/ **COMMERCIAL MUSCADINE CULTURE**

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1. INTRODUCTION

The muscadine grape (*Vitis rotundifolia* Michx) was one of the most pleasant surprises found by the early colonists that settled in the southeastern portion of the United States. Many names including bullace, bullis, bullet and muscadine have been used to denote this grape in the wild and in cultivation.

Photo 1.1: Wild muscadines are an important wildlife food and often climb to the tree tops.

Cultivated grapes of this species are now usually called muscadines although the bronze muscadines are often referred to as scuppernongs. Muscadine, however, is the recognized common name since 'Scuppernong' is actually a cultivar of bronze muscadine found growing wild on the Scuppernong River in North Carolina about 1810. Other popular bronze cultivars in Georgia include 'Fry', 'Carlos', and 'Summit'.

Photo 1.2: Eighty year old 'Scuppernong' vine in Griffin, Ga. Muscadine vines may live to be enormously old in some situations.

Breeding programs have resulted in all of the improved fresh market cultivars planted commercially today. With these cultivars, yields of three to four tons per acre can be expected by growers who apply all the recommended cultural practices including irrigation. Whole sale prices received for high quality, large fruited fresh market types have been good early in the season (early August), but fair to poor in mid-season (late August and Sept.). South Georgia begins harvest in early August and North Georgia about three weeks later. For this reason, the wholesale market for muscadine table grapes in North Georgia does not look very attractive at this time. Prices usually strengthen in late season (Oct.-Nov.), but the primary late season cultivar, Granny Val, is not well adapted to North Georgia.

Yields for mature wine and processing cultivars of muscadines are typically in the five ton per acre range. Young mature vines sometimes yield as high as eight to ten tons per acre. Wholesale prices for wine and processing cultivars is currently about $400 per ton. With a typical yield of five tons per acre, profit margins at $400 per ton are tight. If higher yields or higher prices can be realized, profit potential is much greater. Value added enterprises such as wineries may have potential in some areas with heavy traffic flow and tourist traffic.

2. COSTS AND RETURNS FROM MUSCADINES

Employing the information in this bulletin should result in production of muscadines of good quality and quantity. The question is, "will this production result

in a profit?" Profit can be achieved only when sufficient fruit is sold at a price that covers all costs.

Below is a summary of the costs associated with establishing, growing, and marketing fresh market muscadines.

Table **1.** A substantial amount of capital is required to establish a muscadine vineyard. Potential growers must have capital available from personal sources or be able to borrow funds. Shortage of funds could result in lesser than optimum cultural practices or "shortcuts." Shortcuts would likely result in a less productive vineyard.

Table 1 - Establishment Costs[1] Per Acre	
Year 1	$2567
Year 2	485
Year 3	500
Annual costs to recapture over 15 years at 6%	**$425**

Table **2.** Costs and returns from a mature planting appear in Table 2. The column called "*economic costs*" shows all costs including depreciation, interest, and recapture of establishment costs. These costs are high but with the yields and prices used, an annual return of $350 per acre could be expected. Returns above cash costs could be more than $1000 dollars if there is no debt associated with establishment. If, however, much or all of establishment capital is borrowed, returns could be negative for a few years.

Table 2 - Annual Costs and Returns[1] Per Acre			
	Economic Costs	**Cash Costs** with establishment amortized over 5 years	**Cash Costs**
Expected Yield	6000 lbs	6000 lbs	6000 lbs
Expected Price	$ .49 per lb	$ .49 per lb	$ .49 per lb
Preharvest Variable Costs	$ 649	$ 649	$ 649

[1]Up-dated from "Estimated Costs of Producing Muscadines", 1992. Ag Econ 92-025, The University of Georgia.

Harvest and Marketing Costs	1255	1255	1255
Fixed Costs	686	1266[2]	0
Total Costs	$ 2590	$ 3170	$ 1904
Expected Revenue	$ 2940	$ 2940	$ 2940
Expected Returns	$ 350	$ - 230	$ 1036

Potential growers should satisfy themselves that they can:

- secure sufficient capital until the vineyard is mature.
- produce a good quality and quantity of muscadines
- deliver to an available market

3. USES OF MUSCADINES

Since muscadines have a very fruity flavor, they make excellent consumer products. Some of the muscadines grown commercially in the South are sold to wineries where the grapes are then fermented and sold as specialty products such as appetizer wines. However, certain cultivars, if properly fermented, make excellent dry table wines. Muscadines are also used by processors to make juice, jellies, and jams. The leading wine and juice cultivars, 'Carlos' and 'Noble' were developed by Dr. Nesbit at North Carolina State University.

In Georgia most of the fruit is sold on the fresh market. It is very important that you plant the correct fresh market cultivars of muscadines if your operation is to be a success (see cultivar section). The fresh market muscadine industry in Georgia is a direct result of the breeding work conducted at the Georgia Experiment Station in Griffin by Mr. B.O. Fry and Dr. Ron Lane. We are deeply indebted to them for their excellent work in the areas of muscadine breeding and culture.

4. AREAS OF ADAPTATION

[2]This is not a true fixed cost, but is a fixed cash outflow for the five years of establishment debt amortization.

Although muscadine grapes can be grown successfully in most parts of the state, they are best adapted to the Piedmont and Coastal Plains area. The more severe winters of the high mountain area injure/kill muscadines. Some cultivars such as 'Higgins' and 'Fry' are not recommended for the upper Piedmont (north of Atlanta-Athens) and are injured occasionally in the lower Piedmont and Coastal Plain. To select the most cold hardy cultivars, see the information on cold hardiness in the cultivar chart if you are planting muscadines in the upper Piedmont. Temperatures near or below 0°F. during the winter can be dangerous for muscadines, especially if the vines have been depleted by a heavy crop, lack of fertilizer, etc. (see the section on cold protection).
Photo 4.1: Muscadines are not well adapted to the high mountain area of Georgia.

5. VINEYARD LOCATION

Muscadine grapes produce best in full sun on fertile, well-drained soil with good waterholding capacity. Soils types with high yield potential for row crops make the best muscadine grape sites. Your soil conservation agent can help you determine which soils on your farm are best suited for muscadines. Muscadines can also be grown successfully on lower quality or very sandy soils with timely irrigation and fertilization.

Sites with good elevation and cold air drainage are preferred because they are less prone to late spring freezes. Late spring freezes can be a problem at very low elevations, since cold air settles in these areas during radiation freezes. Muscadines break bud relatively late in the spring, but the new growth is very frost tender and freezes at around 30 degrees F. Fortunately, muscadines will often produce a second crop of blooms from secondary buds after a freeze.
Photo 5.1: If available, select a vineyard site with good air and water drainage.

Muscadines tolerate marginally wet soils better than most fruit crops, but in these situations the vines are not as healthy and consequently not as long-lived. Improvements in soil drainage can be made through preplant bedding, tile drainage, or ditching. When bedding on wet sites, be sure to make the bed wide enough to contain a large volume of well drained soil. A bed at least four feet wide is suggested.

In many counties there are opportunities for pick-your-own operations. Other counties already have one or more existing operations and consideration should be given not to infringe on the market another farmer has developed. There are many other fruit crops which can be successful grown for the pick-your-own market such as blackberries, blueberries, strawberries, peaches, nectarines, and plums. Detailed information on these crops is available from your county Extension office.

6. CULTIVARS

Detailed information on cultivars appears in Table 4 in the back of the bulletin. Cultivar mistakes in fruit growing are common. With most fruits, planting the incorrect cultivar will result in reduced profits. If an incorrect muscadine cultivar is planted for the fresh market, the result could be disaster.

Currently the best fresh market cultivars are all female flowered types. However, a minimum of 1/8 to 1/4 of the vineyard must be planted to self-fertile types to pollinate the female flowered types. For pick-your-own situations, 'Cowart', 'Nesbitt', 'Tara', and 'Triumph' are good choices as pollinizers. For commercial shipping operations 'Granny Val' (South Ga. only), 'Tara', and 'Triumph' are good choices as saleable pollinators. However, 'Cowart' is one of the best pollinizers for 'Fry', so some commercial shippers continue to grow it despite fruit quality problems. (See the section on pollination for additional information). The use of several different pollinizers in a vineyard is recommended in case one pollinizer fails or dies.

Photo 6.1: 'Cowart' has excellent flavor, but poor shipping quality due to "leaks".
'Nesbitt' is similar to 'Cowart' but is prone to overcrop and have low fruit quality.

Photo 6.2 : 'Granny Val' has good yields and fruit size, but serious problems with leaf diseases and cane death on some sites. It has performed best in southwest Georgia.

Photo 6.3 : 'Tara' appears to be one of the best choices as a commercial shipping pollinizer, however, the flavor is inferior to 'Fry'

Photo 6.4 : 'Triumph' has performed well in North Florida, but fruit size has been marginally small for the commercial shipping market in Georgia. It should be a good choice for pick-your-own however.

The fresh fruit shipping muscadine market in Georgia demands an attractive, large fruited, bronze muscadine for the majority of sales. This is also the preferred type for the pick-your-own customer, but greater flexibility exists in this market. 'Fry' is the standard for the fresh market muscadine industry and continues to be widely planted despite its problems with variable yields, leaf diseases, and fruit rots. It's excellent flavor and ability to be harvested when it reaches the greenish-bronze stage are noteworthy. 'Fry' ripens over a period of four or five weeks. 'Summit' has been well received by pick-your-own customers and appears to be gaining acceptance in the shipping market. Growers interested in producing muscadines for pick-your-own and fresh market shipping should consider planting a significant portion of their acreage to 'Fry' and 'Summit'.

Yields of most large-fruited, bronze, female-flowered, muscadines are modest. Typically yields for cultivars like 'Fry' and 'Summit' are only three to four tons per acre. This is due in part to poor pollen transfer and a disorder called "cap stick" or dry calyptra where the petals do not fall off and pollination does not occur. Fruit rots and damage caused by the grape root borer can also reduce yields.

Photo 6.5: 'Fry' is the industry standard, but subject to low yields, fruit rots, and cold injury in some years.

Photo 6.6 : 'Summit' is gaining in popularity since it yield better than 'Fry' and has better leaf disease resistance.

Other bronze fruited cultivars that you may want to experiment with on a trial basis include 'Darlene', 'Early Fry', 'Pam', and 'Sweet Jenny'.

Photo 6.7 : 'Darlene' has excellent quality but has not been a consistent producer on many farms.

Photo 6.8 : 'Early Fry' ripens a week or more ahead of 'Fry' and should receive excellent prices on the market,however, information is limited at this time.

It is rumored that black-fruited muscadines are preferred in Louisiana and some sections of Florida, so the area you plan to market into should be surveyed before planting

the vineyard. In Georgia, at the time of this writing it is recommended that no more than 50% of a fresh market vineyard be planted to black or red fruited muscadine cultivars and these should have large fruit size. One of the most promising black fruited cultivars at this time is 'Supreme' due to its very large size and good flavor. Red fruited muscadines have never been widely planted, but the new cultivar 'Scarlett' has excellent appearance,but questionable productivity.

Photo 6.9: 'Black Fry' has excellent quality but is subject to cracking in wet weather

Photo 6.10: 'Supreme' has exceptional fruit size and has been well received in commercial markets.

Photo 6.11 : 'Scarlett' with its developer, Dr. Ron Lane.

Commercial demand for jelly and jam grapes is very low and fully supplied by existing growers to our knowledge. The muscadine wine grape prices have been very low for many years but have strengthened in recent years..

7. SELECTION AND CARE OF TRANSPLANTS

Be sure the plants you buy have been inspected and certified by the State Department of Agriculture.

Many nurseries sell one or two-year-old bareroot plants or container plants. The one-year-old plants have adequate roots for transplanting, but the two-year-olds are stronger and have a larger root system and top. To ensure that you get the plants you want, place your order as early as August. Most nurseries ship plants during January and February. However, they will honor a request for specific dates and shipping instructions.

Transplant survival depends largely on the care you give the plants when they arrive from the nursery (Figure 1). Take special care to ensure against loss of roots on bare root plants since a portion of the root system may be destroyed when the plants are dug at the nursery. Remove plants from the package as soon as they arrive from the nursery. Since you probably cannot transplant all of them immediately, heel them in, water, and remove them as needed. The root system must be kept moist at all times.

Container plants can be shipped to the farm and left outside during the winter. Water as needed to keep the container media moist. Place the containers close together with the lips touching and pile straw around the outside of the massed plants to reduce the chance of winter injury to the roots. If temperatures below 10 degrees F are expected, move the plants to a enclosed building where the temperature is above 20 degrees F.

Figure 1. These transplants have been heeled in to protect the root system from drying out.

8. VINEYARD ARRANGEMENT AND POLLINATION

Plants of recommended cultivars are either female or self-fertile (perfect flowered). The female cultivars must be interplanted with self-fertile flowering cultivars for pollination. If a majority of female flowered cultivars (such as 'Fry' or 'Summit') are going to be used in the vineyard, several arrangements should be considered: 1. A minimum of every fourth row self-fertile across the vineyard starting with the outside row, or 2. A minimum of every third plant self-fertile in every third row. Harvesting and marketing are most convenient if

you arrange your vineyard in single cultivar rows but currently few or no self-fertile cultivars have the proven marketability of 'Fry'. Recent research at the Georgia Experiment Station in Griffin has indicated that 'Cowart' and 'Carlos' are two of the best pollinizer cultivars to plant with 'Fry'. 'Southland', 'Magnolia', and 'Nesbitt' do not appear to be good pollinizer cultivars for 'Fry'. Always consult your county Extension agent to find out if new cultivars have been released since the printing of this publication. It is very likely the cultivar recommendations will be changing as new cultivars are introduced and our knowledge about existing cultivars increases.

Fruit set of female flowered cultivars can be a major problem in some years. Muscadine pollen is transferred by several species of tiny bees and perhaps also by wind. The most efficient pollinator is thought to be the small miner bee. Unfortunately these tiny bees do not appear to be found in large numbers. Do not spray insecticides during the bloom period if possible. As a consequence of low pollinator numbers, fruit set on female cultivars can be extremely low in some years (<10%). Self-fertile cultivars seldom have problem with fruit set since the pollen need only be transferred a fraction of an inch to reach the stigmatic surface on the female portion of the flower. A number of female cultivars have a problem know as dry calyptra or "cap stick". Muscadine flowers have petals which are fused at the top and pop off the flowers like a shower cap. There is currently no proven control for this problem, but operating an air blast sprayer in the vineyard with no water in the sprayer may be beneficial in removing some of the sticking caps.

Photo 8.1: Grape flowers can be self-fertile, female, or male.

Note to Renee and Mike, please remove the wording on this slide and replace with self-fertile, female, and male under the respective flowers.
Photo 8.2: Cap stick can be a serious problem on female flowered muscadines in some years. Sticking caps prevent pollination

9. ROW ORIENTATION AND LENGTH

North-south rows are the best in most fruit crops since it allows for both sides of the plant to receive direct sunlight. However, soil erosion considerations should receive first priority in Georgia. Consult with your irrigation dealer before deciding on a row length since there is a limit to how far drip lines can be run with standard size tubing (16 mm). Usually the drip lines are run for 200-300 feet in each direction down the rows, with the buried main line in the center of the vineyard perpendicular to the rows. Total row length is a maximum of 400-600 feet for the accommodation of the drip system and ease vineyard management.

10. SOIL PREPARATION

Land preparation should begin the year before planting. Prior to the application of the lime and fertilizer recommended from soil test results, perennial weeds and grasses should be killed. Weeds such as honeysuckle, brambles, johnsongrass, and bermudagrass are relatively easy to kill before the vineyard is planted, but more difficult and expensive to

kill after planting. Your county Extension agent can make helpful suggestions for using recommended herbicides.

After the troublesome weeds have been killed, fertilizers and lime recommended from soil tests should be incorporated in the soil. Raise the soil pH in the top eight inches to 6.5 before planting. Dolomitic limestone is preferred as a liming material because it contains magnesium–an element necessary in large amounts for maximum growth and production of grapes. Phosphorus should be tilled into the soil before planting if it is deficient. Phosphorus moves very slowly downward in most Georgia soils.

Once the lime and fertilizer applications have been made, prepare the soil as thoroughly as you would for planting seed. Harrow the field to incorporate the lime and fertilizer. Use a bottom plow to turn the soil eight inches deep. Harrow the field again. Subsoil as deeply as possible (usually 20-24 inches) down the row and across the row where each plant will be set. If the soil is extremely hard, subsoil the field every two or three feet in both directions. Do not subsoil when the soil is wet, this creates a glazed trench. Harrow the field again to smooth the soil and encourage limed top soil to fall into the soil trench. Recent research from Mississippi indicates a large augered planting hole (24 inches in diameter) results in the most rapid growth of young vines in heavy soil. In sandy soil, a through subsoiling provides good results. Preplant subsoiling should be conducted on all soils, even if an auger is used to make the planting hole, to enhance long term root growth.

11. VINEYARD PLANNING FOR POST AND PLANT SPACING

Set the posts or set the posts and finish the trellis before planting. It is much more difficult to set the posts after planting. Mark the rows and post holes again by running the subsoiler a few inches deep down the row and across the rows. String tied to the end posts can also be used to mark the location for rows and posts.

Set posts 20 feet apart in the rows and 10-12 feet between rows for the single wire trellis. Twenty feet apart in the row and 12 feet between rows is the standard plant and post spacing for the single wire trellis (182 vines per acre). This allows for a plant to be set next to each post, a definite advantage in supporting the fruit load and protecting the plant from damage in the case of mechanical harvest.

Photo 11.1: Plant near the post to help support the area of greatest weight.

Plants can be set as close as 12 feet in the row, and this increases early yields. However, most muscadine cultivars are vigorous and tangling of adjacent plants may be a problem when the vines are set close together. Twelve feet between rows allows for a full size pick-up truck to be driven in the aisles of a mature muscadine vineyard.

For the Geneva Double Curtain, set the posts 20 feet apart in the row and 12-14 feet apart between rows. Set the plants 14-20 feet in the row. The distance between the two cordon (arms) in the Geneva Double Curtain is four feet, so use 14 feet between rows if you plan to drive large equipment down the aisles. To determine the number of posts or plants per acre, multiply the post or plant spacing and divide this into 43,560 (i.e. 14 feet x 14 feet = 196 square feet, 43,560 square feet per acre ÷196 square feet per vine = 222 vine per acre). Following planting, train the vine as outlined in the "Training the Vine"

section of this bulletin. If it is possible that mechanical pruning and/or harvesting may become a part of the vineyard operation, it is extremely important to set the plants near the line posts. In later years, the trellis posts will help protect the trunk from machinery. Muscadines produce their greatest concentration of fruit near the trunk so this is another reason for setting the vines close to the trellis posts. An exception to this rule is if hand harvest with catch frames is planned. In this case it is best to plant the vines between the posts.

Spacing plants as recommended provides good air movement, adequate sunlight, and enough room for the plants to grow. It also provides room for equipment to move freely between the rows. Allow 20 to 30 feet at the end of rows for turn-around space.

12. SELECTION OF POSTS

Posts treated with copper chromium arsenate (CCA) have become the standard of the industry in recent years. They last longer than creosote treated posts. If the posts are treated with creosote or pentachlorophenol, plant the vines at least one foot from the posts. Also, direct the root system away from the post. Be sure the roots are well covered with good topsoil. Posts treated with copper chromium arsenate (CCA) preservatives do not appear to be toxic to muscadine vines so plants may be set as close as six inches from the post. Wood preservative treated posts should be weathered prior to erecting the trellis, so that excessive surface preservative is washed off.

12.1: CCA treated posts are giving good results and have not been toxic to the soil or plants.

Plastic posts are also available but are probably too flexible for muscadine trellises Improvised posts such as old but sound railroad ties, "fat lighter" posts, telephone pole sections, reinforced concrete posts, locust posts, and metal posts made from worn-out road scraper blades can also be used. Road scraper blades may need an additional cross piece welded on the bottom to give them greater stability.

12.2: Geneva double curtain trellis system made from old road scraper blades.

Steel T type posts driven two feet in the ground can be used as an alternative type post. However, they are more likely to fail than wooden posts under extreme weather conditions or crop load.

13. SETTING THE PLANTS

To ensure the greatest success and highest rate of survival, plant muscadines during December, January and February as soon after you receive them as possible. Set bare root plants about three inches deeper than the top roots. Spread the roots out. Set container plants about one inch deeper than they grew in the nursery. If the container plants are pot bound (roots coiled around the pot), use your fingers to untwine some of the roots and spread these roots out in the planting hole. Backfill the hole with top soil and firm with your feet. Water the plants if rain is not received a few days after transplanting.

Do not place fertilizer in the hole prior to planting, and do not make a ground application immediately following planting. Allow the ground to be settled by a drenching

rain or irrigation before fertilizing the plants after bud break in the spring. Follow the recommendations in the "Fertilization" section of this bulletin.

14. TRELLISES

Muscadine single wire trellises normally have the wire 5 feet about the ground. The 5 foot trellis has been the most popular with Georgia growers since it allows for better air circulation that shorter trellises..

Trellis construction is the most expensive step in establishing a muscadine grape vineyard. Since the trellis is relatively permanent, it should be strong enough to support a heavy crop and made of durable materials that will last for many years. **All wood products used in the vineyard should be pressure treated with wood preservatives (or of a specially durable wood type you know will last in your area).**

In sizeable plantings where mechanical harvesters and pruners will be used, the one-wire trellis is recommended. Most experienced growers prefer the one wire trellis because of ease of establishment, pruning, harvesting, and renovation.

Since row widths are such that vineyard machinery can move only in one direction at a time, without room to turn around, extremely long rows should be avoided. If the vineyard site is best suited to long rows, break the rows into sections 400 to 600 feet long, leaving a gap 30 feet wide for convenience of movement through the vineyard. A span of 600 feet is also the maximum safe stress load for No.9 wire.

***One-Wire Trellis*:** End posts should be at least 5 inches in diameter and 8 feet long. Set the end posts 3 feet in the ground so the trellis wire will be 5 feet high. End posts holes can be dug with an auger or post hole. End posts can also be set with a post driver. Several different bracing systems can be used.

"H" bracing (Figure 3) involves setting a 4 to 5 inch post 8 feet long, 3 feet deep, and 6 feet from the outside brace post. Then position a 4 inch x 4 inch pressure treated timber or 4 inch post between the tops of the two posts (hortizonal beam). Run a double 9 gauge wire from the top of the inside post to the bottom of the outside post. Twist the wire with a "twitch stick" to tighten and secure the brace system. It is very important that the top horizontal beam be longer than the vertical post for this system to work properly and not "fold up".

Photo 14.1: The One-Wire Trellis System for growing muscadines. A missing vine allows the "H" bracing to be viewed.

Photo 14.2: Poorly constructed "H" bracing. The wood is not durable enough and horizontal beam is too short.

Deadman bracing (Figure 4) involves setting the end post angled slightly away from the vineyard. Two strands of 9 gauge wire are run from the top of the post to a "deadman" buried four feet from the base of the post and four feet deep. A number of different materials have been used successfully for the deadman. Screw-in mobile home anchors, metal plates welded to steel shanks, concrete dead-men attached to a steel shank, sections of old railroad ties, sections of old posts buried horizontally, and sections of old pipe have all been used successfully.

Figure 4. The deadman anchoring system. Note how the end post is sloped back slightly.

Wooden line posts, 3 to 4 inches in diameter and 7 feet long, should be set so that the wire will be 5 feet high. Usually the line posts are set 2 feet deep. However, growers on "tight" soil sometimes set 6.5 foot posts 1.5 feet deep with good results. Spacing on the line posts is typically 20 feet. Line posts holes can be dug with an auger or post hole digger. If a good job subsoiling is done, the soil will be very soft in the row and easily excavated with a post hole digger.

Wire. Use number 9 galvanized wire or 12.5 gauge high-tensile fence wire. High-tensile strength wire is more difficult to handle than than number 9 wire. Start by wrapping the wire around the upper part of the end post, then stapling it to the side of the end post. Bring the wire up and put another staple in it on the side of the post., before going over the top of the end post. Staple the wire to the top of the post with 2 ½ inch "pole barn" staple. Leave the top staple loose enough so that the wire is not held rigidly. If the wire is bound too tightly by the staple, it may break when tightened. At the other end of the trellis, staple the wire loosely to the top of the end post. Tighten the wire with a fence stainer or claw hammer, then hammer the end staple down just enough to hold the wire from slipping. Put a second staple in the side of the post just below the top. Wrap the wire around the post several times and use a staple driven into the side of the post to hold the wire wrappings. (Fig.5). Periodic tightening after pruning is needed as the wire stretches over the years. Fence stainers, available from livestock supply houses, can also be used at one end of the trellis for easy tightening. They have a rachet-type gear which tightens the wire.

Figure 5. A method of securing the end wire which is low cost and easy to accomplish.

Easy, low cost construction, pruning, and harvesting are the main advantages of the one-wire trellis. The major disadvantage is lower yields. The one-wire trellis yield is about two-thirds the Geneva Double Curtain yield. Despite the lower yields, most experienced muscadine growers prefer the single wire trellis.

Figure 6 . A young vineyard being trained to the Geneva Double Curtain Trellis System.

***Geneva Double Curtain Trellis*:** The Geneva Double Curtain (GC) trellis (Figure 6) developed in New York to train vigorous grapevines, has proven to be a high yielding trellis system. It is especially suited to mechanical harvesting and capitalizes on the vigor of muscadines by providing 28-40 feet of fruiting arm per vine.

Figure 7 . Details for constructing the Geneva Double Curtain Trellis.

The line posts, which are typically 3 to 4 inches in diameter and 8 feet long, are placed 2 1/2 feet in the ground and 20 feet apart (Figure 7). The end brace post is 8 feet long with a minimum diameter of 5 inches. It is placed 4 feet in the ground and angled back slightly away from the row. A 6 1/2 foot post is used as an inside brace

post. Place it 2 1/2 feet in the ground, 6 feet from the outside brace post and position a 4" x 4" timber between the top of the two posts as a brace. Run a double 9 gauge wire from the top of the inside brace post to the bottom of the outside brace post, and twist it to tighten the entire brace system.

The cross arms (supports) are rough sawn, pressure treated, No. 2 grade 2 x 4's or equivalent. The supports are 29 inches long and are pre-drilled two inches from the end to accommodate a 3/8 x 8 inch galvanized bolt. An additional hole is pre-drilled from the other end of the support parallel to the ground to allow the 9 or 11 gauge brace wire to pass through. After passing the loop end of the double wire through the support, place a 3/4 inch washer over the loop and attach a chain repair link to the loop (Figures 8). The line wires run through these chain repair links. The brace wires are now fastened around the top of the post so the supports form a "Y." Both should have approximate 35^{o} angles with the ground and should measure 4 feet from tip to tip. Use nine gauge wire or 12.5 gage high-tensile strength fence wire for the main wires. Both of these main wires are fastened to the top of the outside brace post, then threaded through a 45 inch spreader and 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 tightened around the top of the outside brace post. The trellis wire will be 5 feet 9 inches above the ground using 8 foot line posts.

Pre-fabricated metal cross arms are also available (Figure 10). Although material costs for these cross arms are high, installation costs are reduced using pre-fabricated support. The pre-fabricated metal arms do not need a cross support brace wire between the metal arms, so set seven or eight foot line posts three feet in the ground. The wire should be 5 ½ feet off the ground for good air circulation.

Figure 8. Details of the Geneva Double Curtain Trellis System
Figure 9. A Geneva Double Curtain post using 2 x 4 support arms.
Figure 10. Pre-manufactured Geneva Double Curtain Trellis support arms in the vineyard.

15. TRAINING THE VINES TO THE TRELLIS

Training vines to the trellis is an important part of muscadine production and requires considerable skill and patience. There are four potential systems you may wish to consider. 1. Multiple trunk, trained to a single wire. 2. Multiple trunk, trained to a double wire (Geneva Double Curtain). 3. Single trunk, trained to a single wire. 4. Single trunk, trained to a double wire (Geneva Double Curtain).

16. MULTIPLE TRUNK TRAINING METHOD

If the quality of the nursery plants you received is **very** high, with a large root system and top, you may leave as many long canes (stems) as you need cordons (permanent arms). This is only recommended on fresh market muscadines where mechanical harvesting will never be employed. Multiple trunks make mechanical

harvesting less efficient. The multiple trunks should be kept separate so they will not constrict each other as they increase in diameter. Cut off all unneeded shoots. Provide support for each shoot with a string or long stake as described in the next section. Only let the top bud on each shoot grow and keep side shoots below the wire pinched short. Once the shoot reaches the wire wrap it loosely on the wire as it grows. Pinch the tips of side shoots ten inches from the cordon to encourage the main shoot to keep growing down the wire.

17. SINGLE TRUNK TRAINING METHOD

Although training varies with the type of trellis you use, the first step is the same for both trellis systems. After planting, prune the vines to a single cane. If the plants have a modest root system cut the cane back so only two to four buds are left, then follow the steps for the type of trellis you are using. If the root system is very good, a single long cane can be left to form the trunk. Only let the top bud on the long cane grow. Pinch off any side shoots, but leave the first leaf of the side shoot to help nourish the vine.

One-Wire Trellis: Tie a piece of durable string such as binder's twine to a stake driven beside the plant. Then tie the twine to the overhead wire using a “Y” shape or a “U” shaped piece of wire attached to the trellis. The Y or U shape at the top is to guide the two cordons on to the wire. It should be taut enough so that as the new shoot grows, it can be twined around the string to form a straight trunk for the plant. Vines planted near the post can be trained to a string tied to the head of a long nail and the trellis wire. The nail is driven into the post about 1" deep near ground level. Long tomato or bamboo stakes can also be used and the vine fastened to the stake with cloth or plastic tying ribbon which can be purchased from horticulture suppliers. An economical hand operated machine called a “Max Tapener” is available which dispenses the plastic ribbon, cuts and staples it together in one motion.

Photo 17. 1: Using a “Max Tapener” to attach muscadine cordons.

Each plant will produce three or four shoots when growth begins in the spring. When the strongest shoot is about six inches long, train it to the string. Remove all other shoots. As the shoot grows, periodically wrap the new growth around the twine. While you are training the main shoot, pinch off side shoots of the young trunk . Do not, however, remove the leaves from the trunk. These will help nourish the vine. Removal of side shoots must be done frequently during the first two growing seasons. Be sure your laborers understand the growing point should not be prematurely pinched.

When the young trunk in near the trellis wire, pinch it off about six inches below the trellis wire except in the multiple trunk training method. Allow the top two buds to develop into the cordons (permanent arms) of the vine.

Photo 17.2: Forming two cordons on the single wire trellis. Note how in this case the grower used a “U” shaped piece of wire with a string attached.

After the plant has attached itself to the trellis wire loosely wrap and tie the cordon on as needed. Loose wrapping will help the cordon hold on the wire better than if supported by tendrils alone. To encourage the cordon to grown down the wire, it is important that developing side shoots be pinched off at when they are 8-10 inches in length. Permanent arms of adjacent plants should be tip to tip and not allowed to overlap after the winter pruning.

Photo 17. 3: Tipping side shoots on young vines at 10 inches to encourage the vine to grow down the cordon wire.

Geneva Double Curtain Trellis: The training system used for muscadines on the GDC trellis differs somewhat from the original GDC training system. The original system involves training a vine to two long arms; both on the same wire with succeeding plants down the row on alternate wires. The modified GDC training system for muscadines is such that each vine has four short arms (cordons); two on each wire.

To train muscadines, drive a four inch nail one inch into the line post two feet below where the cross arms are affixed to the post. Then tie nylon or new binder's twine to a stake driven beside the new plant or a nail near ground level.

Each plant will produce three or four shoots when growth begins in the spring. When the strongest shoot is about six inches long, train it to the string. Remove all other shoots. As the shoot grows, periodically wrap the new growth around the twine. At the same time you are training new growth, pinch shoots developing in the axils of the leaves of the young trunk. Do not, however, remove the leaves from the trunk.

When the young trunk is two feet from the trellis wire, pinch out the terminal. Then tie twine from each trellis wire to the nail. Allow two shoots to develop at the top of the trunk and train one to each of the strings. When the two shoots reach the trellis wires, pinch their terminals just below the wires. Then allow the top two buds on each shoot to develop into the permanent cordons (arms) of the vine. Once the cordons become attached to the trellis wires, remove all twine to avoid girdling. To encourage the shoot to grow down the wire, it is important that developing side shoots be pinched off at 8-10 inches. Periodically, tie and loosely wrap the young cordons to the trellis wire as they grow. Loosely tying and wrapping is preferred to allow for annual trellis maintenance and wire tightening without pulling the vines out of their position. When each of the four shoots fill their area, pinch out the terminals. This training will result in individual vines with 28-40 feet of bearing arms depending upon plant spacing in the row. Cordons of adjacent plants should be tip to tip.

18. DORMANT PRUNING OF CORDONS THE FIRST TIME (INITIAL LONG CANE PRUNING SYSTEM)

In order to move the fruiting area of the vine slightly away from the cordon it is desirable to make the first dormant pruning cuts on the side shoots coming off the cordons (arms) at ten inches on the single wire trellis and six inches on the Geneva Double Curtain System. This will allow the cluster of grapes to be far enough away from

the cordon for easy harvest of the grapes and improve air circulation. Shoots coming off the cordon at about a 45 degree angle are the ones preferred for forming the spur system. Shoots coming straight up or straight down should be removed if not needed. In subsequent years, the previous season's growth should be cut back to two to four buds to keep the canopy from becoming too wide.

Figure 11. Pruning the arms at 10 inches from the cordon the first winter they are formed is recommended for the single wire trellis system. This widens the canopy and moves the fruit clusters away from the cordon for easier picking. In future years, prune the current season's growth back to 2-4 buds, however.

19. PRUNING YOUNG BEARING AND MATURE VINES

Annual pruning of muscadines is a must if the vineyard is to be kept at its optimum production level. Unpruned vineyards may bear alternately, are nearly impossible to harvest, and are also more vulnerable to pest attacks because of reduced spray coverage and poor air movement within the canopy.

Before pruning, you should understand the bearing habit of muscadines. The fruit are borne in clusters on new growth (Figure 8). This new growth arises from buds on the previous season's growth. Therefore, a portion of the previous season's growth must be left if a crop is to be realized.

Figure 12. Muscadine flowers are borne on new shoots which arise from buds coming out of last year's growth. The mature shoots that carry the buds for next season's crop are referred to as canes. Canes that are shortened by pruning to 3-4 buds are called spurs.

The basic muscadine plant consists of a trunk and cordons (arms on the wire). On the cordons, fruiting units called spurs are developed (Figure 13). During the dormant season, cut back all shoot growth of the previous summer to spurs with two to four buds (about two to four inches long in most cases). An average of three buds per spur is desirable. Entirely remove canes that are not needed for spurs. If practical remove old fruit stems as they are a source of the ripe rot fungal spores.

On young and fairly young vines, spurs should be spaced four to six inches apart on the cordons. As the vine gets older, each spur becomes a spur cluster. It may become necessary to thin the spur clusters in as few as three years. This thinning may be done by entirely removing every third or fourth spur cluster, or a part of all of the spur clusters.

Photo 12.1: Thinning spurs to about four to six inches apart on young bearing vines

If spur clusters are removed, over a period of years the remaining spur clusters can gradually be thinned to about 12 inches apart. Experience has shown that gradual thinning each year after the third bearing season may be preferable to waiting four or five year before spurs are thinned. The first spur thinning should be on spurs which are

pointed downward and under the cordon. These are the spurs in the poorest position to produce high quality fruit.

All wood arising from the trunk should be removed. This helps maintain vigor at the end of the cordons.

Figure 13. Spur system on a four-year-old muscadine vine.

When pruning, it is important to inspect the cordons. If a cordon becomes weak or diseased, remove part or all of it as needed and train a shoot to take its place. Always be on the lookout for tendrils that have wrapped around the cordons. Unless they are removed, they may eventually girdle the cordon.

Photo 13.1: Cordon where a girdling tendril was removed.

Growers should delay pruning as late as possible in the winter. **Do not** prune the vines from late November through mid-January if possible. Pruning done at this time has resulted in considerable winter injury and vine death. Although late pruning results in heavy bleeding, there is little evidence that bleeding is harmful. Growers who have more vines than can be pruned between mid-January and early March should start earlier and prune their least desirable or most cold hardy cultivars first.

Mechanical pruning with a sickle bar type cutter is recommended for growers who have enough acreage to justify the cost of equipment. Research has been conducted in North Carolina to determine the best pruning configuration for processing muscadine cultivars. In this study the best mechanical pruning configuration (looking down the cordon) was an eight inch by eight inch square with the cordon in the center. If the long cane pruning system is used the first year (initial long cane pruning system), be careful not to mechanically prune back into wood two or three years old. This wood will not produce grapes. Touch up hand pruning is still needed for thinning overcrowded spurs, removing tendrils stangling the cordon, etc.

Mechanical pruning with gasoline powered hedgers or commercial type electric powered hedgers run with a generator in the back of a pickup truck are used by many growers. This is much more rapid than hand pruning, although additional touch up hand pruning is usually needed. Some growers have been able to use the commercial type electric powered hedgers for both the bulk and the detailed pruning.

Photo 13.2: To secure old cordons to the trellis, several types of commercial grape “ties” are available. Note that only one, not two cordon should be attached to the wire.

20. PRUNING NEGLECTED VINES

In neglected vineyards where pruning has not been done for several years, several strategies can be employed. One is to completely remove the old cordons except for a six inch renewal spur at the head of each cordon. Allow new shoots to grow down the wire to form the new cordon. Pinch them when they reach the desired length.

The second option is to cut the growth on one side of the vine (left side) back to two to four buds of the previous season's growth. On the other side of the vine (right

side) cut off all the lateral growth leaving just a naked cordon. This will allow the left side of the vine to produce fruit. The second season, bring the right side of the vine into production and cut the left side back to a naked cordon. In the third season the vine is completely rejuvenated and back to near full production.

21. FERTILIZATION

Fertilization should be based on a soil test. However, if a soil test is not available follow these general recommendations. For the first growing season apply two ounces of premium grade 10-10-10 fertilizer or its equivalent per vine starting after growth begins in the spring and repeated at four to six week intervals if at least four inches of rain or overhead irrigation have been received since the last fertilization. Apply the fertilizer fairly evenly in a circle 2.5 feet in diameter with the vine in the center. This is equivalent to about 1000 pounds per acre if the fertilizer was broadcast. Be careful to avoid placing too much fertilizer within six inches of the trunk so as to not burn the young roots. The total number of fertilizer applications for the year will probably be four to five in south Georgia and three to four in north Georgia. Do not fertilize the vines after late August in south Georgia and late July in North Georgia. Slow release nursery fertilizers also give good results with fewer fertilizer applications. Follow the manufacturers directions on the bag.

During the second year timing and method of applications should be similar to the year before. However, the rate should be doubled to four ounces of premium grade 10-10-10 or its equivalent and the diameter of the broadcast circle should be increased to 3.5 to four feet. This is equivalent to about 1000 pounds per acre if the fertilizer was broadcast.

In the third growing season, if the vines have grown off well, apply two pounds of premium grade 10-10-10 fertilizer or its equivalent per vine in March, plus one pound of 10-10-10 fertilizer per vine in May. Evenly spread these applications along the row in a four feet wide band.

To fertilize an established vineyard take a soil sample and follow the recommendations. Muscadines usually need about 50-60 pounds of nitrogen per acre (0.3 pounds on nitrogen per vine at 181 vines per acre) applied near bud break followed by about 30-40 pounds of nitrogen after fruit set (0.17 pounds of nitrogen per vine at 181 vines per acre). Phosphorus and potassium should be applied according to the soil test. If a soil test is not available apply 3 to 4 pounds of premium grade 10-10-10 fertilizer or its equivalent per plant near bud break. Spread the 10-10-10 fertilizer evenly in a band five to six feet wide centered on the plant row. After fruit set (June in South Georgia-July in North Georgia) apply ½ pound of ammonium nitrate fertilizer per plant or its equivalent. Spread the ammonium nitrate evenly under the canopy On heavy or rich soils, only a single application of fertilizer in the Spring may be needed. The desired

amount of vegetative growth per year is about three feet. If growth exceeds four feet, reducing the amount of nitrogen applied in future years may be advisable.

Fertigation (injection of fertilizer into the drip irrigation system) can be used with excellent results by the astute grower. It may be possible to bring the vines into full production one year earlier with fertigation. If you are interested in fertigation, contact your Extension engineers and horticulturist via your local county Extension office.

Soil pH should be checked every two to three years to determine if lime is needed. If lime is necessary, it is important to use the dolomitic form since grapes have a high requirement for magnesium.

Magnesium deficiency, which shows up later in the season, is of concern to muscadine producers since in severe cases the fruit may shatter prematurely. Symptoms are a yellowing between the veins of older leaves. The yellowing progresses up the shoots as the leaves grow older.

Photo: 21.1 Magnesium deficiency of muscadine showing yellowing between the veins.

If magnesium deficiency is evident and the soil pH is too high to add dolomitic lime, use a soluble form of soil applied magnesium. Magnesium sulfate (Epsom salt) at 100 pounds per acre or sul-po-mag at 200 pounds per acre are two materials often used on mature vines. Young vines can be treated with about two ounces of soil applied magnesium sulfate per vine to correct magnesium deficiency.

Occasionally, it is necessary to apply boron in some vineyards to realize maximum yields, since boron deficiency can cause poor fruit set. If a boron shortage is confirmed by a leaf analysis test, apply five pounds of borax (10% boron) per acre to the soil surface or spray the vines with one pound of Solubor (20% boron) per acre just before bloom. Do not exceed boron recommendations. Excessive boron will injure or kill the plants.

22. IRRIGATION OF MUSCADINES

Irrigation of muscadines is very important in the survival of newly transplanted vines in dry years, rapid growth of young vines, fruit sizing during dry years, and reduction in alternate bearing. Information on muscadines irrigation is very limited, but estimates of muscadine irrigation rates can be made.

Most muscadine growers prefer to use drip irrigation, since the initial cost of installation is lower than overhead and the vines can be irrigated without wetting the foliage and fruit. Consult your local county Extension office and irrigation supplier to obtain information on how to install a drip irrigation system. The drip irrigation tubing can be run on the soil surface or suspended on a wire about 12 inches off the ground. Anchoring the tubing around the posts at the ends of the row is recommended to prevent expansion and contraction of the drip tubing during cold and hot weather. Suspending the irrigation tubing on a wire reduces the chance of rodents chewing on the tubing and also allows the grower to easily monitor the rate of dripping from the emitters. Emitters which have clogged up or partial clogged up can be easily located.

Growers should test emitters for output when they are initially installed and at least once per year thereafter. **Do not** rely solely on manufacturer specifications for output calculations. Emitter quality and durability varies greatly. All emitters do not have to be tested, but a random sampling of a few emitters should be tested. Testing output is as simple as catching water from emitters for a specified amount of time, and then calculating the volume of output. When running a test, make sure the irrigation line is fully charged (let it operate for 10 to 15 minutes) before you begin to catch water. These simple tests can provide you with great confidence as you calculate water usage on a per acre basis.

Most growers initially install one, 1 gallon drip emitter per plant, in the center of the row about two to three feet from the trunk of the vine. During the first year, attach "spaghetti" tubing to each emitter to route the water to the planting hole. After the first year the spaghetti tubing can be removed. When the vines are three years old, a second drip emitter should be installed on the opposite side of the vine trunk. Drip irrigation systems should be operated regularly (even daily) during dry weather to replace water lost by evaporation and plant use. Drip irrigation only wets a small area of soil, and you cannot expect to store large quantities (i.e., 3 or 4 days supply) of water in the soil using drip irrigation. Recent research at the Georgia Station has shown that 6 to 8 gallons of water per vine per day gives maximum yield response to single trellised vines more than four years old. At a planting density of 181 plants per acre (a common plant density), this would require a total water supply (well capacity) of 1500 gallons per acre per day on mature vines during hot weather.

Table 3 - Muscadine Irrigation with a Drip System

Estimated gallons/water/day/acre during dry soil conditions

Weather Conditions	Pan Evaporation (in/day)	Vine Age 1	2	3	4+
Mild	.1	125	250	375	500
Warm	.2	250	500	750	1000
Hot	.3	375	750	1125	1500

A general rule of thumb for irrigation capacity of your well would be about 1 acre of muscadines per day for each gallon per minute output of the well. Thus, a well with a 10 gallon per minute output (600 gallons per hour; 14,400 gallons per 24 hr period) could irrigate about 10 acres of muscadines over a 24 hr period with irrigation zoning during peak water demand periods. The system should be operated daily unless 0.25 inches of rain falls. In general, you can keep your system off 1 day for each 0.25 inches of rain received, up to about 2 inches of rain total.

Sprinkler irrigation is sometimes used on muscadines. Its usage is less desirable as it can lead to prolonged periods of wetted foliage, which can promote disease

problems. Also, the efficiency of water usage is much less for overhead sprinklers since a significant fraction of the water is lost to the atmosphere by evaporation during application. If sprinkler irrigation is used, expect to apply 1 to 2 inches of water per week during the heat of the summer. It would be best to split applications of water (apply 0.75 to 1 inches twice a week) in order to utilize rainfall more efficiently. Pan evaporation estimates given on television weather reports or in newspapers can be used to guide irrigation application amounts. For example, during the heat of the summer, pan evaporation amounts of 0.3 inches per day are common. If the plant utilization rate is 75% of pan evaporation, or 0.22 inches per day, then, without rainfall, 1 inch of sprinkler irrigation would need to be applied every 5 days under hot conditions. Tensiometers or resistance blocks may be used to measure soil moisture and help determine when to irrigate.

After harvest, greatly reduce the amount of irrigation water applied from drip or sprinkler systems. Apply only enough water to keep vines healthy and maintain the foliage. For drip irrigation, this could mean running the system every third day. For overhead irrigation, apply a maximum of 1 inch of water per week. In October, discontinue irrigation in order to allow the vines to harden off in preparation for winter.

Photo 22.1: Drip irrigation emitter which puts out one gallon per hour.

Photo 22. 2: Drip system suspended on a lower wire. This makes maintenance and observation of the system much easier.

Photo 22.3: Suspended microsprinkler system in kiwi vineyard. This is a hybrid between drip and overhead sprinklers. It can be run less often than drip, because a larger volume of soil is wetted.

Photo 22.4: Overhead irrigation is excellent with regard to supplying water to the vineyard, but has the disadvantage of washing off pesticides.

23. SOIL AND LEAF ANALYSIS FOR MUSCADINES

Monitor the nutritional status of vineyards by soil and leaf tissue samples. Soil samples are ideally taken in late summer or fall since the soil pH is lowest at this time. Leaf samples should be taken in June and early July. Each sample should be a single cultivar of vines of approximately the same age and vigor. Collect a double fist full of mature leaves located opposite fruit clusters on fruiting shoots. Place in a paper bag and take these to your county Extension office for shipment to the lab in Athens. Several private labs also operate in the state. There is a fee for leaf analysis samples.

Table 4. Diagnostic levels based on whole-leaf nutrient concentrations for muscadine grapevines sampled in mid-or late summer (Mills and Jones, 1996).

Element (unit)	Deficient	Sufficient	Excessive
N(%)	1.65	1.65-2.15	>2.15
P(%)	0.12	0.12-0.18	>0.18

K(%)	0.80	0.80-1.20	>1.20
Ca(%)	0.70	0.70-1.10	>1.10
Mg(%)	0.15	0.15-0.25	>0.25
B(ppm)	<15	15-25	>25
Cu(ppm)	<5	5-10	>10
Fe(ppm)	<60	60-120	>120
Mn(ppm)	<60	60-150	>150
Mo(ppm)	<0.14	0.15-0.35	>0.35
Zn(ppm)	<18	18-35	>35

24. RECOMMENDATIONS FOR ORGANIC METHOD GROWERS

Muscadines can be grown by the organic method in Georgia assuming you do not have a serious problem with grape root borers and you select the most disease resistant cultivars. Even so, losses from fruit rots may be high in some years when heavy rainfall occurs in late summer during the ripening season. Research has been conducted by the USDA in Georgia in an attempt to find synthetic fabric mulch barriers for the control of graperoot borers. Contact your county Extension office, they can obtain the latest information for you on this subject.

To fertilize muscadines using the organic method you first need to determine the deficiencies in your soil via a soil test. Then determine the nutrient content of the organic fertilizer source you have available such as dried cow manure. This can be done via your county Extension office. Using your soil test report and information on the amount of nitrogen needed from the fertilizer section in this bulletin, the amount of organic fertilizer needed can easily be calculated. For instance, mature muscadine vines need about four pounds of 10-10-10 fertilizer as an estimate for their spring fertilization. This is 0.4 pounds of actual nitrogen. Dried cow manure often contains about 2% nitrogen (test the content of your manure source, manures vary greatly in their fertilizer content). Therefore, you need about 20 pounds of 2% nitrogen cow manure spread evenly under the vines to provide .4 pounds of nitrogen. If you are going to grow organic muscadines, make sure the post type you use is approved for organic growing.

25. POSSIBLE STRATEGIES FOR OVER PRODUCING CULTIVARS

Some cultivars of muscadines such as ‘Delight’, ‘Granny Val’, ‘Janebell’, and ‘Pineapple’ often set more fruit than they can properly mature. No research has been conducted on this problem, but growers may wish to experiment with several possible techniques to reduce the problem. Heavier pruning, by cutting off all the current season’s growth except for one bud per spur, should result in better leaf to fruit ratios. Increased spur thinning, by thinning the spur clusters to 14-15 inches apart on the cordons of old mature vines should have a similar effect. Growers may also wish to experiment with clipping off some of the fruit clusters after fruit set to improve the leaf to fruit ratio. Leave no more than two fruit clusters per fruiting cane. Additional fertilizer may also be beneficial in cases where additional leaf growth is needed, but try this on an experimental basis.

Photo 25.1: Cultivar with poor leaf to fruit ratio. The sugar content of the grapes will be low.

26. COLD PROTECTION AND RECOVERY STRATEGIES

Muscadines are frequently damaged when temperatures at or below 0^{o}F occur. The following are suggestions which may help to lessen or eliminate cold injury and speed the recovery of the vines.

1. Do not plant cold tender cultivars in north Georgia and avoid them in middle Georgia if possible. Do not plant cold tender cultivars on marginal sites (too wet, poor soil, very low elevation, etc.) anywhere in the state.
2. Prune cold tender cultivars late in the winter.
3. Do not overcrop cold tender cultivars. Do not allow any cultivar to carry significant amounts of immature fruit into the winter. This can be a death sentence. Apparently, the immature fruit continues to "sap" the vine even into the winter.
4. Keep the vines healthy by control of the grape root borer and retention of the leaves with fungicides, proper weed control and proper fertilization.
5. Do not wrap vines excessively on the wire while training. The cold metal wire is a good conductor of warmth away from the vine. (This statement is a supposition; not a proven fact.)
6. Cold damaged vines frequently will lose one arm or a section of an arm. If pruning has not been conducted prior to the cold injury, a long, vigorous "bull" cane can be placed on the trellis wire after cutting off the damaged arm.

Vines killed to the ground will often resprout. Use milk cartons or some type of physical protection around the vines after the new shoots emerge to prevent contact with herbicides.

Photo 26.1: Cold injury to a cordon. A new strong cane can be used to replace the dead cordon.

27. WEED CONTROL AND COVER CROPS

Muscadines have a shallow root system and do not tolerate weeds well. A weed free strip four feet wide should be maintained under the vines. As the vines age increase the width of the strip to the edge of the wheel tracks on your equipment.

Use herbicides or mulches to keep the strip along the rows free of weeds and grasses (Figure 14). Crimson clover or subterrean clover can be planted in the fall and allowed to reseed before mowing the aisles. The clover should be killed out under the vines before muscadine bud break. Several weed control chemicals cleared for use on grapes do an excellent job. They can be applied with tractor-mounted or hand-operated equipment.

See your county Extension agent for specific weed control recommendations. The Georgia Farm Chemical Handbook is revised every year to include the latest information on grape weed control. Be sure to keep a current copy on hand. A typical program for grape weed control involves an application of glyphosate plus preemerge herbicide applied before bud break in the spring (before March 15th), followed by several applications of a “burn down” type herbicide during the summer. In the fall, before Oct. 15th, a burn down herbicide is mixed with a preemerge and applied to control winter weeds. Types of preemerge herbicides used are rotated to prevent crop injury.

Figure 14. A good herbicide program is a key in good vineyard management. Photo 27.1: Good weed control in a mature vineyard. Note how the herbicide band extends to the edge of the wheel track.

28. MUSCADINE GRAPE DISEASES

For many years, muscadine grapes were considered more disease resistant than bunch grapes. Many muscadine grape growers did not regard special disease control efforts as necessary. Recently, however, yields of some muscadine grape cultivars have been greatly reduced by diseases. These disease outbreaks are probably due in part to the intensified planting of muscadine grapes and the introduction of new cultivars which are often less disease resistant than the native muscadine grape. Several species of fungi attack muscadine grapes causing leaf spots and fruit rots. The most common diseases found on muscadine grapes in Georgia are black rot, bitter rot, ripe rot, Macrophoma rot, powdery mildew and angular leafspot.

Black Rot

Black rot, caused by the fungus Guignardia bidwellii, is the most destructive disease of bunch grapes in Georgia. It may be developing into a problem on some muscadine grape cultivars. The black rot fungus overwinters on infected canes and leaves. In the early spring, the fungus infects new growth as soon as it appears. The disease continues to spread throughout the vine attacking the rapidly growing immature plant parts including fruit, tendrils, leaves and canes. Fruit infection can occur at any time before maturity, but most infection is thought to occur before the fruit is half grown.

The signs of fruit infection are dry, black, scabby spots (Figure 15). On very susceptible cultivars, these spots may become large and crack open. Black rot does not cause a decay of mature berries, but infection of immature berries may cause mummification and drop.

Leaf infections (Figure 16) appear as tiny, reddish-brown spots on the upper surface. The spots enlarge to one-fourth inch or more in diameter and turn dark brown. A ring of black fungus spore producing structures develops near the edge of the brown area.

Figure 15 . Black rot causes a dark scab-like spot on the fruit of muscadine grapes.

Figure 16. Black rot on muscadine grape leaves.

Bitter Rot

Bitter rot, caused by the fungus Greeneria uvicola is common in most muscadine vineyards. It overwinters on stem lesions and mummified berries. This disease primarily damages fruit. However, it can infect leaves, tendrils and stems. The fruit becomes most susceptible as it approaches maturity. Symptoms on mature fruit (Figure 17) first appear as somewhat bleached or whitened water soaked spots. The fungus spreads through the entire berry causing a soft rot. Black fungus spore producing structures develop on the rotted areas. Finally, the decayed berries, now nearly covered with the fungus fruiting structures, shrivel into dry, dark colored mummies. The mummy caused by bitter rot and ripe rot (see below) consists of the dry shriveled fruit skin covered with fungus fruiting bodies, the internal fruit flesh having been consumed by the fungus.

Figure 17. Bitter rot on fruit of muscadine grape. There is usually a somewhat bleached band between the black bumpy fungus-covered area and tissue not yet rotted.

Ripe Rot

Ripe rot, caused by the fungus Glomerella cingulata, has become one of the two (the other being Macrophoma rot) most important diseases of muscadine grapes in Georgia. The cultivar `Fry' which is currently the major cultivar for the commercial fresh market, is especially susceptible to severe losses from ripe rot. This disease appears suddenly and spreads rapidly. Ripe rot (Figure) attacks the fruit as it ripens. Fungus spore producing bodies form on the surface of the decayed berries, giving the bronze cultivars a reddish color. They release large quantities of pinkish to rusty red colored spores during rain or other wetness (Figure 18). This pink to rusty red appearance of the diseased fruit is unique to ripe rot. As the berries become completely decayed, they shrivel to mummies. The disease is carried into the next season in mummified fruit and infected fruit stems retained on the vine.

Figure18. Ripe rot on fruit of muscadine grape. The infected area takes on a rough, rusty red appearance.

Figure19. Ripe rot on a red skinned variety is often difficult to see unless the pink to orange fungus spores are produced.

Macrophoma Rot

Macrophoma rot, caused by the fungus Botryosphaeria dothidea, is the other major disease of muscadine grapes in Georgia. It overwinters on the remains of infected berries. The causal fungus is very widespread and can be commonly found on many cultivated and wild woody plants. This disease can cause severe crop losses on `Fry' and other susceptible cultivars.

Macrophoma rot (Figure 20) begins as a small tan to dark brown spot which may have some fungus spore producing structures in the center. Soon a water-soaked, light brown soft rot spreads out of the spots and consumes the entire berry. Like ripe rot, Macrophoma rot attacks the fruit as it ripens. It appears suddenly and increases rapidly during the ripening period.

Figure 20. Macrophoma rot causes a glossy light brown water soaked lesion.

Powdery Mildew

Powdery mildew is caused by the fungus Uncinula necator. The damage on muscadine grapes is largely confined to the fruit. Shortly after bloom, affected berries will show a white to gray powdery or dusty growth on the surface. These berries become russetted and may crack open. Some berry drop or reduction in berry size at harvest may also occur. Powdery mildew seldom damages muscadine grape foliage. The cultivar `Magnolia' is very susceptible to powdery mildew.

Angular Leafspot

Angular leafspot, caused by the fungus Mycosphaerella angulata, only attacks the leaves and causes premature loss of foliage. Symptoms (Figure 21) first appears as faded angular spots on the leaves. The spots quickly darken to brown and may be surrounded by a distinct halo. The cultivar Magnolia is very susceptible. No cultivars are particularly resistant. Leaf loss due to angular leafspot can result in poor fruit quality.

Figure 21. Angular leafspot on muscadine grape leaves**.**

29. Controlling Muscadine Grape Diseases

Muscadine grapes are native to and grow in the southeastern United States, a warm humid region with considerable potential for plant disease. Most of the diseases of muscadine grapes that require control are caused by fungi and can be controlled with various degrees of success with timely fungicide applications. Current fungicide recommendations for control of muscadine grape diseases are available from local Extension offices.

There are several vineyard practices that can significantly improve the results of any fungicide program, particularly those aimed at control of fruit rot diseases. Two of these practices involve the design of the vineyard itself and must be considered well before planting. One is the trellis system. In middle and north Georgia the Geneva Double Curtain (two wire “T” bar) trellis has the potential to increase yields about 30 percent compared to a standard single wire trellis. In practice, many muscadine growers have not liked this trellis system because of higher initial cost and higher maintenance cost than the single wire trellis. The two wire trellis also presents problems in disease control. Where a two wire Geneva Double Curtain is used, there is a much denser foliar canopy between the outside of the vine and the inner portion of the vine where a large percentage of the fruit develop. This foliage provides a barrier that tends to trap and hold moisture and is difficult to penetrate with fungicides. Both factors make fruit rot diseases of muscadine grapes more difficult to control where a Geneva Double Curtain trellis is used. Because of this increased difficulty in disease control, a Geneva Double Curtain trellis is not recommended in any area where the combined average rainfall for July and August exceeds 11 inches.

The second factor to consider is choice of irrigation system. An overhead irrigation system also wets fruit and foliage each time it runs. This increased wetness benefits pathogens of fruit and foliage in the same manner as rainfall. That is, it splashes the fungus spores around and provides moisture needed for infection. An irrigation system operating below the vines could provide water to the plants just as well without enhancing conditions for disease development. In areas where frost protection is needed, an overhead system can be installed in conjunction with an under vine summer irrigation system.

Another practice which should aid in disease control is to strip fruit from vines at the end of the season. We have consistently observed that growers who supplement their fresh fruit business with sale of grapes at the end of the season for juice products have less fruit rot problems than growers whose market is fresh fruit only. In harvesting for processing, mechanical harvesters strip all remaining fruit from the vines. In most fresh market only operations, tons of rotting fruit are left in the field on pollinizer cultivars and on vines incompletely harvested as the demand for fresh fruit weakens. It has also been observed that some fruit rot diseases such as ripe rot overwinter better in rotted fruit left in vines than in rotted fruit on the ground. Putting fruit on the ground provides distance between spores produced on old fruit and the current fruit crop. It also exposes old fruit to attack by an array of insects and secondary fungi, etc. not present on the vines. Removing rotted fruit in mid-winter during pruning would be a suitable alternative to end of season vine stripping.

Good weed control can also relate to improved disease control. Allowing weeds to grow up under or around the vines will tend to trap moisture and restrict air movement under the vines. This condition is very favorable to disease development.

Disease control in muscadine grapes generally require use of fungicides most years. Control of black rot during bloom, powdery mildew, and angular leafspot is not difficult. Control of bitter rot, ripe rot and Macrophoma rot is more difficult. Ripe rot sprays need to begin shortly after bloom when small grapes are formed. Macrophoma rot and bitter rot sprays need to begin as soon as grapes first show signs of ripening. Waiting to see disease can reduce control of Macrophoma rot about 50 percent. The effect of these fungicide sprays can be enhanced by use of single wire trellises, below vine summer irrigation systems, vineyard sanitation and weed control.

Insects likely to damage grapevines or grapes include grape berry moth, grape root borer, and aphids. Your county Extension office can recommend proper control measures for these pests.

30. HARVESTING AND MARKETING

Muscadines ripen from early-August to mid-October, depending on the cultivar, location and weather conditions. The manner in which the grapes will be marketed will play a role in determining the best means of harvesting.

Fresh-Fruit Market. Fruit destined for fresh consumption, whether consumed locally or to be shipped, should be hand harvested. Even carefully hand picked fruit may require additional sorting and grading to make the best possible pack. Fruit mechanically harvested or hand-shaken from the vine will bruise during harvest and will spoil quicker. If the fruit is to be shipped a considerable distance or stored for a few days, select only those cultivars that have a dry stem scar or can be clipped as mature clusters. ‘Fry’ is normally picked as individual berries on the first harvests and then clipped in clusters on the later harvests. Cultivars with a wet stem scar will exude their juice onto the fruit surface and provide an ideal environment for the growth of spoilage organisms.

Some growers pick, then grade and pack in a packing house, while other growers pick, grade, and pack in the field. Quality control is more difficult with field packing.

Photo 30.1: Muscadine table grapes coming from the field and destined for a chain of convenience stores.
Photo 30.2: Hand harvesting muscadines. Typically muscadines are picked about every seven days during the ripening season.
Photo 30.3: Field boxes for transporting muscadines to the packing house.
Photo 30.4: Grading muscadines after picking and before final boxing.
Photo 30.5: Mobile field packing rig on the back of a pickup truck. Note the scale for checking the weight.
Photo 30.6: Later pickings of ‘Fry’ can be clipped in clusters for distant shipping.
Photo 30.7: Muscadine box with a telescoping lid. The since 1998 Georgia grows have packed in 20 pound net weight boxes to reduce bruising.

Muscadines have been successfully stored for up to three weeks if they are refrigerated immediately after harvesting. The practical storage life under typical conditions is, however, about a week. To maximize the length of storage, the grapes should be stored at temperatures of 32^{o} to 33^{o}F. with a relative humidity of 70% or higher. The standard muscadine cardboard box holds 20 lbs. of grapes and has a telescoping lid like a peach box.

Processing Market. In growing muscadines to sell for processing, it is important to contact the processor **before** planting the vines and know the terms of the contract first. Important contract provisions include the cultivar requirements, length of the contract, price, quality standards (juice pH and soluble solids), and a cost-of-living increase clause.

Fruit for the processed market can be shaken from the vines onto cloth sheets spread on the ground or into catch frames under the vines. Mechanical harvesters are used by growers with vineyards large enough to justify the cost of the machine. Mechanical harvesters may be used finish the harvest for the processing market after the fresh fruit season is finished. In N.C. blueberry harvesters are often used to harvest muscadines. However, unlike a dedicated grape harvester, which usually has a side delivery into a truck, blueberry harvesters catch the fruit in lugs.

Photo 30.8: Grape mechanical harvester in a muscadine vineyard

Fruit harvested by machine or by shaking is bruised and spoils quickly. Therefore, the fruit should be processed as soon as possible. If there will be a delay in getting the fruit to the processing plant, it is best to store the fruit at 32^{o} to 33^{o}F.

Pick-Your-Own Market. Modern muscadine cultivars can be effectively marketed on a pick-your-own basis where the customer base is already acquainted with muscadines. Customers prefer a PYO because it allows them to select their own fruit in any quantity at a savings over prices available in local retail stores. Some PYO operations charge a “grazing fee” for eating while picking. This allows customers to enjoy themselves to the fullest while picking. In starting a PYO, it is best to start out small and expand as the demand for grapes increases.

In planning a PYO, you must consider traffic flow and parking. Convenience to the field and the highway make for a better business. Customers often become disgruntled if they have to do too much walking to and from the field. Plants may be damaged if sufficient parking and turnaround space are not provided.

Another requirement which contributes to the success of a PYO operation is top quality grapes in clean fields. Weedy, overgrown fields tend to reduce the customers' interest in returning. Having clean rest room facilities, as well as rain shelters, and water fountains will please customers.

Photo 30.9: Pick you own sales area at the Sturgis operation in Georgia. The metal funnel is used to sack up the grapes and the meat scale is used to weight the grapes. A certifiable scale is required if you sell by the pound.

standard of any product mentioned; neither does it imply approval of any product to the exclusion of others which may also be suitable.

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AN EQUAL OPPORTUNITY EMPLOYER
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Table 5- FRESH MARKET MUSCADINE CULTIVARS

Cultivar	Flower Type[1]	Fruit Color	Berry Size	Harvest Season	Vine Vigor	Winter Hardiness	Comments
African Queen (Pat)	F	Black	Large	Mid	H	G?	Production questionable, tangy flavor, dry scar
Alachua	SF	Black	Medium	Early-mid	H	G?	Tough skin and medium size limit fresh market potential, even ripening
(T)Black Beauty (Pat)	F	Black	Large	Early-mid	H	G	Production questionable, good quality, cap stick problems, may crack in wet weather
(T)Black Fry (Pat)	F	Black	Large	Early-mid	H	M-G?	Fairly productive, usually good but variable quality, can be clipped in clusters, may crack in wet weather, may have leaf disease problems

Cultivar	Flower Type[1]	Fruit Color	Berry Size	Harvest Season	Vine Vigor	Winter Hardiness	Comments
Cowart	SF	Black	Med.-large	Mid	M	F	Individual berries ripen unevenly - will shatter, poor shipper, good pollinizer for 'Fry'
(T)Darlene (Pat)	F	Pinkish/ Bronze	Very large	Early-mid	H	G	Poor cropping a problem in South Georgia due to low flower numbers , berries may tear slightly when picked, cluster clipping recommended for shipping, fair to excellent flavor, consistent size, possible leaf and fruit disease problems
(T)Delight (Excel) (Pat)	SF	Dark Bronze	Large	Late	L	P-F	Often over produces reducing quality, dry scar

Cultivar	Flower Type[1]	Fruit Color	Berry Size	Harvest Season	Vine Vigor	Winter Hardiness	Comments
*(T)Early Fry (Pat)	F	Bronze	Large	Very early	M-H	G?	Productive, very promising new cultivar, can't be picked as green as 'Fry' and have good quality, ripens ahead of 'Fry', possible leaf disease problems, highly recommended for trial
Farrer (Pat)	F	Black	Large	Mid-late	H	G	Elongated fruit, wet scar, good U-pick
*Fry	F	Bronze	Large	Early-late	L	P	Standard for fresh market, fruit rot, leaf spot problems

Cultivar	Flower Type[1]	Fruit Color	Berry Size	Harvest Season	Vine Vigor	Winter Hardiness	Comments
*Granny Val (SW Ga.) (Pat) (Note Comments)	SF	Bronze	Large	Late	L	P	Very productive, over cropping and lack of leaves due to disease and low vigor has been a problem, needs a good fungicide program to control leaf diseases, has not performed well in N. or Middle Georgia (cold injury), or on some farms in S Ga.(leaf disease and die back problems)
Higgins	F	Pink/ Bronze	Large	Mid	M	P	Poor shipper, elongated fruit
Ison (Pat)	SF	Black	Medium	Early	V.H.	G	Will shatter off clusters once picked, may shrivel on vine, dry scar, good processing potential
Janet (Pat)	SF	Bronze	Large	Mid	H	G	Wet scar, possi-ble U-pick, good quality

Cultivar	Flower Type[1]	Fruit Color	Berry Size	Harvest Season	Vine Vigor	Winter Hardiness	Comments
Janebell (Pat)	SF	Bronze	Large	Early-mid	H	G	Often over produces,large clusters,long stemmed clusters, dry scar
Jumbo	F	Black	Very large	Mid	H	G	Poor quality un-less vine ripe
(T)Late Fry (Pat)	SF	Bronze	Large	Late	H	G?	Fruit show severe powdery mildew scarring in most locations, not recommended
Loomis	F	Black	Med.-large	Mid-late	H	G	Great taste, 72% dry scar, tough skin
(T)Nesbitt	SF	Black	Large	Mid-late	H	G	Good U-pick, may over crop, may show Pierce's disease symptoms
(T)Pam (Pat)	F	Bronze	Very large	Early-mid	H	G	Production low on some farms, attractive, good quality, can be eaten when greenish bronze, can be cluster clipped for shipping

Cultivar	Flower Type[1]	Fruit Color	Berry Size	Harvest Season	Vine Vigor	Winter Hardiness	Comments
Pineapple	SF	Bronze	Medium	Mid-late	H	G?	Pineapple flavor, productive large clusters, wet scar possible, U-pick
*(T) Polyanna	SF	Purple	Med.-large	Mid-late	H?	?	Fairly new release from Florida, good disease resistance, size might be a bit small for shipping, producing well in Tifton, somewhat tough skin
Rosa	F	Reddish/ bronze	Med.-large	Mid	M	G?	Variable flavor
(T) Scarlett	F	Red	Large	Mid	M	G	Fairly newrelease, beautiful red color, productivity has been disappointing

Cultivar	Flower Type[1]	Fruit Color	Berry Size	Harvest Season	Vine Vigor	Winter Hardiness	Comments
Southland	SF	Black	Medium	Mid-late	M	P	High percent dry picking scars, too small for shipping
Sterling	SF	Bronze	Med.-large	Mid	M	Very G.	Marginal quality
Sugar Pop (Pat)	F	Bronze	Large	Mid-late	H	G?	Productivity questionable, good flavor
Sugargate (Pat)	F	Black	Very large	Early	M	P	Usually very poor yields in S. Ga., slightly better in Piedmont
*Summit	F	Pinkish/ Bronze	Large	Mid	H	G	A top performing cultivar, generally not quite as attractive as Fry but better dis-ease resistant and yield

Cultivar	Flower Type[1]	Fruit Color	Berry Size	Harvest Season	Vine Vigor	Winter Hardiness	Comments
*Supreme (Pat)	F	Black	Very Large	Mid-late	L-M	?	Rising cultivar, exceptional fruit size, will shatter, dry scar, good flavor, young vines may lack vigor, subject to die back if stressed
(T)Sweet Jenny (Pat)	F	Bronze	Large	Early	H	G?	Fairly productive, good quality, edible skin, dry scar, appearance may be rough, may have fruit rot and leaf disease problems, excessive number of parthenocarpic fruit some years

Cultivar	Flower Type[1]	Fruit Color	Berry Size	Harvest Season	Vine Vigor	Winter Hardiness	Comments
*Tara	SF	Bronze	Large	Mid	H	G	Productive, attractive but flavor inferior to Fry, some skin browning, good leaf disease resistance, one of the best bronze pollinizers available
*Triumph	SF	Pinkish/ Bronze	Med.-large	Early	M	P	Productive, good early season pick-your-own, will shatter if cluster clipped, good pollinizer
Watergate	F	Bronze	Large	Mid	M	P	Melting pulp, wet scar, soft, must clip in clusters to ship

Table 6-5- PROCESSING MUSCADINE CULTIVARS

Cultivar	Flower Type[1]	Fruit Color	Berry Size	Harvest Season	Vine Vigor	Winter Hardiness	Comments

Carlos	SF	Bronze	Medium	Early	H	G	Juice, jelly, most popular white wine muscadine
Cowart	SF	Black	Med.-large	Mid	H	F	Juice, jelly
Doreen	SF	Bronze	Small-	Late	H	G?	Very productive, may overcrop
Golden Isles	SF	Bronze	Medium	Mid	H	G?	Less "musky" muscadine for wine
Ison	SF	Black	Medium	Mid	H	G?	Good pigment stability
Magnolia	SF	Bronze	Medium	Mid	M	G?	Juice, jelly, wine, susceptible to powdery mildew and fruit rots
Noble	SF	Black	Small	Early	H	G	Jelly, best red wine muscadine due to more stable pigments

* - Probably the best choice
(T) - Limited trial only, try only a few vines on your farm before making a larger planting
Flower type - F = female flowered (needs self-fertile pollinator); SF = self-fertile
Vine Vigor - L = low, M = medium, H = high
Appoximate berry size-S=<5 grams, M = 5-8 grams, L = 9-10 grams, VL = >10 grams (28.35 grams=1 ounce)
Winter Hardiness - P = poor, F = fair, G = good