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Influence of Training System, Pruning Severity, and Spur Length on Yield and Quality of Six French-American Hybrid Grape Cultivars

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A four-year study was conducted on three red and three white commercially important French-American hybrid grape cultivars to determine their responses to training systems, pruning severities, and spur lengths. Chelois and Chancellor, both red, were the highest yielding cultivars, and Chelois was the most vigorous. Verdelet and Aurore, both white, were the lowest yielding cultivars, but had higher percent soluble solids and lower acidity at harvest than the higher yielding red cultivars. Regression analysis showed that the Verdelet and Aurore cultivars had a higher pH at a given percent soluble solids than did Seyval (white), Villard Noir (red), Chelois, and Chancellor cultivars. All cultivars except Aurore had higher yields on the Geneva Double Curtain (GDC) training system than on the single-wire, bilateral cordon system. Training system had no effect on pH or acidity, but the GDC training system produced lower percent soluble solids. There were no differences between the 10 + 10 and 20 + 10 pruning severities on yield, pruning weight or quality parameters, probably due to the productivity of noncount nodes. No differences occurred between the two-node spurs and the four-node spurs on yield, pruning weight, or quality parameters.

Extensive research has been conducted on fruit load or pruning severity (2,8,9,10,12,13,14,15,16), training systems (8,9,16,17) and spur lengths (11,20) of *Vitis vinifera* and *Vitis labrusca* cultivars. Although Wagner (18) has made general characterizations of many French-American hybrid cultivars as to their suitability for wine production, most research efforts on the French-American hybrids have been largely cultivar evaluations with little research work on fruit load (3,4,5,19) and training systems (3,6). The French-American hybrid cultivars have allowed for wine grape production in areas where *Vitis vinifera* cultivars could not withstand either the climate or disease pressure, and a major portion of the wine produced in Arkansas is made from these cultivars. This study evaluated six French-American hybrid cultivars commercially important in Arkansas, on Geneva Double Curtain and single-wire, bilateral cordon training systems at two balanced pruning levels with two spur lengths.

Materials and Methods

This four-year (1977-80) study was conducted in a vineyard of French-American hybrid grapes established in 1974 at the Arkansas Agricultural Experiment Station, Fayetteville. The vineyard contained six cultivars: three red cultivars - Chelois (Seibel 10-878), Chancellor (Seibel 7053), and Villard Noir (Seyve-Villard 18-315); and three white cultivars - Verdelet (Seibel 9110), Seyval (Seyve-Villard 5-276), and Aurore (Seibel 5279). Vines were spaced 2.44 meters within the rows and 3.05 meters between the rows.

Treatments were type of cultivar, pruning severity, level of nodes per spur and training systems. Pruning severities consisted of 10 + 10 and 20 + 10 schedules: 10 or 20 nodes retained for the first 454 grams of one-year-old dormant prunings and 10 additional nodes retained for each additional 454 grams of prunings removed. Vines were pruned to either two or four nodes per spur. The training systems used were a Geneva Double Curtain (GDC) and a single wire-bilateral cordon system (BC) on a 1.8 meter high trellis. The experimental design was a 2 x 2 x 2 x 6 factorial with two replications of two-vine plots.

Representative samples of three clusters from count nodes, nodes which were counted during balanced pruning, were selected from each plot at three separate stages of fruit maturity. The first sample from each cultivar was taken when the BC, four-node, 20 + 10 treatment vines reached a soluble solids percentage of approximately 12.5. The next sample was taken about seven days later, and the final sample was taken about 14 days later, at fruit harvest. Samples were placed in non-vented polyethylene bags and frozen for later quality analyses. In 1978, 1979 and 1980, fruit from non-count nodes, basal buds which were not counted during balanced pruning, was harvested separately from fruit from count nodes to determine their respective yields. In 1977, the fruit from count and noncount nodes were not kept separate.

Quality analyses were conducted by thawing frozen samples in a cold room at 2°C overnight. Berries were separated from the stems, and samples were blended for 15 seconds in a laboratory blender and allowed to warm to 20°C. Percent soluble solids was determined using a Bausch and Lomb Abbe refractometer. Beakers containing the blended samples were covered with watch glasses, placed in a water bath at 85°C for one hour, and then allowed

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to cool to 20°C. To remove pulp and seeds, samples were strained through two layers of grade 50 cheesecloth. A 5-mL aliquot of centrifuged juice was diluted to approximately 150 mL with deionized water, the initial pH was recorded, and the samples were titrated to pH 8.4 with 0.1 N NaOH. Titratable acidity was recorded as mL of 0.1 N NaOH used per 5 mL of juice and converted to percent tartaric acid.

All data for each year and all years together were subjected to analysis of variance and F test using the University of Arkansas Statistical Analysis System (SAS). Duncan's multiple range test at the 5% level was used to separate means of the main effects, and least significant difference (LSD) was used to separate means of the interactions.

Results and Discussion

Over four years, Chelois and Chancellor had the highest mean yields followed by Villard Noir and Seyval (Table 1). Aurore and Verdelet were the lowest yielding cultivars, with the early maturing Aurore having slightly higher yields than Verdelet. In each of the four years, Aurore was the earliest maturing cultivar and Villard Noir was the latest maturing cultivar (data not shown). Yearly yields were similar to the four-year mean with the exception of 1977, when Verdelet had comparable production with Villard Noir and Aurore. After the high yields on Verdelet in 1977 (the first fruiting year), this cultivar suffered severe winter injury during the winter of 1977-78. The winter injury was so severe that there were losses of many cordons and some entire vines. Verdelet is the most, cold sensitive of the six cultivars and, because of this injury, had low yields for the remainder of the study. Accurate yield determinations for Aurore in 1979 could not be made due to extensive damage to the fruit by birds. Even the lowest yielding cultivars produced commercially acceptable yields (above 12 tonne/ha) for the 4-year mean.

Table 1. Mean yield (t/ha) by cultivar, training system, pruning severity, and spur length, 1977-1980.

	Year				
Treatment	1977	1978	1979	1980	1977-80
Cultivar					
Red					
Chelois	27.5a[z]	28.9a	19.4b	26.9a	25.6a
Chancellor	24.7ab	24.1b	25.2a	22.4b	24.1a
Villard Noir	22.2bc	21.4b	25.7a	17.0c	21.6b
White					
Seyval	23.3b	22.8b	18.4b	15.8c	20.1b
Aurore	16.9d	14.3c	----[y]	13.9cd	15.0c[y]
Verdelet	18.8cd	14.3c	7.3c	10.7d	12.7d
Training System					
Bilateral Cordon	20.3b	18.9b	18.1a	16.6b	18.5b
Geneva Double Curtain	24.2a	23.0a	20.3a	19.0a	21.7a
Pruning Severity					
10 + 10	22.5a	20.6a	20.0a	17.5a	20.1a
20 + 10	22.0a	21.3a	18.4a	18.1a	20.0a
Spur Length					
2 nodes	22.9a	21.0a	18.9a	17.8a	20.2a
4 nodes	21.6a	20.9a	19.5a	17.8a	20.0a

[z] Means within treatments and years separated by Duncan's multiple range test, 5% level.

[y] Bird damage prevented accurate yield determination. x yield for 3 years only.

Yields were measured on count positions for three years. During that period, Villard Noir had the greatest percentage of total yield from count positions, but this was due to the extremely high yields on count positions in 1979. Since noncount buds of these cultivars were so productive and there was a mean difference of only 6.9% between the 10 + 10 and the 20 + 10 pruning schedule (Table 2), it is obvious that these French-American hybrid cultivars cannot be effectively balanced pruned.

The high-yielding Chelois also had the highest pruning weights for each year and for the four-year mean (Table 3). In general, the other five cultivars had similar vine vigor for the four-year mean. As a result of a severe drought during 1980, extremely low pruning weights were obtained for all cultivars during this growing season. This season had the lowest rainfall (23 cm), the highest accumulation of degree days (3484), and the most days (19 days) over 37.8°C (100°F) since 1936.

Table 2. Percent total yield from count positions by cultivar, training system, pruning severity, and spur length, 1978-1980.[z]

Treatment	Year 1978	1979	1980	1978-80
Cultivar				
Red				
Chelois	52.3a[y]	46.0bc	63.7a	54.0b
Chancellor	57.2a	23.9d	48.2b	43.1d
Villard Noir	51.0a	81.0a	58.2a	63.4a
White				
Seyval	52.9a	37.8c	44.8b	45.2cd
Aurore	52.1a	----[x]	39.3b	45.7cd
Verdelet	55.7a	53.2b	48.1b	52.4bc
Training System				
Bilateral Cordon	53.9a	46.8a	55.7a	52.4a
Geneva Double Curtain	53.2a	50.0a	45.1b	49.4a
Pruning Severity				
10 + 10	50.3b	46.1a	45.8b	47.5b
20 + 10	56.8a	50.7a	54.9a	54.4a
Spur Length				
2 nodes	54.2a	44.5a	50.0a	49.9a
4 nodes	52.9a	52.3a	50.8a	52.0a

[z] Fruit from count and non-count positions were not separated in 1977.

[y] Means within treatments and years separated by Duncan's multiple range test, 5% level.

[x] Bird damage prevented accurate yield determination.

Table 3. Pruning weight (kg/vine) by cultivar, training system, pruning severity, and spur length, 1977-1980.

Treatment	Year 1977	1978	1979	1980	1977-80
Cultivar					
Red					
Chelois	1.5a[z]	2.0a	2.6a	0.9a	1.8a
Chancellor	0.8cd	1.1b	1.1b	0.6b	0.9b
Villard Noir	0.4e	1.1b	1.1b	0.4cd	0.7bcd
White					
Seyval	1.2b	0.7c	1.1b	0.3d	0.8bc
Aurore	0.9c	0.6c	0.8bc	0.6b	0.7cd
Verdelet	0.5de	0.9b	0.6c	0.4c	0.6d
Training System					
Bilateral Cordon	0.9a	1.1a	1.3a	0.5a	1.0a
Geneva Double Curtain	0.9a	1.0b	1.2a	0.5a	0.9a
Pruning Severity					
10 + 10	0.9a	1.1a	1.2a	0.5a	0.9a
20 + 10	0.9a	1.1a	1.2a	0.5a	0.9a
Spur Length					
2 nodes	0.9a	1.1a	1.2a	0.5a	0.9a
4 nodes	0.9a	1.0a	1.3a	0.5a	0.9a

[z] Means within treatments and years separated by Duncan's multiple range test, 5% level.

The lowest yielding cultivars, Aurore and Verdelet., had the highest percent soluble solids at harvest during the four-year study (Table 4). All red cultivars produced lower percent soluble solids at harvest than did the white cultivars in the drought-stress year of 1980 and for the entire study.

Verdelet had the highest pH and lowest acidity values at harvest for two of the years, especially the drought stress year of 1980, and for the four-year mean (Tables 5 and 6). Across the four years, the white cultivars had higher pH and lower acidity values at harvest than did the red cultivars. These overall high pH values of the white cultivars may have resulted partially from blending the samples. Carter *et al*. (7) has shown that white grape samples blended in a Waring Blender were 0.2 to 0.3 higher in pH than samples prepared by grinding in a "Squeezo" strainer, pressing in a laboratory press or pressing in a potato ricer. The use of a nonblending method for sample preparation of the white cultivars would have given more representative pH values.

By harvest each year, all cultivars, with the exception of Chancellor in 1977, had developed higher pH values than recommended by Amerine *et al*. (1) for red wine (less than 3.4) and white wine (less than 3.3) (Table 5). Although the pH values were high for all cultivars by harvest, the acids were acceptable (above 0.60) for all years with the exception of Verdelet during the dry-hot season of 1980 (Table 6).

The increase in pH with each increase in percent soluble solids was similar in all red cultivars and Seyval as indicated by regression analysis (Figs. 1 and 2). However, Aurore and especially Verdelet had a more rapid increase in pH with an increase in percent soluble solids. The decline in acidity with each increase in percent solids was greater in Verdelet than in the other five cultivars (Figs. 1 and 2). The other cultivars lost acidity at about the same rate as the percent soluble solids increased.

The main effects of training system indicated that, across the four seasons, the GDC training system produced higher yields than the BC system (Table 1). However, Aurore did not benefit from the GDC training system (Fig. 3). In the high yielding year of 1977, Verdelet produced higher yields on the GDC system, but not during the remainder of the study where yields were low (data not shown). The GDC training system was a superior training system under conditions of high fruit loads. This increase in yield from the GDC system was not a result of increased pruning weights (Table 3).

The GDC training system produced fruit that was lower in percent soluble solids at harvest than the BC system for two of the years and for the four year mean (Table 4). This result was probably directly related to the higher yields produced by the GDC system. However, over the four year period, there were no differences in pH (Table 5) or acidity (Table 6) at harvest between the training systems.

Table 4. Percent soluble solids by cultivar, training system, pruning severity, and spur length, 1977-1980.

	Year				
Treatment	1977	1978	1979	1980	1977-80
Cultivar					
Red					
Chelois	18.2a[z]	15.5b	17.2b	14.8c	16.4c
Chancellor	17.1b	16.3ab	16.6b	14.8c	16.2c
Villard Noir	17.0b	16.4ab	16.9b	15.1c	16.4c
White					
Seyval	16.9b	17.1a	17.6b	17.5b	17.3b
Aurore	19.0a	17.0a	18.8a	17.6b	18.1a
Verdelet	16.2b	17.6a	19.5a	20.1a	18.3a
Training System					
Bilateral Cordon	17.6a	17.2a	17.6a	17.2a	17.4a
Geneva Double Curtain	17.2a	16.1b	17.9a	16.1b	16.8b
Pruning Severity					
10 + 10	17.4a	16.9a	17.9a	16.9a	17.1a
20 + 10	17.4a	16.4a	17.6a	16.6a	17.0a
Spur Length					
2 nodes	17.3a	16.7a	17.7a	16.9a	17.1a
4 nodes	17.5a	16.7a	17.9a	16.4a	17.1a

[z] Means within treatments and years separated by Duncan's multiple range test, 5% level.

Table 5. Fruit pH by cultivar, training system, pruning severity, and spur length, 1977-1980.

	Year				
Treatment	1977	1978	1979	1980	1977-80
Cultivar					
Red					
Chelois	3.80ab[z]	3.69c	3.61bc	3.78c	3.72bc
Chancellor	3.47d	3.79abc	3.68ab	3.70cd	3.66c
Villard Noir	3.63c	3.73bc	3.66ab	3.63d	3.66c
White					
Seyval	3.75b	3.69c	3.74a	3.91b	3.77b
Aurore	3.85a	3.80ab	3.68ab	3.78c	3.77b
Verdelet	3.63c	3.88a	3.58c	4.32a	3.85a
Training System					
Bilateral Cordon	3.68a	3.80a	3.66a	3.87a	3.76a
Geneva Double Curtain	3.69a	3.73b	3.66a	3.83a	3.73a
Pruning Severity					
10 + 10	3.68a	3.77a	3.66a	3.87a	3.74a
20 + 10	3.69a	3.76a	3.66a	3.84a	3.74a
Spur Length					
2 nodes	3.69a	3.75a	3.64a	3.85a	3.73a
4 nodes	3.69a	3.78a	3.67a	3.85a	3.75a

[z] Means within treatments and years separated by Duncan's multiple range test, 5% level.

Table 6. Percent tartaric acid by cultivar, training system, pruning severity, and spur length, 1977-1980.

Treatment	Year				
	1977	1978	1979	1980	1977-80
Cultivar					
Red					
Chelois	0.76d[z]	0.99a	1.07a	0.68b	0.87a
Chancellor	0.92a	0.80c	0.93bc	0.74a	0.84a
Villard Noir	0.88ab	0.90b	1.00ab	0.75a	0.88a
White					
Seyval	0.81cd	0.89b	0.86c	0.60c	0.79b
Aurore	0.77d	0.80c	0.77d	0.64c	0.74c
Verdelet	0.83bc	0.76c	0.84cd	0.35d	0.69d
Training System					
Bilateral Cordon	0.83a	0.85a	0.91a	0.63a	0.80a
Geneva Double Curtain	0.82a	0.86a	0.91a	0.63a	0.80a
Pruning Severity					
10 + 10	0.83a	0.84b	0.90a	0.62a	0.80a
20 + 10	0.82a	0.87a	0.92a	0.63a	0.81a
Spur Length					
2 nodes	0.83a	0.86a	0.90a	0.63a	0.81a
4 nodes	0.82a	0.85a	0.92a	0.62a	0.80a

[z] Means within treatments and years separated by Duncan's multiple range test, 5% level.

At harvest, there were no differences in yield (Table 1), pruning weight (Table 3) or quality attributes (Tables 4,5,6) between the 10 + 10 and 20 + 10 pruning severities nor between the two-node spur length and four-node spur length. However, for the four-year mean, the 20 + 10 pruning severity resulted in greater yield from the count positions (54.4% of total yield) as compared with the 10 + 10 pruning severity (47.5% of total yield).

Conclusions

All six of the cultivars produced commercially acceptable yields with an average yield above 12 tonne/ha. However, Verdelet had low yields for the last two years of the study due to winter injury. All cultivars had similar pruning weights with the exception of Chelois, which had twice the dormant pruning weight of the next most vigorous cultivar.

The white cultivars had higher percent soluble solids and pH and lower acidity than did the red cultivars. All cultivars had excessively high pH values and low percent soluble solids, indicating a need for early harvesting and amelioration. The pH of Verdelet and Aurore increased at a faster rate during the development of soluble solids than the pH of the other cultivars.

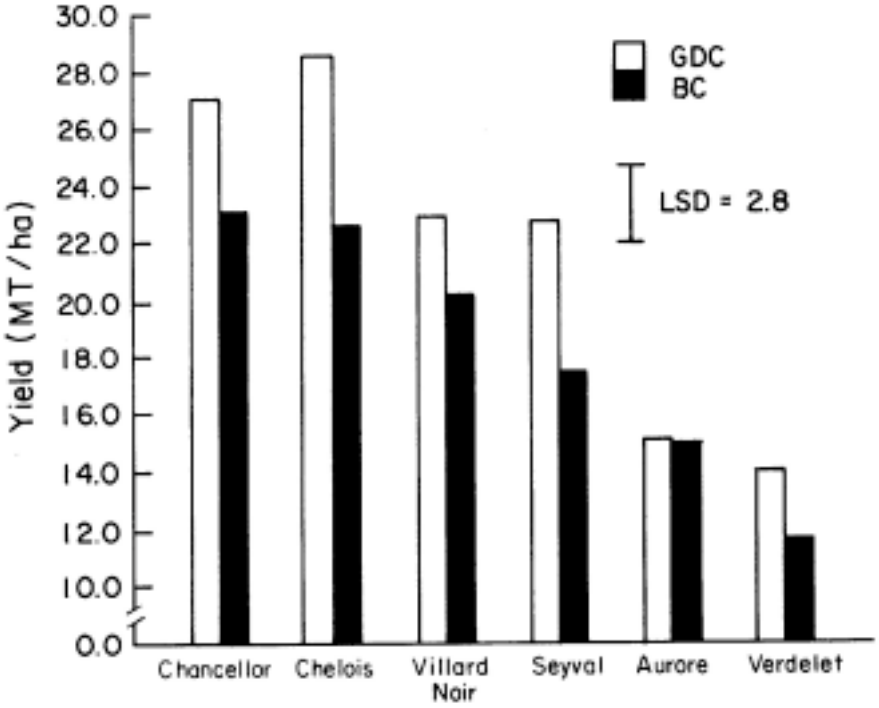

Fig. 3. Interactive effects of cultivar × training system on yields of French-American hybrid grapes (4-year mean).

(Figures 1 & 2 are out of order. Please see next page)

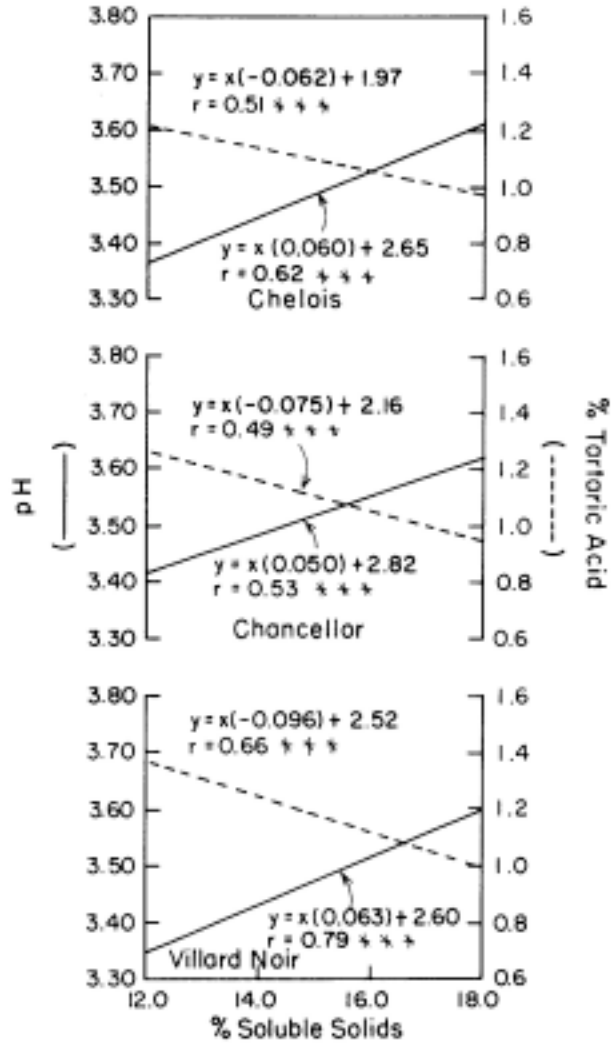

Fig. 1. Relationship between % soluble solids and pH in juice of Chelois, Chancellor and Villard Noir (4-year mean).

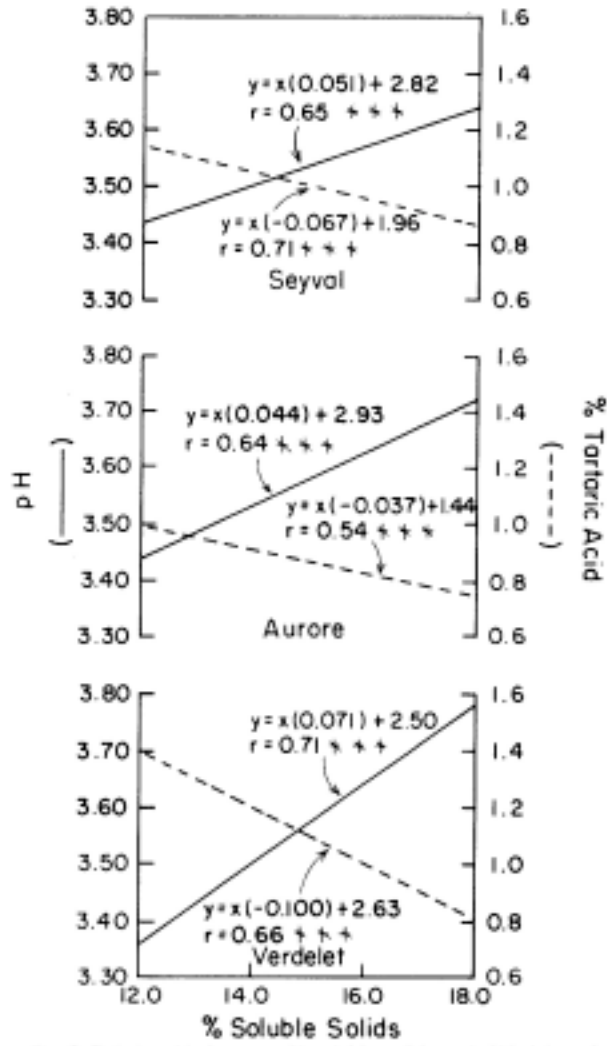

Fig. 2. Relationship between % soluble solids and pH in juice of Seyval, Aurore and Verdelet (4-year mean).

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All cultivars except Aurore were more productive and had higher percent soluble solids on the GDC system than on the BC system. Since the yield increases on the GDC system did not result from increased vine vigor, the GDC system probably resulted in superior bud development and light distribution in the canopy. There were no differences in pH or acidity between the two training systems.

There were no differences in yield, vine vigor, or quality between the 10 + 10 and 20 + 10 pruning severities and only a small difference in percent of total yield from count positions between the two pruning severities. The basal buds that are in non-count positions were highly productive and, thus, prevent the use of the traditional balance pruning method currently used on Vitis labrusca cultivars. The two-node and four-node spur length also produced no difference in yield, vine vigor or quality, indicating equal bud development along the spur.

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