



Balanced Vines and Balanced Pruning

In question are two separate issues: big vs. small vines and balanced vines. You can have balanced vines with both big and small vines. While pounds of fruit and brush will differ between the two, ratios of fruit to brush should be similar. Vine balance is something to strive for, no matter the terroir and no matter the price point of the resulting wine. Achieving balance, whether with big or small vines, is about manipulating the two elements of the fruit wt to brush wt ratio. If a vine is out of balance visually or according to Smart rules, you can either manipulate the fruit weight by leaving more or fewer buds at pruning or manipulate brush weight by watering or fertilizing more or less. A grower can manipulate to create a bigger vine that can be balanced with more fruit or to create a smaller vine with less but better fruit by watering less and fertilizing less. Rootstock selection and spacing decisions are more about what vine size you want than vine balance. Deciding on how big a vine should be is a separate issue from balance and it can be confusing when talked about together. So if we are exclusively talking about vine balance after all the decisions about vine size have been made, a grower can be measuring fruit and brush weight every year and still never be in complete balance. Shatter one year, greater than normal rainfall the next are examples of unpredictable factors that can influence balance. These all can affect the balance numbers. It is a process that needs constant adjustment and that hopefully will over time trend toward a more consistent balance. - Jeff Newton, Coastal Vineyard Care Associates. Santa Ynez, CA.

That's a great summary of the complexity of issues swirling around vine size and balance by friend and ace viticulturist, Jeff Newton. I'll try to go a step beyond his concise summary and explain some of the principles and ideas behind the concepts of vine size and balance. With pruning season upon us, it's a good time to think about balanced pruning and balanced vines. I wish there was a simple formula for achieving balance in vines but it is an elusive goal in most vineyards. Vineyards are dynamic systems, as are the conditions from year to year, so finding consistent balance is a real challenge. I am reminded by Jim Law that pruning in the East is confounding due to our tremendous variability, both intentional and unintentional among vines and vineyard blocks. This is its own problem. The cumulative effects of winter injury, differences in vine age (and, hence, vine size), differences in soil, vigor, species/cultivars of vines, vine density and trellis and yield goals all make it virtually impossible to make uniform recommendations.

In much of Eastern viticulture vine balance is critical to high quality wine production and the long term sustainability of the vineyard. Vine balance impacts two critical goals common to all wine growers in colder Eastern regions:

- Ripen fruit to full maturity for optimum wine quality
- Ripen wood to maximum maturity for cold hardiness

A vine in balance makes both of these goals more realistic and achievable. It is the result of careful site selection and evaluation, proper vineyard design, high quality vineyard development, utilizing viticulture best practices, and a lot of hard work and luck.

Small and close is definitely in vogue now, but it may not always be the best or fastest route to quality.

Size before Balance

Before balance can be achieved, vine size must be established. Vine size, and its associated balance, is determined by the terroir of a vineyard. Terroir, according to my definition, is the cumulative effects and interaction between soil, climate, plant, and viticulture on a vine. Each terroir will have its own peculiar effects on a vine and yield a vine of a particular size. A vine in a deep and fertile soil will grow to a bigger size than one in a shallow, well-drained, nutrient-depleted soil. Most soils in the East tend towards fertile with high water holding capacity, which are terroir characteristics that encourage bigger vines. To some extent, we are able to apply viticulture to the terroir equation and manipulate vine size with techniques and tools such as rootstocks, fertilizers, irrigation, etc. A particular terroir has its own kinetic potential (strength or vigor) which is expressed by a vine in its growth characteristics, both perennial (size of permanent parts like trunk and cordons) and annual vine vigor (growth of shoots, leaves, and fruit). Vigor is an important viticulture term that refers to the relative strength of a vine's growth during the growing season, but is subject to viticulture decisions and manipulations. For example, even on a deep, fertile soil, if you space vines 20 feet apart they will not fill the assigned trellis space. If vines are planted three to four feet apart in the same soil they will encroach on their neighbor's assigned space. Balance is that happy medium where a vine grows comfortably in its assigned three-dimensional space and yields fully mature fruit and wood at harvest. Once a vine's size has been determined, it is up to the grower to bring that vine into balance to optimize its form and function to produce the most of the best quality fruit possible.

A site needs to be analyzed for potential vine size and vigor before many critical decisions about rootstock, spacing and trellis can be made. In a place with many vineyards, like Napa Valley, that might mean looking across the fence at your neighbor's vineyard to see how big his vines grow on similar soils. But in the East, where with rare exceptions contiguous vineyards are absent, it means getting out a crystal ball and trying to divine what lies beneath the surface and how that, along with weather (soil moisture and heat) and the vine (rootstock and a variety's general size and vigor tendencies), will result in a vine of the desired size. The only way to do this is with a backhoe and a soil scientist who knows how to read soil physical properties. Also important are the results of soil tests, remembering that the numbers are only as useful as the expertise of the interpreter. Using this information, a judgment on site capacity can be made. It is a prediction. A grower will only know the truth about vine size once the vines are established.

Vines come in all shapes and sizes and are either in or out of balance. Vine balance is achieved when vine size and vineyard design are in harmony. It is important to note that no matter what the size of a vine, there is an associated balance that should produce good fruit. A vine trained to

Geneva Double Curtain on 14x8 spacing with 60 nodes has just as much need for balance as a small, guyot trained vine with 8 nodes on meter spacing. In both cases, if the vine is in balance the result will be better fruit quality. In the case of the GDC and other divided systems, the result is often more and better fruit. In my humble estimation, the very upper echelon of wine quality demands a small vine on a low capacity soil with ideal seasonal water inputs and the right nutrient balance and viticulture inputs. But very high quality wines in production quantities are possible with a bigger, balanced vine. The shades of variation in balance and its impact on the fruit, and hence wine quality, are infinite and, in many cases, indistinguishable, even to the educated palate.

Vine size and vine balance intermingle and must be understood as both separate yet interactive phenomenon. A vine of a particular size is grown according to expectations for the wine and the terroir. For example, white wine varieties are generally less fickle about size and balance than reds. Whites tend to make good wines over a wider range of ripeness so they are more flexible in their dimensions. Ideally, all components of terroir are in such proportions that a vine grows in balance within its natural size limitations, and the canopy size (measured in pruning weights) and crop size (measured in yield components) are available in just the right amounts to result in perfectly mature fruit at harvest. Of course, other factors such as weather, diseases, and pests will conspire to influence this scenario. When components of vine size take a vine out of balance, then viticulture comes to the rescue. After the fact or band-aid viticulture to control vine size is often difficult to execute and enforce. It may mean adjusting bud numbers by changing training systems, manipulating vine/water/nutrients relationships, or crop size. More enduring opportunities to change rootstock or even location are lost. That is why pre-plant decisions to create vine balance are so important.

The Utopian Vine

Let's say you picked just the right place on the planet to plant your vines. What is the wine potential? It will be influenced by vine size and the ability to achieve balance. Think of Pinot Noir in La Tache, or Syrah in Hermitage, Riesling along the Mosel, Cabernet Sauvignon in Oakville, or Merlot in Pomerol. These are rare examples of a convergence and agreement of terroir components in one small area supported by viticultural knowledge and experience accumulated over centuries that, when added up and interacting with a fine vintage year, result in great wine. These are examples of well balanced vines in extremely different terroirs. Can you visualize a cultivated vine in perfect natural balance? After being pruned to the proper node count, just the right number of shoots grow to the exactly the proper length and size – no shoot thinning, leaf plucking, or hedging is necessary – the resulting canopy is in perfect proportions. The vine sets the right amount of fruit relative to photosynthetic capacity so no cluster thinning is needed. Shoot growth ceases just before veraison and the fruit ripens to perfection. Nutrients and water are available in just the right amounts. Temperature is in the ideal range. Cane diameter, internode length, leaf area index, leaf size and color, and all the statistical measures of balance are achieved. Canes harden off fully before the deepest freezes of the winter arrive. In this scenario, the grower has minimal input. I'm not sure if this ever happens in viticulture, but I think it is important that every grower have a mental image of what a perfectly balanced vine would be like in his vineyard. It is a goal that a grower can strive for as we try to match the best soil, climate, and plant to minimize our viticulture inputs. But in the real world of growing wine, it is viticulture that gives us the ability to manipulate the vine into balance.

A balanced vine can be measured according to both qualitative and quantitative criteria. For the experienced viticulturist, there is certainly a visual sense of what a balanced vine looks like. Lucie Morton, a viticulture consultant in Virginia doesn't like pruning "by the numbers." She is more comfortable looking at each individual vine and pruning according to its needs. If it is undervigorous, prune harder to encourage next year's growth. If it is too vigorous, prune lighter and let it spread out its energy among more shoots. It takes many years of experience pruning and managing vines to understand these complex relationships and know how to properly prune a vine. A balanced vine just looks "right" from the front and sides, up close and from eight feet away. The measures constitute all the visual cues that comprise a quantitative analysis, but it is based on experience and is adjustable according to the evaluation of visual analysis and collected data. So a small vine on high density spacing on shallow soils will have a different set of measures than a large vine on a divided trellis on wide spacing. Both vines can be well balanced and have the potential to produce excellent quality fruit.

Tools to Balance Vines

Creating a balanced vine begins with balanced pruning in the dormant season. Balance pruning is a concept developed by Dr. Nelson Shaulis, the esteemed research viticulturist at Cornell University. It is best explained by the authors (all disciples of Dr. Shaulis) of *Cultural Practices for Commercial Vineyards...*

Balanced pruning is a research-developed technique that uses measurement – the weight of canes (the preceding summer's shoot growth) – node counting and a pruning formula for estimating vine capacity. It assumes the selection of well-exposed canes with fruitful buds. Each pruning formula (nodes per pound of cane prunings) is based on the growth and fruiting characteristics of the variety. Vine capacity can, and does, vary greatly between adjoining vines in a row. Balanced pruning, with an appropriate formula, avoids either overpruning or underpruning these vines of differing capacity and is the first step in achieving the annual desired quality, with maintained or improved vine capacity for the following year's crop.¹

Dr. Shaulis developed these principles mainly for native vine species in New York. He made correlations between the amount of biomass a vine produced in a season and how much it might expect to sustain in the following year. In order to make this correlation, brush weights are taken while pruning and an appropriate number of buds or nodes are assigned according to those weights. On Concord, as well as on other native species, the formula is 30 + 10, meaning 30 nodes for the first pound of brush and another 10 nodes for each additional pound of pruning weights. Concord vines tend to be large in size and mass and so 30 + 10 shouldn't cause a panic. It is not unusual to leave 120 nodes on a vine. Some recommendations are offered for hybrid varieties based on relative cluster size. For small clustered varieties like Foch and Leon Millot, 20 + 10 is suggested. Medium clusters such as Aurore at 10 + 10. And for large clusters like Chancellor and Seyval, the node count is 20 + 10 with the suggestion that supplemental flower-cluster thinning and suckering be used. Due to potential winter injury, recommendations for vinifera are cautious. The recommendation is for light pruning and adjusting to 20 + 20 with a maximum of 60 nodes on 8' vine spacing followed by flower cluster thinning. As with the balance parameters offered by Dr. Richard Smart, another disciple of Nelson Shaulis, these formulas are not etched in stone. They are guidelines that each grower should adjust according

¹ Cultural Practices for Commercial Vineyards. T.D. Jordan, R.M. Pool, T.J. Zabadal, J.P. Tomkins. Miscellaneous Bulletin 111. Cornell University. 1966.

to the specific performance of the vineyard. They are a starting point towards achieving vine balance. We will also see how total brush weights can be used to balance vines against other vine measures such as yield.

One frequently asked question about balanced pruning is if it is necessary to account for brush trimmed during the growing season. In a word, no. As long as brush is trimmed consistently from season to season, brush weights should be consistent. It isn't necessary to weigh each vine. In a uniform block of vines, a few vines per acre will give a good indication of brush weights. Areas of notable weakness or vigor should be weighed and node counts adjusted accordingly. The grower should then make an effort to understand why vines are under or overly vigorous and the proper viticulture solutions should be applied.

There are a variety of viticulture tools that can help to bring a vine into balance. Rootstocks are key among them. In the right application, they can have a dramatic impact on vine performance. Vine density and trellis choice are also important. Giving a vine room to stretch out and seek its natural balance point (nodes per linear foot of trellis) gives the grower a shot at high quality fruit. Soil moisture management, either adding through irrigation or removing with cover crop or vigor diversion techniques can help vine balance. Nutrient management is also an important tool.

Quantifying Vine Balance

Richard Smart travels around the world spreading the gospel of canopy management and vine balance. His book *Sunlight into Wine* is considered to be the bible of canopy management. In it, a set of "golden rules" of vine balance are offered. Ratios comparing measurable components of the vine and yield, as well as specific vine characteristics, are the indicators of balance. These are guidelines for creating, adjusting, and measuring a balanced vine. All growers should understand that these guidelines are useful tools and not viticultural doctrine. Every vineyard, in fact, every vine is unique and only the grower of those vines can fully understand the cultural and environmental impacts on the vine that will affect balance. Smart's rules were developed for vinifera vines growing in an arid climate in Australia. These conditions alone vary dramatically from those experienced in the Eastern U.S. So accept the utility of the rules but approach with caution.

In the golden rules, ratios between measurable vine characteristics are used. Here are a few of the key values that can be used during the dormant pruning season:

- 12-16 nodes per pound of pruning weight
- 5-10 pounds of fruit per pound of pruning weight
- 0.2 – 0.4 pounds of pruning weight per linear foot of trellis
- 4-5 shoots per linear foot of trellis.

Note that Smart's 12-16 nodes/lb pruning weight is less than the Shaulis recommendation. Jeff tells me that in Santa Barbara 4-5 lbs of fruit/lb of pruning weight is the target so you can see right away the variability depending on region, vine balance and wine goals. There is another set of measures that apply to a full canopy and include shoot and internode length, leaf area index, leaf layers, proportion of exterior leaves and fruit and other more obscure indices. Fruit to brush

weight and total brush weights may be the most important indices for a grower to collect and consider when determining size and judging balance.

Dr. Andy Reynolds, well known to us as the viticulturist at Brock University in Ontario, recently summarized his view of vine balance...*“There is a general acceptance that high quality wines are produced from vineyards where balance is maintained between yield and vegetative growth. Balance is defined variously as either a range of crop loads (yield:cane pruning weight ratio of 5-12:1) or as a cane pruning weight of 20-30 g/cane.”*²

If your harvest and pruning weight measurement and fall generally between these boundaries, your vine is probably in pretty good balance. Confirm these with a visual analysis of vine and canopy size and position, crop load and growing conditions during the season. For hybrid and native varieties, these numbers can generally be increased up to 50%. Experience on a particular site will be the guide to setting consistent numbers that will balance production and quality.

The hard part, of course, is getting this incredible array of balance measures into alignment with each other. If you adjust one, you affect another, or many others. I believe the analogy of herding cats may be appropriate. Do not fixate on one or two but seek the best compromise between as many balance components as you can handle. If you find yourself outside of these parameters, then some difficult decisions must be made. An out of balance vine can be a real struggle to manage. Vines with too much vigor have canopy management issues that create disease, bud fruitfulness, and fruit ripening problems. An undervigorous vine may lack productivity and also struggle to maintain a proper size canopy and fully ripen fruit. It is an irony of viticulture that vines too big or small may both struggle to ripen grapes properly. Adjustments must be made to bring the vine into balance. In the case of a small vine, the soil may need amending, more water and nutrients, or even a different rootstock choice may be necessary. If the vines yield >0.4 lb of pruning weight per foot of trellis, it may be necessary to divide the canopy to increase the node count.

Jim Law reminded me that cluster weights are important, especially in any cropping decisions based on two clusters per vine that will influence bud counts at pruning. He has found that on 6' spacing, double guyot training that 2-2.5 shoots per foot give him the optimal yields for quality without creating too much shoot vigor.

All of this implies that a grower who cares enough about wine quality and the health of his vines will take the time to collect the data to develop a historical database. I know of no grower who likes to collect data but if you believe it can serve a useful purpose maybe it won't be so painful. Choose random sentinel vines in each distinct vineyard block, mark them and set up a spreadsheet for the data, 2-3 vines per acre for large vineyards, more for smaller ones. In sections with problems or unique features, sample these specifically. Then collect the yield and pruning data each year. Apply the golden rules and see how your vines measure up.

While balance and uniformity are not the same thing in a vine, they interact closely to impact fruit quality. Vine balance is a component of uniformity. A lot is said these days about achieving uniformity in vineyards in order to achieve optimal grape quality. A key component of

² Timing of Shoot Thinning. Dr. Andrew Reynolds. 2005. American Journal of Enology and Viticulture. Vol 56, no 4.

uniformity, at the vine and vineyard level, is an ability to bring balance at both levels. With mature vineyards normalized differential vegetative index (NDVI) or infra-red technology can be used to detect subtle differences in canopy size, and this can help to unmask a variety of potential problems such as water availability, nutrition, disease, phylloxera, or a host of other vine maladies. Alone or in combination, these problems will likely affect vine balance and should be taken into account during any vineyard analysis.

The Economics of Vine Size and Balance

The argument rages on... big vine vs. small vine. Which makes better wines and better profits? It is no secret that the cost of farming small vines is very high and that the practicality of an estate winery is almost required to support the viticulture. The wine style and price point may be the key arbiter for targeting a particular vine size and terroir and achieving balance. Divided systems in balance can produce wines of excellent quality and discerning qualitative differences can be a matter of splitting hairs. One undeniable fact, however, is that the realities of vine density and size and balance are inevitably linked to bottle price. It is the trickle-down economics of wine. Smaller vines with small yields and intensive viticulture are more expensive to farm than big vines with higher yields. In order to pay for the higher development and management costs, a higher price for wine is necessary.

The economics of the vineyard are different between independent and estate vineyards, often dramatically. The costs of development and operation need to be closely scrutinized, considering the diminishing return in perceptible wine quality and vine densities and costs go up as size decreases. I was astonished to see some Bordeaux chateau planting upwards of 15,000-20,000 vines per hectare. When does this end? 9x5 may be the best return on quality and investment even though it may not make the very best wine.

I encourage anyone who is thinking of planting a vineyard to do the proper site assessment to determine soil capacity and potential vine size. At this point, there is no sample vine to take pruning weights from, so it becomes a matter of collecting and assessing data and then looking into a crystal ball. Having a good soil scientist and viticulturist behind your decisions will certainly help. A mature vineyard should be subject to regular analysis for vine balance through pruning weights and other important indices.

Finally, I encourage all growers to get off the farm and visit other vineyards known for excellence. There you will form a visual impression of what a balanced vine should look like. Talk to the wine grower and find out exactly what was done to achieve the balance in the vines. Ideally, visit around harvest and taste the grapes and analyze the canopy and crop level. Taste the wines for affirmation, preferably with the wine grower or with family and friends and good food and then go back and create your own balance and fine wines.

I'd like to thank Jeff Newton and Jim Law for their help with this article. They were able to bring their enormous experience and knowledge to these very complex viticulture issues.

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Reference resources:

1. Smart, Richard and Mike Robinson. 1992. *Sunlight into Wine*. Winetitles.
2. Hellman, E.W. 2003. *Oregon Viticulture*. Oregon State University Press.