Yield and Quality of *Vitis* Hybrid 'Suwannee' as Affected by Training System and Pruning Severity

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Abstract. The influence of bilateral cordon (BC) and cane training systems and level of pruning severity on vegetative and reproductive characteristics of *Vitis* hybrid 'Suwannee' were determined from 1987 to 1989. In 1987, yield and quality were similar on BC- and cane-trained vines. In 1988, shoot count, yield, and quality were similar regardless of training system and pruning severity (50, 70, or 90 nodes per vine). When data from both training systems were combined, yield was related to the number of shoots. Vines pruned more severely compensated by producing more shoots from non-count (non-node) positions on the canes, cordon, or spurs. Similarly, in 1989 yield and berry quality were not affected by training system or levels of pruning severity (50, 70, 90, or 110 nodes), although berry weight was affected by training system, and shoot count and shoot length were affected by level of pruning severity. Interactive effects of training system and pruning level were not significant in either year. An analysis of combined data for 1989 indicated that yield was affected by the number of nodes and shoots. Thus, 'Suwannee' may be trained to the BC system, which is more readily adapted to mechanization. Pruning to a specific number of nodes per vine was not critical.

A major limitation in the culture of bunch grape hybrids arises from a lack of quantitative data concerning training systems and levels of pruning severity. *Vitis* hybrids in Florida are trained to a cane system whereby four to eight canes are retained with ≈ 50 to 110 nodes (depending on desired pruning severity) and are hand-tied to the wire(s). This system is labor-intensive and is not adaptable to mechanization. The bilateral cordon (BC) (Morris, 1985; Morris and Cawthon, 1980, 1981) or the Geneva double curtain (GDC) systems (Shaulis et al., 1973) are adaptable to mechanized pruning and harvesting, thereby greatly increasing vineyard management efficiency (Morris and Cawthon, 1981). Studies comparing yield and quality of several cultivars of *V. labrusca* (Morris, 1985; Morris and Cawthon, 1980, 1981; Morris et al., 1984a, 1985), French-American hybrids (Howell et al., 1987; Morris et al., 1984b; Wolpert et al., 1983), and *V. vinifera* (Ka-

simatis et al., 1985) have shown that the BC and cane-training systems resulted in similar yields and quality. Pruning severity (or the number of nodes) required for an optimum balance of yield and quality of *V. labrusca* 'Concord' and 'Niagra' has been determined (Morris and Cawthon, 1980, 1981; Morris et al., 1984a). Fundamental data are lacking concerning the influence of training systems and levels of pruning severity on bunch grape hybrids of the southernmost United States. A knowledge of the adaptability of these *Vitis* hybrid cultivars to different training systems and the effect of node number on yield and quality are prerequisites for successful mechanization.

Our objective was to determine the influence of training system and pruning severity on vegetative and reproductive growth characteristics of *Vitis* hybrid 'Suwannee'.

A 0.23-ha experimental vineyard containing *Vitis* hybrid 'Suwannee' was established in 1985 at the Agricultural Research and Education Center, Monticello, Fla. In-row and between-row spacing were 2.4 and 3.0 m, respectively. Vines were trained to a cane or a BC system at a height of 1.8 m. All vines had a single trunk. Irrigation was supplied daily via drip irrigation.

The performance of BC- and cane-trained vines was evaluated from 1987 to 1989. Vines were trained during 1985 to 1987. BC-trained vines were established with cordons extending 1.2 m from either side of the trunk. Shoots emanating from all directions of the cordon

were pruned to three-node spurs. For cane-trained vines, two 1.0- to 1.4-m-long canes were selected on each side of the trunk and tied to the wire in 1987. Nodes were not counted for either training system during this initial year. Vines were hand-harvested 8 Aug. Cluster weight was determined from three intact, randomly selected bunches. The three-bunch samples were frozen for quality analysis. For this analysis, fresh fruit samples (≈ 500 g) were crushed in plastic bags and squeezed through cheesecloth by hand. The juice was clarified by centrifugation at $3500 \times g$ for 15 min. Soluble solids concentration (SSC) was measured with an Abbé refractometer (Reichert Scientific Instruments, Buffalo, N. Y.) and pH was determined using a combination glass electrode. Titratable acidity was determined by diluting a 5-ml sample to 150 ml with deionized water and titrating to pH 8.2 with 0.1 N NaOH (Zoecklein et al., 1990). Titratable acidity is expressed as percent tartaric acid equivalents. All analyses were performed in duplicate. The experiment was established and analyzed as a completely randomized design by analysis of variance procedures (SAS Institute, 1985). Each training system was replicated six times; each replicate consisted of three vines.

In 1988, the experimental design was expanded to encompass training system and levels of pruning severity. BC-trained vines were pruned to three- to five-node spurs for a total of 50, 70, or 90 nodes per vine. For cane-trained vines, three to eight canes, comprising 10 to 20 nodes, were selected per vine. Fifty, 70, or 90 nodes were retained for cane-trained vines. Total number of buds, which includes buds from count (nodes) and non-count positions on cordons, canes, and spurs, was determined on 29-31 Mar. Shoots were counted on 20-24 Apr. Vines were hand-harvested 8 Aug. Yield, cluster, and berry weights were measured and pH, titratable acidity, and SSC were analyzed as described above. In addition, juice color was quantified from absorbance at 420 nm in a 10-mm cell with a double-beam spectrophotometer (Zoecklein et al., 1990). The experiment was analyzed as a 2×3 factorial with a minimum of five single-vine replicates for each training system at each level of pruning severity. In addition, data were pooled for both training systems and subjected to regression analyses by the general linear model procedure (SAS Institute, 1985).

The training systems/pruning severity experiment of 1988 was repeated in 1989, with one modification: The number of nodes per vine was 50, 70, 90 (as in 1988), and 110. Vines with 110 nodes were selected from vines pruned to 90 nodes in 1988. The number of buds from count (node) and non-count (other than node) positions were counted 15-17 Mar. and 29-31 Mar., and shoot length and shoot number were measured 24-27 Apr.

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Table 1. Relationship between number of nodes, buds, and shoot production and yield for *Vitis* hybrid 'Suwannee' (1988). Data for bilateral cordon- and cane-trained vines were pooled.

Dependent variable ^z	Independent variable (no. retained)	Equation	Significance ^y		
			r ²	Terms	Model
Shoot production	Node	y = 82.17 + 0.336x	0.14	L**	**
	Bud	y = 69.96 + 0.367x	0.21	L***	***
Yield	Shoot	y = 176.7 - 5.00x + 0.050x ² - 0.0016x ³	0.24	L*Q*C*	**

^zOnly significant relationships are presented. Cluster and berry weights, pH, titratable acidity, soluble solids concentration, and color were not significantly affected by the independent variables.

^yLinear (L), quadratic (Q), and cubic (C) components and overall model significant at $P = 0.05$ (*), 0.01 (**), or 0.001 (***), based on F values.

Table 2. Effect of training system, level of pruning severity, and number of nodes retained on shoot production, shoot length, and berry weight of *Vitis* hybrid 'Suwannee' (1989).

Training system ^z	Nodes retained (no.)	Shoot production		Berry wt (g)
		No.	Length (cm)	
Cordon	50	89	101	3.1
	70	104	100	3.4
	90	104	104	3.3
	110	141	93	3.2
Cane	50	81	89	3.1
	70	89	100	3.2
	90	111	108	2.8
	110	119	86	3.0
Training system		NS	NS	*
Node no.		***	*	NS

^zOnly significant relationships are presented: yield, cluster weight, pH, titratable acidity, soluble solids concentration, and color were not affected by training system or node number. All training system × node number interactions were not significant.

NS,*,***Nonsignificant or significant at $P = 0.05$ or 0.001 , respectively.

The experiment was analyzed as a 2×4 factorial, with a minimum of five single-vine replicates for each treatment. Data were also pooled for both training systems, as in 1988, and analyzed by regression procedures (SAS Institute, 1985). Vines were hand-harvested 17 July. Berry weight was estimated from a 10-berry sample. Yield, cluster weight, pH, titratable acidity, and SSC were determined as described previously.

Yield, cluster weight, pH, titratable acidity, and SSC differed by no more than 5% to 10% for BC-trained and cane-trained vines during 1987 and none of the differences were significant (data not shown). In 1988, there were no significant main effects (training system or node number) or significant interactions (data not shown). Despite a rather wide range in level of pruning severity (50 to 90), the number of shoots per vine were similar (95 to 108). Remaining variables [yield (15.3-19.1 kg/vine), cluster weight (108-143 g), berry weight (3.1-3.4 g), pH (3.50-3.59), titratable acidity (0.81% to 0.88%), SSC (12.4-13.7), and color (abs at 420 nm 0.308-0.362)] were also similar across treatments. BC- and cane-trained vines were analyzed collectively since dependent variables were not affected by training system. Few significant correlations occurred when the dependent variables were related to the independent variables, number of nodes, buds, and shoots (Table 1). Shoot count was weakly correlated with number of nodes ($r^2 = 0.14$) and buds ($r^2 = 0.21$), with a linear model. Yield was weakly correlated with number of shoots ($r^2 = 0.24$), with a cubic model.

Shoot production was significantly affected by number of nodes in 1989, yet a

120% increase in the latter translated into only a 50% increase in the former (Table 2). The number of shoots produced increased 20% when the 50- and 90-node treatments were compared. The only other significant effect associated with number of nodes was shoot length. Yield was conspicuously low in 1989 (4.4 to 7.4 kg/vine), after high yields during 1988 for all treatments. A higher berry weight for the BC-trained vines was the only significant training-system effect. The range of values of other dependent variables were as follows: cluster weight (60-82 g), pH (3.25-3.47), titratable acidity (1.00-1.19), and SSC (12.5-14.7). No significant training system node interactions occurred for any variable.

Dependent variables were compared to the number of nodes, buds, and shoots for 1989 data (Table 3). Shoot production was positively correlated with number of nodes and buds. Conversely, shoot length was inversely correlated to these variables. Yield was weakly correlated with number of nodes and shoots.

Training system and levels of pruning severity had little or no influence on yield and quality of 'Suwannee' grapes. Cane pruning is considered to be among the most difficult and costly of all training systems (Winkler et al., 1974), although it is currently the recommended training system for *Vitis* hybrid bunch grapes in Florida (Cox, 1986). The BC-training system is adaptable to mechanical pruning and harvesting, and experiments on *V. labrusca* cv. Concord have shown that yield and quality are similar to cane-pruning systems (Morris and Cawthon, 1980, 1981; Morris et al., 1984a, 1985). The BC-training

system is also currently used on many cultivars of *V. vinifera* in California (Kasimatis et al., 1985; Winkler et al., 1974). The major perceived impediment to a BC-trained system for *Vitis* hybrid bunch grapes in the southernmost United States is an accumulation of *Xylella fastidiosa* (the bacterium responsible for Pierce's disease) in the xylem vessels of the cordon (J. Mortensen, personal communication). If this becomes a limitation of the BC-system, then cordon renewal may eventually become necessary.

Some of the lack of effect of number of nodes retained may be ascribed to a relatively weak correlation between this variable and shoot production (Tables 1 and 3). Data from both training systems indicate that, in 1988, shoot count varied from 95 to 108 for node counts of 50 to 90. For the 50-node treatment, ≈50% of the shoots were derived from primary buds of nodes; the remainder were derived mostly from latent primary buds on the cordon, spurs (or cane), and to a lesser extent from secondary buds. The lesser the pruning severity, the greater the proportion of primary shoots derived from nodes. Clearly, since yields of the two training systems were not significantly affected by level of pruning severity, shoots emanating from other areas of the vine were about as productive as primary shoots derived from nodes.

Similarly, the percentage of total yield derived from nodes (count positions) or non-count positions of French-American hybrid grapes varies with training system and level of pruning severity (Howell et al., 1987; Pool et al., 1978; Wolpert et al., 1983). Jackson et al. (1984) found that *V. vinifera* pruned less severely produced a lower number of shoots per node, although yield was sometimes increased with many nodes due to a higher number of clusters per shoot. In our study, when pruning levels ranged from 50 to 110 nodes per vine, the number of nodes and shoots were positively correlated (Table 2). Although for each training system an increase in shoot production did not translate into an increase in yield or change in quality of the fruit in either year, the combined data indicated that yield was weakly correlated to the number of shoots in 1988 (Table 1) and to the number of shoots and nodes in 1989 (Table 3).

In conclusion, 'Suwannee' grape appears to be amenable to a BC-training system without sustaining a reduction in yield or quality. Pruning to a specific number of nodes did not translate to a proportional number of shoots. Fruitfulness appeared to be largely self-regulating, in that great variations in level

Table 3. Relationship between number of nodes, buds, shoot production, and yield for *Vitis* hybrid 'Suwannee' (1989). Data for bilateral cordon- and cane-trained vines were pooled.

Dependent variable ²	Independent variable (no. retained)	Equation	r ²	Significance ³	
				Term	Model
Shoot production	Node	y = 49.38 + 0.703x	0.63	L**	***
	Bud	y = 34.67 + 0.64x	0.83	L***	***
Shoot length	Node	y = -25.4 + 2.02x - 0.013x ²	0.19	L**Q**	**
	Bud	y = 69.59 + 3.86x - 0.0268x ² + 0.000055x ³	0.35	NS	**
Yield	Shoot	y = -15.46 + 2.16x - 0.0100x ²	0.20	L**Q**	**
	Node	y = 2.77 + 0.0324x	0.14	L*	*
	Shoot	y = 0.382 + 0.048x	0.24	L***	***

²Only significant relationships are presented. Cluster and berry weights, pH, titratable acidity, soluble solids concentration, and color were not significantly affected by the independent variables.

³Linear (L), quadratic (Q), and cubic (C) components and overall model significant at $P = 0.05$ (*), 0.01 (**), or 0.001 (***), based on F values.

of pruning severity had little or no influence on yield or quality. Pruning *Vitis* hybrid 'Suwannee' to a specific number of nodes was not a sufficiently precise method to manipulate crop load. Cluster thinning may be a reasonable alternative to regulate yield and quality, as in many cultivars of French-American hybrid grapes (Howell et al., 1987; Pool et al., 1978; Wolpert et al., 1983). It is not clear whether the performance of other *Vitis* hybrids, such as 'Stover' or 'Blanc DuBois', is similar to that of 'Suwannee'; thus, one must avoid treating *Vitis* hybrid cultivars adapted to the southernmost United States collectively until provided with the quantitative data.

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