

Final Report for research supported by the New York Wine and Grape Foundation

**Effect of Pruning, Training, Thinning, and Shoot Positioning on the Yield and Quality of
'Concord' Grapevines**

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The goal of the Concord juice grape industry in Western NY is to maximize grape yield per acre, minimize production costs, and maintain or increase juice quality. Although the attainment of this goal would deliver maximum profitability for Concord growers, the elements of the goal have inherently opposing processes. For example, it has been shown that minimal pruning can decrease production costs while increasing yield but the negative relationship between yield and juice soluble solids delays fruit ripening under that viticulture practice. Geneva Double Curtain training has been shown to increase both yield and juice soluble solids over single curtain; however, production costs increase with GDC. Production systems that strike the most profitable balance between yield, quality, and production cost need to be identified and evaluated within Concord production regions.

This project represents the New York component of a three-state cooperative project on the production and juice quality of Concord grapes. In the cooperative project, Concord grapes were grown under similar production systems in New York, Michigan, and Washington and harvested at a pre-determined level of ripeness ($16^{\circ}\text{brix} \pm 0.5$ East, $16.5^{\circ}\text{brix} \pm 0.5$ West). Vegetative, yield, juice and climatic data were compared between the production treatments as well as between the three production regions.

Objectives for New York Project:

To evaluate the effect of pruning severity, training systems, crop adjustment, and shoot positioning on the yield and quality of Concord grapevines.

To identify vineyard management practices that lead to the most profitable relationship between yield, juice quality, and production costs.

Objectives for Three-State Cooperative Project:

To determine the impact of seasonal growing conditions and crop management practices on Concord yield and juice quality.

To develop predictive models and crop management strategies to enable growers to control and manipulate yield and juice quality.

Configuration of the three-state juice quality experiment

Treatments	NY	MI	WA	Figure Key
Balanced pruned (50+10)			X	Bal*
Balanced pruned (20+20)	X	X		Bal*
Balanced pruned (20+20) w/ shoot positioning	X	X		BalSP
90 Nodes (fixed)	X	X		Node90
130 Nodes (fixed)	X	X	X	Node130
Mechanical pruned w/ sidecut and vine separation (target 260 nodes)	X	X	X	Mec
Minimal pruned	X	X	X	Min
Minimal pruned w/ shoot positioning	X	X		MinSP
Minimal pruned w/ crop adjustment	X	X		MinCA
Mechanical pruned w/ crop adjustment			X	MinCA*
90 Node Geneva Double Curtain	X			GDC90
130 Node Geneva Double Curtain	X		X	GDC130
260 Node Geneva Double Curtain	X		X	GDC260

Results

The following figures show the five year average from each treatment and from each state in the study. Different letters above the bars indicate a difference in means at the 5% level as determined by Duncan’s multiple range test.

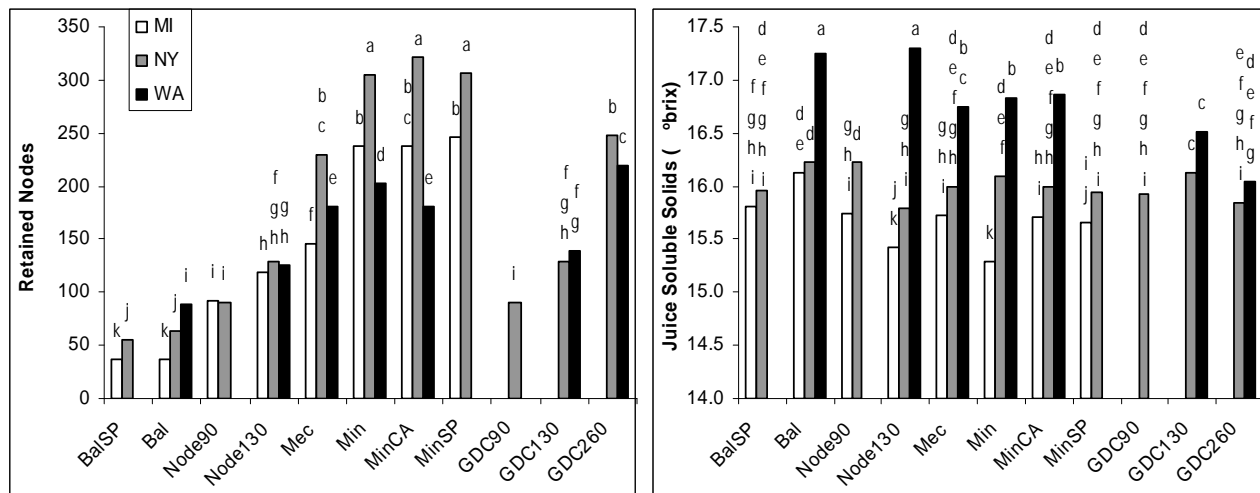


Figure 1: Confirmation of imposed treatments and target juice soluble solids at harvest.

The pruning treatments of the project gave a range of retained nodes per vine in each of the states and for both HRU and GDC. In New York, retained nodes ranged from 50 in balanced pruned vines to over 300 in minimal pruned crop adjusted vines.

The original goal of the project was to harvest all the treatments a pre-determined juice soluble solids level (16 °brix in the East and 16.5 °brix in the West ± 0.5). All eleven treatments in NY were within the established °brix range. On average, Michigan was low on Node130 and

Min pruned vines and Washington was high on Bal and Node130 pruning; however, the target was only missed by a few tenths of a degree.

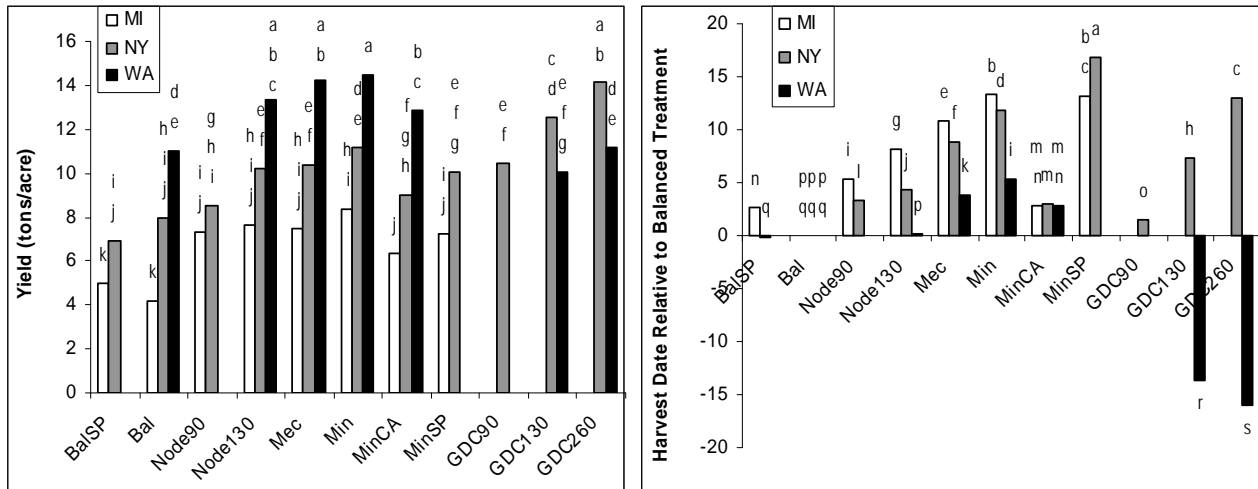


Figure 2: Yield and Relative Harvest Date

Increasing retained nodes increased yield and relative harvest date in all three states. Relative harvest date is defined as the number of days it took a particular treatment to reach the target harvest juice soluble solids relative to balanced pruned vines.

The effect of retained nodes on yield was not linear and a yield plateau could be determined. In HRU vines in NY and WA, the yield plateau occurred at 130 nodes but the yield maximum was not the same between the two states. Maximum HRU yield in NY was 10.2-11.1 tons/acre and maximum HRU yield in WA was 13.4-14.5 tons/acre. The yield plateau in MI occurred at 90 nodes where the maximum yield was 7.6-8.4 tons/acre. Maximum yield in each of the states was probably a function of average vine size at the three different sites (see later discussion).

For GDC, the yield plateau was not conclusively reached in NY or MI and the maximum yield was 14.2 tons/acre for NY and 11.2 tons/acre for WA. Although the yield plateau for GDC was not reached in NY, field observations indicated that 260 node GDC vines were stressed under the high crop level. Leaving more than 260 nodes would probably not have led to additional yield potential.

MI had the greatest and WA had the least delay in relative harvest date with increasing node number with NY being intermediate to the two. Vine size may have influenced the difference between the states. The site in MI had relatively low, NY had intermediate, and WA had large vine size which influenced the rate of fruit maturation at a given crop level. Other influencing factors leading to higher sugar accumulation rates in WA may have been irrigation, greater GDD accumulation, and higher total solar radiation in WA.

Interestingly, the relative harvest date continued to increase even after the yield plateau had been reached in each state. For example, as the number of retained nodes was increased above 130 buds in NY, there was not a corresponding increase in yield; however, there continued to be an increase in relative harvest date and a decrease in ripe nodes of periderm. Above 130 retained nodes, the vines reached the point of “yield compensation.” A reduction in cluster weight (because of reductions in berry weight and berries/cluster) compensated for the increased

clusters/vine in the higher node number treatments. Therefore, yield does not continue to increase with increasing bud number.

The higher bud number treatments also marked a distinct change in canopy structure and density that influenced the rate of fruit and wood maturity. Shoot density was significantly greater and total leaf area was numerically greater in treatments above 130 nodes. However, the exposed or functional leaf area was not different, indicating that there was a significant proportion of shaded leaf area in the high bud number treatments.

Minimal pruning with shoot positioning was the most inefficient treatment of the study. Shoot positioning exaggerated the canopy shading of an already dense and shaded canopy. Those vines had unstable yields, late harvest dates, and low ripe nodes of periderm.

Thinning minimal pruned vines decreased the crop, decreased the relative harvest date, and increased the ripe nodes of periderm over minimal pruned control vines. Therefore, thinning had a strengthening effect on the vines. The low cost of minimal pruning and the strengthening effect of crop thinning make the minimal thinned treatment an attractive option for low cost vineyard production. However, the shoot density and internal canopy shading of minimal pruned vines represents a risk to the overall system (i.e. high water use, inefficient shaded leaves). Caution should be used when practicing minimal pruning, with or without thinning, even on the best vineyard sites in New York.

In NY, GDC yielded 2-3 tons/acre more at the same harvest date or a 3-7 day earlier harvest for the same yield. If vine size can be produced and maintained so that sufficient leaf area can be produced to fill the trellis, GDC has been shown to increase both yield and quality (earlier harvest date) of Concord.

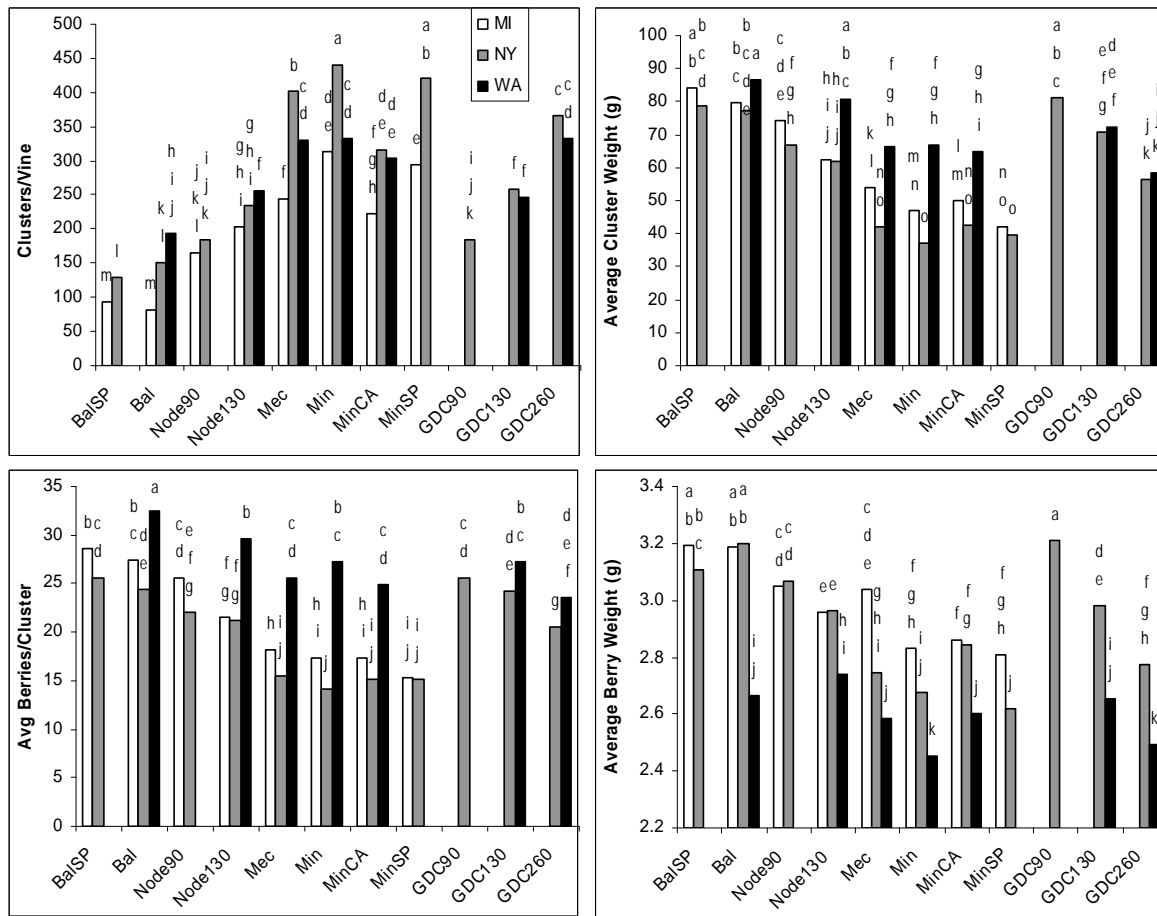


Figure 3. Components of Yield:

As the retained nodes increased, clusters/vine increased while cluster weight, berries/cluster, and berry weight decreased. This is the typical yield compensation pattern seen in other grapevine pruning studies.

When comparing a given treatment between states, WA had greater cluster weight because of greater berries/cluster. The greater fruit set in WA is probably a function of both greater solar radiation during the period of cluster development and better weather (more sun and higher temperatures) during bloom. WA also had lower berry weight than NY or MI.

NY GDC130 had greater berries/cluster, cluster weight, and clusters/vine than NY Node130. This again shows the advantage of increased light interception on vine productivity with GDC.

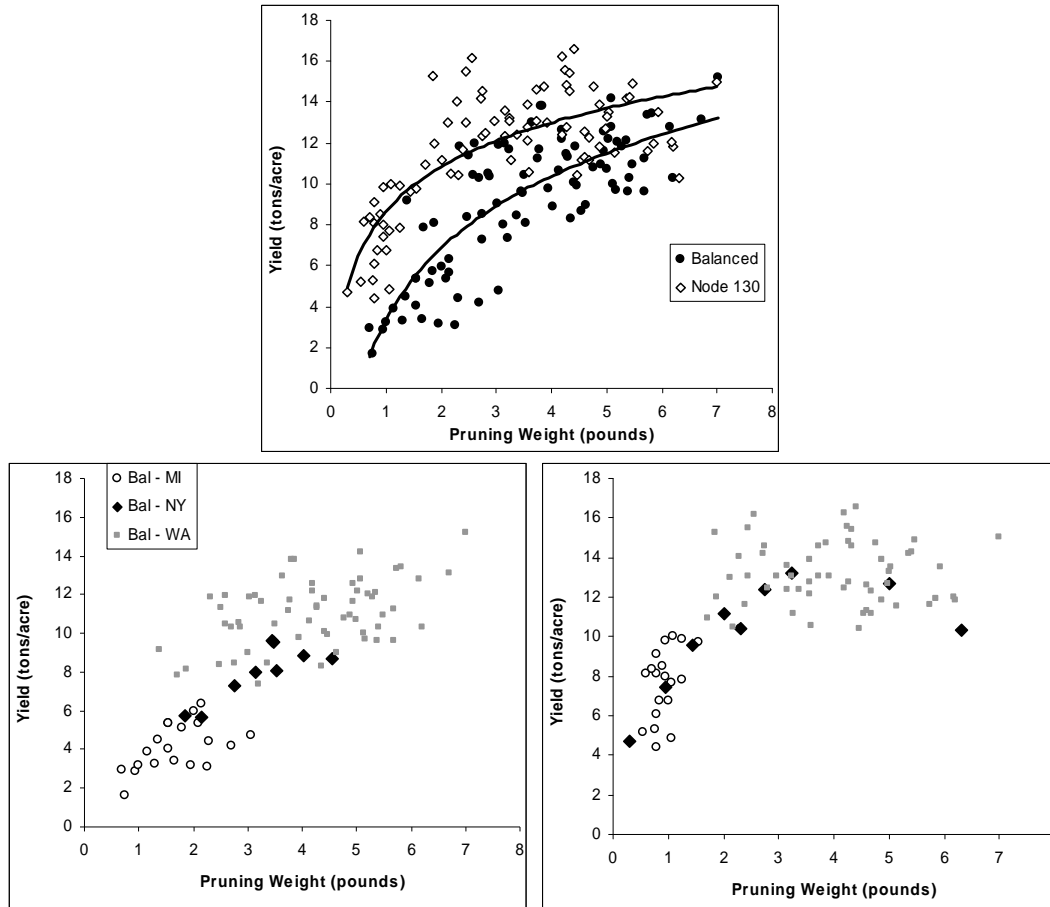


Figure 4. Pruning Weight and Yield:

As expected, pruning weight had a strong correlation with yield. The top figure shows the pruning weight – yield relationship of balanced pruned vines and Node130 vines. In this case, the data for all three states were pooled. In each state, average pruning weight decreased with increasing node number and yield. When comparing balanced pruning and 130 node pruning, balanced pruned vines retained fewer nodes with less crop. Consequently, more vine resources went into vegetative growth leading to greater pruning weight. Node130 pruning retained more buds forcing a larger crop and lower average pruning weight.

The bottom two figures show the same data as the top figure (balanced pruned on the left and Node130 on the right); however, the bottom figures break the data out according to state. WA had the highest pruning weight, NY was intermediate, and MI had the lowest pruning weight in the study across all the pruning treatments. These data clearly show that maximum Concord production is achieved when the vines have 3 pounds or more of pruning weight (at 9’x8’ spacing and HRU training) – a lesson that has been known for at least 50 years. The most stressful treatment in WA was better than the least stressful treatment in MI because the vine size in WA was so much greater than the vine size in MI. Whether it is climate, site, or management that achieves large vine size, it is this indicator of vine growth and health that is the best yardstick for productivity.

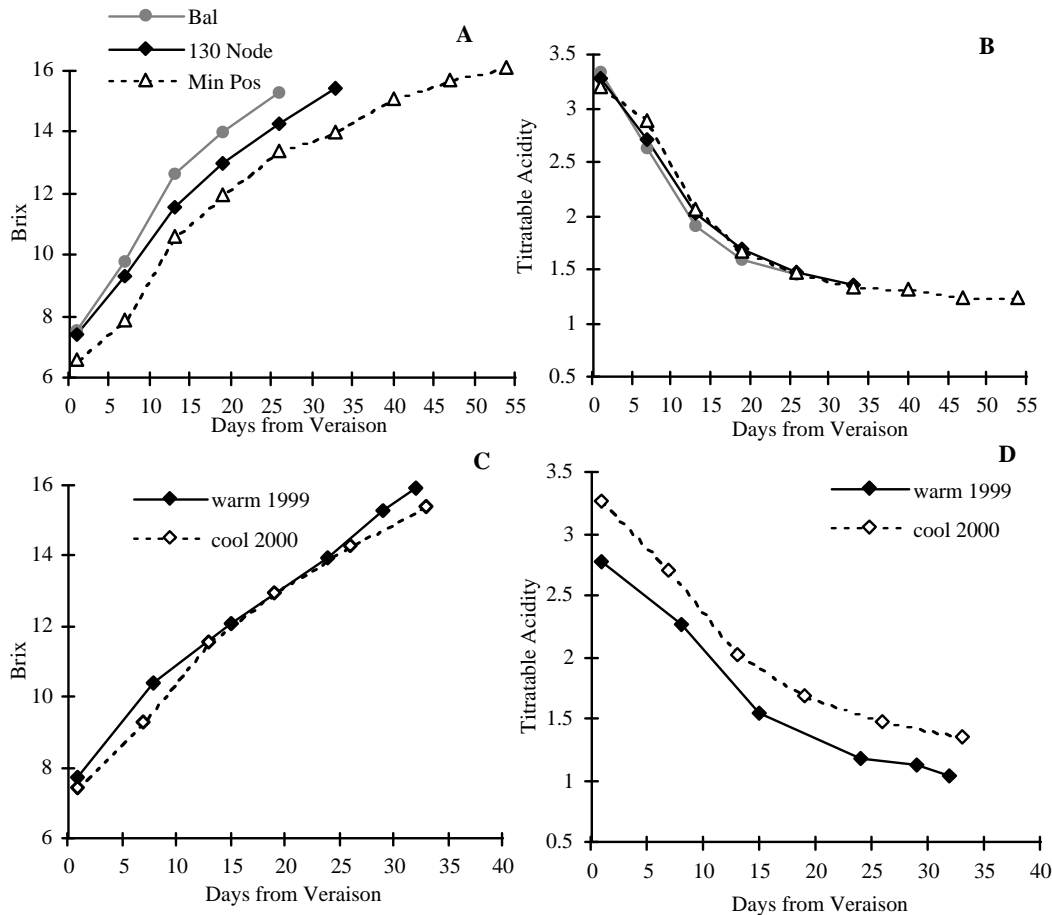


Figure 5: The effect of crop load on juice soluble solids (A) and titratable acidity (B) from veraison to harvest in a single year. The effect of year on juice soluble solids (C) and titratable acidity (D) from veraison to harvest on a single treatment. (all NY data)

Figure 5A shows that increasing crop load decreases the rate of sugar accumulation in the fruit. A dense and inefficient canopy with a lot of shaded leaf area can further delay brix accumulation and delay harvest. At veraison, Concord fruit is typically between 7 and 7.5 °Brix and veraison marks the point at which there is a rapid build up of sugars in the fruit. Although there can be year to year differences, Figure 5B shows that there is no effect of crop load on the reduction of juice titratable acidity (TA) in any given year. From other research done at the lab, vines with larger crops tend to have lower TA but this is usually not statistically different.

In addition to the effect of crop load on sugar accumulation within any given year, there can be differences in fruit development from year to year within a given crop load. Figure 5C shows sugar accumulation from veraison to harvest in a cool (2000) and a warm (1999) year when the vine crop load is held constant (fixed node pruning). Note: the data is based on “days from veraison” not “day of the year.” Veraison will be later in a cool year based on calendar date. At constant crop load there is little difference in sugar accumulation from year to year once veraison starts. On the other hand, the growing season heat accumulation can have a large effect on TA (Figure 5D). A cool year produces juice of higher acid because the berries enter veraison with higher acid concentrations. The literature indicates that temperatures during fruit

development stages other than fruit ripening (ie. stages I and II) can affect final fruit acidity. Theoretically, temperatures from veraison to harvest will determine the rate of acid reduction post-veraison. Unusually hot weather in late August and early September could increase the rate of acid reduction. However, the weather information shows how New York typically loses heat not gains heat during the same period. Therefore, temperatures in June and July may be more important in determining final TA in Lake Erie Concord fruit.

When comparing state differences, WA had high juice pH (3.4-3.5) and intermediate TA (1.0). NY had low pH (3.1-3.2) and high TA (1.1-1.4), and MI had intermediate pH (3.3) and low TA (0.8-0.9). There was a positive correlation between juice soluble solids and juice color. Since the fruit was harvested at a determined soluble solids concentration, there was little difference between treatments. MI tended to have higher average juice color which was probably related to low vine size and lower yield.

Conclusions

Many conclusions can be made from this study and much more useful information will come from the project as the data is further explored. There are general rules of vine physiology that are ubiquitous between the states, there are state to state differences in site and environment, there are differences between treatments within a state, and there are differences between vines within a treatment and within a state. The following are some general conclusions for efficient Concord production.

The relationship between vine size and yield is ubiquitous among sites. Optimum vine size (ie. 3.0 pounds of pruning weight, 9'x8' spacing, HRU training) has a larger impact on vine productivity than the method of pruning – within reasonable limits.

In both HRU and GDC treatments, less severe pruning leads to greater retained nodes, higher yield, and later relative harvest date. However, it is important to note that the relationship between retained nodes and yield is not linear. There is a point at which greater retained nodes does not translate into higher yields. Furthermore, excessive retained nodes leads to high shoot density and greater shaded leaf area which delays fruit and wood maturity at the same crop level.

GDC vines have greater exposed leaf area/acre than HRU vines. We continue to see the advantage of higher yields and higher juice soluble solids (or earlier harvest date for the same crop level) in Geneva Double Curtain.

Thinning minimal pruned vines increases the leaf area to fruit ratio and provides for an earlier harvest date. Thinning also appears to have a strengthening effect on the vines that is measured as greater ripe nodes of periderm and earlier leaf area development than standard minimal pruned vines.

Shoot positioning appears to have a negative effect on the growth of both balanced pruned and minimal pruned vines. In balanced pruned vines, shoot positioned vines have less pruning weight in years of similar crop levels or they do not have more pruning weights in years of lower crop levels. In minimal pruned vines, shoot positioning increases canopy leaf layers (average of 4.5 leaf layers on one side of the canopy), increases canopy shading, and delays both wood and fruit maturity.