

## EFFECT OF TWO WIRE VERTICAL AND GENEVA DOUBLE CURTAIN TRAINING SYSTEMS ON BERRY QUALITY AND YIELD OF MUSCADINE GRAPES

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**Abstract.** The performance of 31 cultivars of muscadine grapes (*Vitis rotundifolia* Michx.) was analyzed under two training systems for 5 years (1978 to 1982). Average yield from 'Carlos', 'Coward', 'Creek', 'Dixie', 'Higgins', 'Jumbo', 'Noble', and 'Southland' exceeded 7 tons/acre over a 3-year period. Vines trained to a Geneva double curtain produced an average 11% increase in yield and an average 0.6° increase in soluble solids as compared to the two wire vertical training system. No consistent difference occurred in the number of berries/cluster, berry weight, berry shape, number of seeds, berry flavor, berry scar, or pH between the training systems.

Currently, recommendations concerning grape training and pruning systems in Florida are largely based upon

research performed in other areas. The single wire (SW), 2 wire vertical (2WV), and Geneva double curtain (GDC) training systems are often used on muscadine grapes in the Southeast (1,3,4,5,8,9,12). Vines trained to a GDC have generally produced higher yields with better than or equal berry quality in many regions of the county (2,6,7,10,11). However, GDC establishment and pruning costs tend to be somewhat higher than the other systems. Although the performance of spur and cane pruned vines in the Southeast has been compared (3), no reports comparing the GDC and SW or 2WV on muscadine grapes appear in the literature. The purpose of this study is to compare the performance of 31 cultivars of muscadine grapes under 2 training systems and to update cultivar recommendations for north central Florida.

### Materials and Methods

From 1976 to 1978, 31 cultivars of muscadine grapes were planted and trained to either a GDC or a 2WV training system at the AREC in Monticello, FL. GDC-trained

Table 1. Yields of 31 cultivars of muscadine grapes from 1978 to 1982 trained to a Geneva double curtain (GDC) and a two wire vertical (2WV) system. Average yield computed from 1980 to 1982. Average SE=0.8, n=3.

Cultivar	Yield (tons/acre)											
	1978		1979		1980		1981		1982		Avg	
	GDC	2WV	GDC	2WV	GDC	2WV	GDC	2WV	GDC	2WV	GDC	2WV
Albemarle			1.3	1.9 <sup>y</sup>	3.8	3.9	6.8	5.1	7.5	6.2	6.0	5.1
Bountiful			2.6 <sup>y</sup>	2.5	4.9	3.0	3.2	1.9	4.5	5.3	4.2	3.4
Carlos	2.0 <sup>y</sup>	4.2	4.7	7.8	7.2	8.1	7.0	7.7	5.2	9.1	6.5	8.3
Chief	1.8	2.0	5.3	5.2	9.6	6.9	6.2	5.6	4.5	3.6	6.8	5.4
Chowan <sup>z</sup>					0.9 <sup>y</sup>	1.4	3.1 <sup>y</sup>	3.4	1.4	1.7	1.8	2.2
Coward	2.7	2.2	2.2	3.9	6.6	4.3	7.6	8.3	7.5	9.1	7.2	7.2
Creek			1.2	1.9	7.6	5.8	8.7	9.1	10.1	4.2	8.8	6.4
Dearing	0.8 <sup>y</sup>	0.5	1.2	2.4	3.8	3.6	3.3	3.5	3.8	4.7	3.6	3.9
Dixie	2.9	3.4	5.1	1.2	7.8	7.4 <sup>y</sup>	8.3	6.1	6.2	8.3	7.4	7.3
Dixieland <sup>z</sup>					1.3	0.6	1.6	1.9	1.8	1.2	1.6	1.2
Dixiered			2.3 <sup>y</sup>	3.2 <sup>y</sup>	3.8	2.3	1.2	1.8	8.0	8.2	4.3	4.1
Fry	1.4	0.7	3.0	0.4 <sup>y</sup>	5.3	3.1	2.4	0.9	8.9	8.2	5.5	4.1
Higgins	2.7 <sup>y</sup>	1.4	3.7	3.1	8.0	3.5	10.3	8.3	12.4	8.4	10.2	6.7
Hunt				0.9 <sup>y</sup>	2.0 <sup>y</sup>	2.1	4.8 <sup>y</sup>	4.3	8.7 <sup>y</sup>	5.5	5.2	4.0
Jumbo	2.3	1.3 <sup>y</sup>	2.9	4.0	4.2	3.0	7.2	8.2	10.9	10.9	7.4	7.4
Magnolia		1.1	3.9	5.1	3.1	2.7	2.8	4.0	5.4	8.8	3.8	5.2
Magoon				3.0 <sup>y</sup>	4.9 <sup>y</sup>	8.2 <sup>y</sup>	3.4 <sup>y</sup>	4.9 <sup>y</sup>	3.8 <sup>y</sup>	5.3 <sup>y</sup>	4.0	6.1
Noble	3.2	3.9	10.0	9.6	12.2	10.8	10.5	7.7	9.3	10.2	10.7	9.6
Pink Hunt <sup>z</sup>					0.5 <sup>y</sup>	1.0	2.1	1.7	4.3	3.2	2.3	2.0
Pride			2.3		5.8	1.7	5.9	4.6 <sup>y</sup>	8.4	3.8 <sup>y</sup>	6.7	3.4
Redgate			3.1	4.2	5.6	6.3	6.8	5.2	5.7	6.7	6.0	6.1
Rich	1.1	0.8	2.6	2.4	2.9	1.6	6.7	5.1	5.9	5.0	5.2	3.9
Roanoke					1.2	5.8	3.2	4.5	3.7	6.5	2.7	5.6
Scuppernong	3.0 <sup>y</sup>	3.5 <sup>y</sup>	2.4 <sup>y</sup>	4.9	6.3 <sup>y</sup>	3.4	2.5	1.5	1.6	5.5	3.5	3.5
Southland	2.0	3.1	5.0	6.3	7.3	9.5	6.7	6.1	6.8	7.6	6.9	7.7
Sugargate							1.3	1.3	1.9	2.8	1.6	2.1
Summit						1.0	4.9	4.8	5.4	8.8	5.2	6.8
Topsail			0.6 <sup>y</sup>		2.1 <sup>y</sup>		4.0 <sup>y</sup>	1.1	5.3 <sup>y</sup>	2.1	4.7	1.6
Watergate			0.8 <sup>y</sup>	1.8 <sup>y</sup>	2.6	0.7 <sup>y</sup>	9.4	9.4 <sup>y</sup>	8.6	4.5 <sup>y</sup>	6.9	4.9
Welder	3.2	4.0	4.4	6.5	8.4	4.6	6.6	5.2	6.5	7.4	7.2	5.7
Yuga			0.7 <sup>y</sup>	1.3	4.0 <sup>y</sup>	2.6	7.1 <sup>y</sup>	4.8	9.8 <sup>y</sup>	4.9	7.0	4.1
Overall avg. <sup>z</sup>	2.2	2.3	3.1	3.7	5.5	4.5	6.0	5.3	6.9	6.6	6.1	5.5

<sup>z</sup>Cultivars planted later than others and not included in computation of overall averages.

<sup>y</sup>n = 2 replications.

Table 2. The effect of Geneva double curtain (GDC) and two wire vertical (2WV) training systems on % soluble solids of muscadine grapes from 1978 to 1981.

Cultivar	1978		1979		Soluble solids (%) 1980		1981		Avg		
	GDC	2WV	GDC	2WV	GDC	2WV	GDC	2WV	GDC	2WV	GDC + 2WV
Albemarle	19.4	17.9	17.9	16.4	17.8	14.9	14.8	14.8	17.5	16.0	16.8
Bountiful	15.4	16.2	13.9	14.7	13.8	15.5	14.3	14.0	14.4	15.1	14.8
Carlos	14.5	15.5	14.1	15.3	14.1	16.7	14.5	13.8	14.3	15.3	14.8
Chief	16.1	16.4	15.1	15.4	14.2	14.8	16.0	16.0	15.4	15.7	15.6
Chowan					16.9	15.5	16.4	16.0	16.7	15.8	16.3
Cowart	14.5	14.7	14.1	14.2	14.1	14.4	14.3	13.8	14.3	14.3	14.3
Creek			14.7	13.5	17.5	15.1	15.0	15.0	15.7	14.5	15.1
Dearing	19.1	18.1	18.6	17.6	18.2	17.2	15.5	15.0	18.1	14.5	16.3
Dixie	18.2	16.0	18.1	15.9	19.3	14.8	15.0	15.0	17.7	15.4	16.6
Dixieland			16.6	15.4	18.7	16.3	14.8	14.5	16.7	15.4	16.1
Dixiered			15.0	12.8	14.0	9.6	17.0	16.0	16.3	12.8	14.6
Fry	16.8	16.5	15.5	15.3	16.1	15.6	16.5	16.0	16.2	15.9	16.1
Higgins	16.2	14.9	14.9	13.6	16.8	14.2	14.5	13.5	15.6	14.1	14.9
Hunt			14.6	14.0	16.3	15.1	15.0		15.3	14.6	15.0
Jumbo	13.8	14.7	13.1	14.0	13.2	15.0	13.8	13.3	13.5	14.3	13.9
Magnolia	13.6	14.2	13.5	14.1	12.5	13.7	15.0	14.5	13.7	14.1	13.9
Magoon	16.3	18.5	16.0	18.2	14.1	18.5	16.0	16.5	15.6	17.9	16.8
Noble	13.8	14.4	14.1	14.7	13.7	14.9	13.5	13.0	13.8	14.3	14.1
Pink Hunt					17.2	14.4	14.5	14.0	15.9	14.2	15.1
Pride	15.1	15.6	14.1	14.6	14.3	15.3	15.0	14.5	14.6	15.0	14.8
Redgate			15.8	15.3	16.7	15.6	15.0	16.0	15.8	15.6	15.7
Rich	14.0	15.0	14.4	15.4	13.3	15.3	14.5	15.5	14.1	15.3	14.7
Roanoke			12.5	12.1	12.0	11.2	12.8	12.5	12.4	11.9	12.2
Scuppernong	13.5	13.8	14.1	14.4	13.3	13.9	14.5	13.5	13.9	13.9	13.9
Southland	15.8	16.0	15.1	15.2	15.2	15.5	15.5	15.0	15.4	15.4	15.4
Sugargate					21.0	16.5	17.0	16.5	19.0	16.5	17.8
Summit					21.1	16.9	16.5	14.5	18.8	15.7	17.3
Topsail			21.4	21.3	19.9	18.7	18.8	18.8	19.8	19.7	19.8
Watergate			16.1	15.1	16.3	15.3	14.0	13.0	15.5	14.5	15.0
Welder	17.2	17.6	17.7	18.1	17.5	18.3	16.0	15.0	17.1	17.3	17.2
Yuga			16.1	14.8	17.3	14.6	16.5	16.5	16.6	15.3	16.0
Overall avg	15.7	15.9	15.4	15.2	16.0	15.3	15.3	14.9	15.8	15.2	15.5

vines were trained to 2 parallel wires 4 ft apart and 6 ft above the ground. Two wire vertical trained vines were trained to wires one above the other, 3 and 6 ft above the ground. Each treatment was replicated 3 times as single plant replications. Plant spacings were 18 and 12 ft within and between rows, respectively, for GDC-trained vines and 18 and 10 ft within and between rows for 2WV-trained vines.

Fertilizer (8-8-8) was broadcast at 1 lb./vine during March and July. Vines were supplemented with a magnesium sulfate (6 to 8 oz/vine) during June and dolomite every several years to maintain the pH near 6.5.

Grapes were harvested mechanically during September. Berries were collected in a modified catch frame, cleaned free of debris and weighed. Twelve fruit from each vine were combined by the trellis type and crushed in a blender for one combined reading of soluble solids.

Fruit quality evaluations were performed during 1980 on berry samples pooled for each trellis type. Berry size, weight, stem scar, soluble solids, number of seeds and pH were determined on the same 4 randomly selected berries/replication at harvest. Berry length and width were measured with calipers and berry weight with a small scale. Stem scar (% torn) was recorded prior to crushing [(1980) by hand, seed were counted for each individual fruit, then averaged] for analyses of seed number, soluble solids and pH. Seed number was determined by dividing the total number of seeds by berry number. Soluble solids and berry pH of the extracted juice was determined with a tempera-

ture compensated American Optical Model 10423 refractometer and a Corning Scientific Model No. 10 pH meter, respectively. Flavor ratings were subjectively determined by one individual. Cluster size was estimated from 12 randomly selected samples from each cultivar in the field.

The data were not subjected to analysis of variance procedures since trellis type was not randomly assigned across the vineyard. Average standard errors accompany yield data for an indication of yield variation over time.

## Results

Vines bore fruit during the 3rd year, although significant yields were not generally obtained until 1980 (Table 1). Yields continually increased until 1982 at which time the study was terminated. All cultivars planted in 1976 except 'Bountiful', 'Dearing', 'Roanoke', 'Scuppernong', and 'Topsail' produced greater than 4 tons/acre averaged over a 3-year period (1980-1982). Yield from 'Carlos', 'Cowart', 'Creek', 'Dixie', 'Higgins', 'Jumbo', 'Noble', and 'Southland' exceeded 7 tons/acre over this period. 'Chowan', 'Dixieland', 'Dixiered', 'Pink Hunt', and 'Sugargate' were planted in 1978 and thus yields are not directly comparable to the other cultivars. Missing plants due to mortality (Table 1, denoted by n = 2) were not included into yield computations. Vines trained to a GDC produced an average of 0.6 tons/acre (11%) increase in yield over the 2WV system, although the response was cultivar dependent. 'Creek', 'Higgins', 'Pride', 'Topsail', 'Watergate', and 'Wel-

Table 3. The effect of Geneva double curtain (GDC) and two wire vertical (2WV) training systems on berry number/cluster of muscadine grapes from 1978 to 1980.

Cultivar	Berry no./cluster								
	1978		1979		1980		Avg <sup>z</sup>		
	GDC	2WV	GDC	2WV	GDC	2WV	GDC	2WV	GDC + 2WV
Albemarle			5	6	7	7	6	7	7
Bountiful			13	13	10	7	12	7	10
Carlos	7	6	11	10	10	7	9	8	9
Chief			10	9	8	7	9	8	9
Chowan					8	10			
Cowart	9	8	8	8	8	8	8	8	8
Creek			15		7	7	11		
Dearing			9	10	9	9	9	10	10
Dixie	8	10	13	12	13	9	11	10	11
Dixieland					6	7			
Dixiered			12		9	13	11		
Fry			8	9	11	8	10	9	10
Higgins	9	9	10	7	10	7	10	8	9
Hunt			9		10	6	10		
Jumbo	9	7	9	9	7	6	8	7	8
Magnolia	8		13		9	10	10		
Magoon			9	10	10	10	10	10	10
Noble	11	13	17	20	8	11	12	15	14
Pink Hunt					4	8			
Pride	5		9		8	9	7		
Redgate			19		11	13	15		
Rich		10	12	10	9	8	11	9	10
Roanoke					9	11			
Scuppernong	12	9	11	12	12	10	12	10	11
Southland	8	8	8	8	10	8	9	8	9
Sugargate			7		6	8	7		
Summit					11	7			
Topsail			6		7	8	7		
Watergate			9		7	8	8		
Welder	10	9	7	12	11	9	9	10	10
Yuga			14		10	12	13		
Overall avg.	9	9	10	10	9	9	9.7	9.7	9.7

<sup>z</sup>Overall average not computed for those cultivars with less than 2 yrs of data for each training system.

der' yielded at least 2.0 tons/acre more when trained to a GDC, but only 'Magoon' and 'Roanoke' yielded at least 2.0 tons/acre more when trained to a 2WV. When exceptionally high yields (over 10 tons/acre) occurred it was almost invariably on GDC-trained vines. Soluble solids of GDC-trained vines were slightly higher than 2WV-trained vines every year except 1978 (Table 2). The average increase in soluble solids was 0.5° for all years combined. 'Roanoke' produced berries which were extremely low in soluble solids while 'Albemarle', 'Chowan', 'Dearing', 'Dixie', 'Dixieland', 'Fry', 'Magoon', 'Sugargate', 'Summit', 'Topsail', 'Welder', and 'Yuga' all averaged over 16.0% soluble solids.

Training system did not have an effect on berry number/cluster (Table 3). 'Noble' had the greatest number of berries/cluster and 'Albemarle' and the large fruited 'Jumbo' had the fewest number/cluster. The average number of berries per cluster was about 10. 'Fry', 'Summit', 'Jumbo', and 'Sugargate' bore the largest fruit under both training systems (Table 4). Overall, berries from GDC-trained vines were slightly larger than 2WV-trained vines. Training system did not have a consistent influence on berry shape, seed number, flavor, % dry scar or pH, although berries from GDC-trained vines were slightly higher in soluble solids.

#### Discussion

The choice of a training system should ultimately hinge on the cost of establishment and maintenance vs. yield and

fruit quality. The GDC training system has often resulted in higher yields and fruit quality mainly due to enhanced leaf exposure to sunlight (2,6,7,10,11). It is also commonly recognized that the GDC system is labor intensive compared to other systems. Another factor which may influence the choice of training system is the type of mechanical harvester available in the area, although many harvesters can be modified to either system.

A much greater increase in yield than the 11% reported in this study would be expected if the GDC system was compared to a SW system (J. Mortensen, personal communication). Brightwell and Austin (1) comparing the SW, 2WV, and the overhead arbor on 'Hunt' and 'Tarheel' grapes found that the 2WV produced a 40% and the overhead arbor 110% increase in yield over the SW. However, the yield response may be partially explained by differences in trellis height, i.e., SW (4 ft), 2WV (5 ft), and overhead arbor (7 ft)(1). Similarly, grapes at the AREC-Monticello are grown along the top wire at 6 ft above the ground compared to 4.5 ft in Leesburg. Six foot trellises have been shown to produce higher yields, increase pruning weights and improve berry quality of 'Concord' compared to a 4 or 4.5 foot height (10,11).

The 0.6° average increase in soluble solids with the GDC system is also due to improved light interception and advanced berry maturity (10). The modest increase in yield and soluble solids of the GDC over the 2WV system in light of the increased labor requirements, sheds doubt on

Table 4. Berry characteristics of bronze and black muscadine grapes trained to a Geneva double curtain (GDC) and a two wire vertical (2WV) training system during 1980.

Cultivars	Wt. (g)		Length (cm)		Width (cm)		Seeds (no.)		Flavor <sup>z</sup>		Scar (% torn)		Soluble solids		pH	
	GDC	2WV	GDC	2WV	GDC	2WV	GDC	2WV	GDC	2WV	GDC	2WV	GDC	2WV	GDC	2WV
<b>Bronze muscadines</b>																
Carlos	5.0	5.5	1.9	2.0	1.9	1.9	4	4	3	3	20	0	14.1	16.7	3.5	3.4
Chowan	5.9	5.6	2.1	2.1	2.0	2.0	3	4	2	2	10	60	16.9	15.5	3.4	3.2
Dearing	3.2	3.0	1.9	1.8	1.7	1.6	4	3	3		40	0	19.2	17.2	3.6	3.2
Dixie	4.0	5.1	1.8	2.0	1.9	1.9	4	4		3	0	50	19.3	16.9	3.6	3.5
Dixieland	9.2	10.2	2.5	2.6	2.5	2.6	4	4	3		40	40	18.7	16.4	3.9	
Dixiered	7.4	6.2	2.5	2.4	2.3	2.2	3	3			10	0	14.0	9.6	3.7	3.7
Fry	13.9	12.4	2.9	2.7	2.7	2.7	4	2	3	3	100	80	16.1	15.6	4.0	3.6
Higgins	8.5	7.6	2.6	2.6	2.4	2.4	3	3			60	60	15.9	14.2	3.6	3.3
Magnolia	4.6	5.2	2.1	2.0	1.9	1.9	3	3	4	4	60	80	12.5	13.7	3.4	3.6
Pink Hunt	5.3	5.4	2.4	2.2	2.3	2.0	3	4	3	3	80	100	17.2	14.4	3.2	3.5
Redgate	3.5	3.5	1.8	1.9	1.7	1.8	4	4	3		20	0	16.7	15.6		3.2
Rich	6.4	5.8	2.2	2.1	2.1	2.0	4	4	2	2	40	20	13.3	15.3	3.3	3.3
Roanoke	5.7	4.9	2.1	2.2	2.0	1.9	4	4	2	3	80	70	12.0	11.7	3.3	3.3
Scuppernong	5.2	4.9	2.0	2.1	2.0	2.0	4	3	3	3	15	70	12.3	14.0	3.0	3.7
Summit	11.0	10.6	2.6	2.7	2.5	2.5	3	3	3	4	40	40	21.1	16.9	4.1	3.8
Topsail	5.9	3.8	2.1	1.9	2.0	1.8	2	3	3		40	10	19.9	19.7	3.5	3.3
Watergate	9.8	6.9	2.5	2.2	2.5	2.2	4	4	3	2	70	40	16.3	15.3	3.6	3.3
Welder	3.7	3.2	1.9	1.8	1.7	1.7	4	4	3		20	40	17.5	18.3	3.8	4.2
Yuga	3.8	3.0	2.0	1.9	1.8	1.6	3	3			40	100	17.3	14.7	3.0	3.2
<b>Black muscadines</b>																
Albamarle	5.5	5.8	2.3	2.2	2.1	2.0	4	4	4	4	70	70	17.8	14.9	3.3	3.4
Bountiful	3.3	3.5	1.8	1.7	1.6	1.7	3	3	3	3	80	40	13.8	15.5	3.2	3.2
Chief	3.6	3.3	1.7	1.8	1.7	1.6	3	4	2	2	30	0	14.2	14.8	2.2	3.0
Cowart	6.8	7.5	2.3	2.3	2.2	2.2	3	4	3	3	60	50	14.1	14.4	3.0	3.0
Creek	2.9	3.9	1.7	1.9	1.6	2.0	4	3		3	70	50	17.5	15.1	3.0	3.3
Hunt	6.1	4.5	2.1	2.1	2.1	1.8	4	3	3	4	100	80	16.3	15.1	3.2	3.3
Jumbo	15.3	13.0	2.9	3.0	2.8	2.7	4	3	3	3	80	80	13.2	14.4	3.4	3.8
Magoon	3.4	3.4	1.7	1.7	1.6	1.6	4	3	3	3	60	65	14.1	17.9	3.0	2.7
Noble	2.8	3.3	1.7	1.8	1.7	1.7	4	4	3		80	50	13.7	14.9	3.2	3.6
Pride	9.1	9.2	2.7	2.5	2.4	2.5	3	3	3	3	100	80	14.3	15.3	3.2	3.5
Southland	4.8	5.0	2.0	2.0	1.9	1.9	4	4	3	3	0	40	15.2	15.5	3.1	3.2
Sugargate	10.1	12.0	2.7	2.9	2.5	2.6	4	4		3	40	60	21.0	16.5	3.6	3.5
Avg	6.3	6.0	2.2	2.2	2.1	2.0	3.6	3.5	2.9	3.0	50	50	16.0	15.3	3.3	3.4

<sup>z</sup>Taste rating: 1 = unacceptable, 2 = poor, 3 = fair, 4 = good.

the superiority of this system under Florida conditions. Undoubtedly as trellis height decreases, shading of the bottom arms will increase and the GDC system will perform proportionately better. More significant yield differences will also occur when the GDC is compared to the SW system. Growers must decide for themselves what system best meets their needs. For instance, the bottom arms of the 2WV may have to be summer pruned to avoid contact with herbicides sprayed toward the ground. In addition, U-pick considerations may dictate that trellis height not exceed 5.5 ft.

Cultivar recommendations from this study do not differ greatly from those of previous studies in Florida (8,12). 'Noble' performed exceptionally well averaging over 10 tons/acre but because of its small size it is best adapted as a juice or wine grape. Of the large fruited grapes, 'Fry', 'Summit', 'Jumbo', and 'Sugargate', 'Magnolia', 'Summit', and 'Hunt' scored best in a taste test. For specific information concerning all 31 cultivars tested, the reader is referred to reference 8.

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