

1. Cut away most of the permanent arm (cordon), and leave only a 6-inch "stub" at the head of the vine (Figure 10) for each arm that requires renewal. Use one of the new shoots that will

arise in the spring from the renewal area for training into a new fruiting arm.

2. Remove all other shoots that develop from the renewal area during the summer. These will only compete with the shoot you have selected for the new fruiting arm. You will essentially lose a season of production as a result of this procedure.
3. If more than one vine is involved in a renewal project, cut back half of the vines the first year, and the remainder the second year to avoid losing an entire crop.
4. In many instances, setting new vines may be preferable to renovating poorly trained vines that do not have good trunks and fruiting arm structures.

Harvesting

Harvesting of muscadine grapes begins in early September and continues through October, depending on location and variety. Generally, the fruit is picked over

several harvests for fresh marketing and in one harvest for processing.

Mechanized harvest: Mechanical harvesters permit once-over harvest for grapes to be processed, working at the rate of 1 acre per hour. This equipment is very expensive, and growers are advised to have their wine grapes custom-harvested. Bulk bins handled with forklifts are used with harvesters, completing the mechanization process.

Catch-frame harvesting is used where custom harvesting services are unavailable and the vineyard is too small to justify an investment in a mechanical harvester. Catch frames fit under vines and collect berries as they fall. Berries are usually shaken from the vine by striking the trellis with a padded club, and the catch frame funnels them into a suitable sized container, commonly perforated plastic bins. Catch-frame harvesting requires three to five people for maximum efficiency. Average time per vine is 3 to 7 minutes.

Fresh fruit: Carefully hand-pick fruit that is to be used for fresh sales. Some varieties, such as Carlos, are easily removed from the vines and have a dry stem scar. Other varieties (Fry, Magnolia, and Noble) tear when pulled from the cluster and have wet stem scars, so clip the entire cluster with shears. Sort and grade the berries, then package the best fruit in a suitable container. Unlike the American (Eastern Type) Bunch Grape industry that has established USDA standards, there are no maturity standards or grades for fresh bronze or black muscadine varieties. To prolong shelf life, use plastic clamshells and hold grapes at approximately 34° F until the fruit is sold.

Customer harvest ("U-Pick"):

Some growers have had success with growing muscadines for customer harvest. Successful U-Pick operations are located near population centers. It is best to start a U-Pick vineyard on a small scale and expand as demand for fruit increases. Pre-picking fruit for sale at the vineyard or for sale at farm markets and/or satellite stands is becoming increasingly important as fewer people seem to have the time and interest in harvesting their own grapes. Larger grapes like Triumph, Nesbitt, and Supreme are becoming increasingly popular for direct marketing.

Conclusion

As a commercial grower or prospective grower, you can now fit the pieces together on the most current varieties of muscadines for both fresh and processing uses, and follow the guidelines on vineyard establishment, management, harvesting, and marketing.

In addition to the information in this publication, consult with successful growers, research stations, winery representatives, and your local Cooperative Extension agent for advice before planting. After you have decided to plant, follow the guidelines carefully. To be successful, you must do a complete job of growing and marketing. There are no secrets or shortcuts.

References

- Grape Root Borer.** Insect Note #G-4, NC State University, <http://www.ces.ncsu.edu/depts/ent/notes/Fruits/fruitg3.html>
- Insects Reported on Grapes in North Carolina,** Insect Note #G-2, NC State University, <http://www.ces.ncsu.edu/depts/ent/notes/Fruits/NoteG-2.html>
- Muscadine Grape Diseases and Their Control.** Fruit Disease Note #12, NC State University, <http://www.ces.ncsu.edu/depts/pp/notes/Fruit/fdin012/fdin012.htm>

Muscadine Grapes. Fouad M. Basiouny and David G. Himelrick, Eds. 2001, ASHS Press, Alexandria, VA, <http://www.ashs.org/ashspress/mgrapes.html>

North Carolina Agricultural Chemicals Manual, "Muscadine Grape Spray Program," NC State University, published annually and on the Web at <http://ipm.ncsu.edu/agchem/chptr7/707.pdf>

North Carolina Agricultural Chemicals Manual, "Weed Control in Fruit Crops," NC State University, published annually and on the Web at <http://ipm.ncsu.edu/agchem/chptr8/813.pdf>

Prepared by

E. Barclay Poling, Professor, Horticultural Science

Charles M. Mainland, Professor Emeritus, Horticultural Science

William T. Bland, Agricultural Research Technician, Horticultural Science

Bill Cline, Research and Extension Specialist, Plant Pathology

Kenneth A. Sorensen, Professor, Entomology

*Special thanks to the North Carolina Grape Council, Inc., and
the Southern Region Small Fruit Consortium
for underwriting the cost of printing this publication.*

2,000 copies of this public document were printed at a cost of \$0,000.00 or \$.00 per copy.



Published by

THE NORTH CAROLINA COOPERATIVE EXTENSION

Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Employment and program opportunities are offered to all people regardless of race, color, national origin, sex, age, or disability. North Carolina State University, North Carolina A&T State University, U.S. Department of Agriculture, and local governments cooperating.