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How to Measure Grapevine Leaf Area

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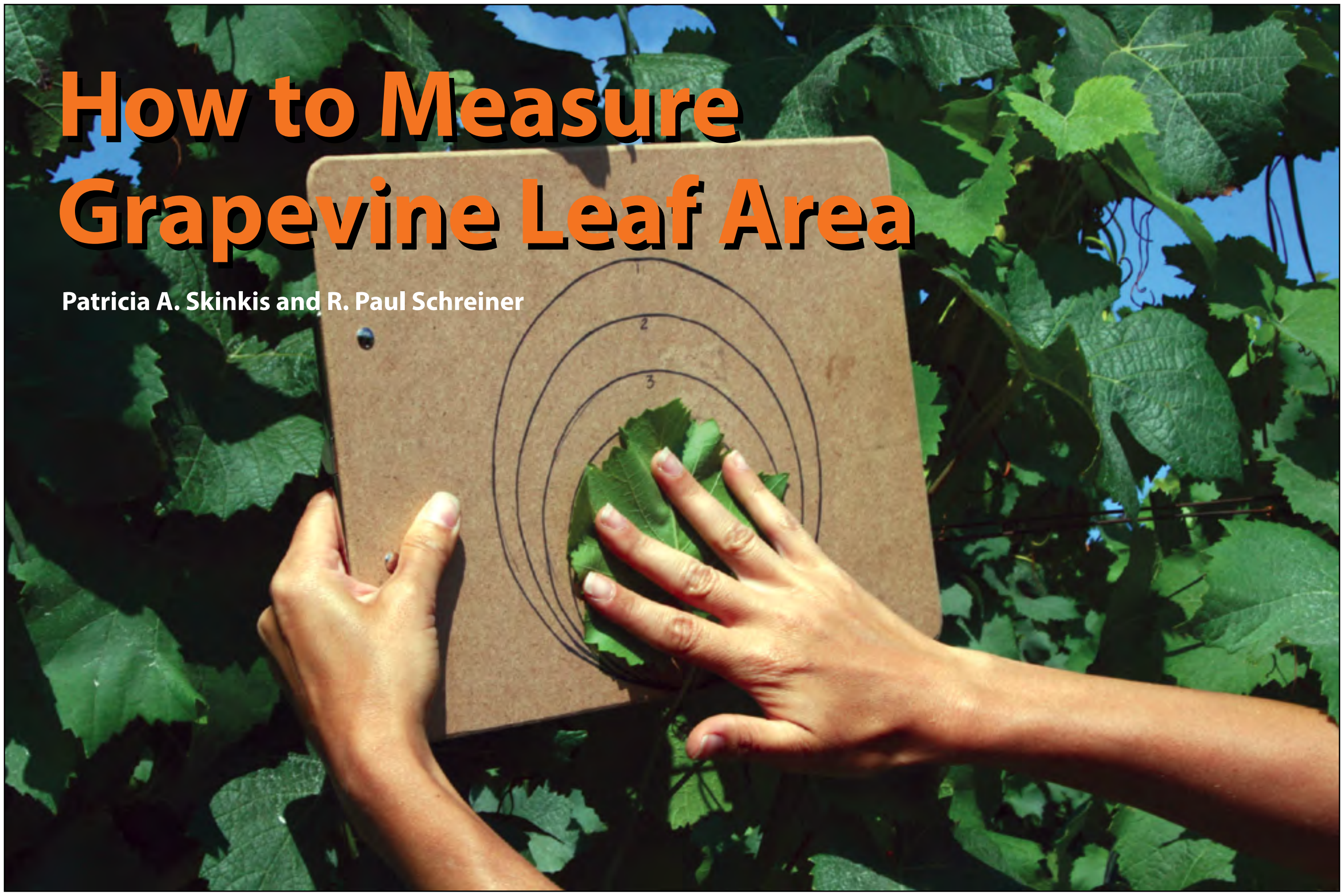

Figure 1. A leaf area template can be easily made using typical office supplies. The template, above, is being used to measure leaf area of Pinot noir vines. (Photo: Patricia A. Skinkis, © Oregon State University)

Leaf area is a measure of canopy size and is one of the factors by which vine balance can be calculated. Like pruning weights, leaf area can be used to quantitatively describe areas of high or low vigor in your vineyard. The vine needs to grow adequate leaf area to provide carbohydrates to support current season growth and development and to store adequate carbohydrate reserves needed for growth during spring of the following year.

The vine's leaf area changes through most of the season, and leaf area measurements can be a moving target. For this reason, methods used to quantify leaf area are typically done at véraison (onset of ripening) when the canopy has ceased growth. Measurements can be taken earlier in the season, but keep in mind that the canopy will continue to grow via leaf enlargement and new leaf development on lateral shoots even if you are maintaining the same canopy volume by hedging. The best way to measure leaf area without requiring expensive leaf area scanners or removing leaves from the vine is to use a simple template method. This template consists of concentric circles that represent different leaf sizes (Figure 1). These circles are compared to the actual leaves on a vine, and by counting the number of shoots per vine and measuring leaf area on representative shoots, you can estimate whole vine leaf areas in your vineyard.

Why measure leaf area?

By measuring leaf area of representative vines, you can determine vine balance of your vineyard using canopy size relative to fruit weight (vegetative versus

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reproductive growth). The leaf-area-to-yield ratio is one way to quantify vine balance, which will help you determine the management requirements for your vineyard. Much canopy management research suggests that between 2.4 and 5.8 square feet of leaf area per pound of fruit is required for optimum ripeness (Kliewer and Dokoozlian 2005), though this range may need to be adjusted upward for cool climates like western Oregon and low-yielding cultivars like Pinot noir. With leaf area data, you can also make comparisons of canopy density and vigor between vineyards or within a block by making a few calculations using your leaf area data, shoot counts, vine spacing, and canopy height.

A nondestructive leaf area protocol is provided to help you measure leaf area in your vineyard. This protocol will help you learn how to use the data you collect to compare canopy size and vigor to help with management decisions to achieve vineyard uniformity, optimize productivity, and enhance fruit quality.

Materials

- clipboard
- fine-tip permanent marker
- compass
- ruler
- flagging tape
- vineyard map
- flexible measuring tape (seamstress tape)
- data sheets (see page 7)
- pencil or pen

This is a non-destructive method that can be used to estimate the whole vine leaf area within your vineyard. This method works best with two people, one who can measure leaf size and another who can record the data. This method should be conducted at véraison or later as this is when the canopy has finished growing for the season. A simple 6-category template consisting of concentric circles that represent the major groupings of leaf sizes has been developed for estimating whole vine leaf area (Figure 2). This allows you to determine leaf area without removing leaves.

Step 1: Develop the template

On the back of a clipboard, draw a series of concentric circles starting from the edge of the board and measuring the smallest circle (category 6) and moving to the largest (category 1). Use a compass to set the diameter per the 6-category scale (Table 1, page 3), and draw the outline of each circle with the compass, using the bottom of the clipboard as the starting point for each circle. Carefully outline the circle with a black permanent marker. Write the corresponding leaf size inside the outline of each circle. The final product should look like a series of concentric circles with a point from which all circles emerge (Figure 2). Note: this template was used to compare each of the six cultivars in Table 1, but the actual leaf area (determined using a scanning leaf area meter) in each category from the template was slightly different among grape varieties due to differences in leaf shape. This is important when performing your calculations in Step 4. The same template is used for all cultivars in the field. If you prefer, you can also use the mean leaf size (Table 1) for all cultivars rather than using the cultivar-specific sizes when performing your calculations in Step 4. This will still give you good information, but it will be slightly less precise.

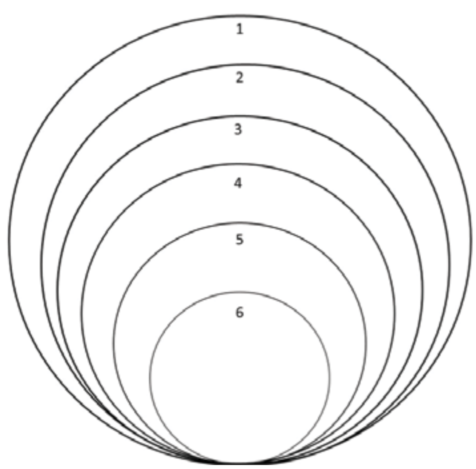

Figure 2. A series of six concentric circles are traced onto a clipboard and used for measuring leaf surface area. These categories are based on different size classes of grape leaves and measured for average leaf area that falls within that outline of each circle. A clipboard makes a nice template for the field. (Photo: Patricia A. Skinkis, © Oregon State University)

Table 1. Template category and scale for leaf area assessment of different grape cultivars

Mean leaf size (in²) for each of six template categories								
Category	**Circle diameter (in)**	**Chardonnay**	**Gewürztraminer**	**Merlot**	**Pinot gris**	**Pinot noir**	**Riesling**	**Mean**
1	7	38.7	30.7	48.0	30.1	41.7	33.9	**37.2**
2	6 ¼	28.5	23.7	24.4	24.4	27.7	26.3	**25.8**
3	5 ¼	20.0	17.7	17.7	19.7	20.3	19.3	**19.1**
4	4 ½	13.6	12.4	12.9	12.9	13.2	13.1	**13.0**
5	3	6.2	6.7	6.2	6.3	5.9	6.8	**6.4**
6	2 ¼	3.2	4.0	3.2	2.8	2.9	3.3	**3.2**

Step 2: Identify your reference vines

Before starting measurements in your vineyard, identify your reference vines where you will obtain leaf area data. A minimum of 20 to 30 vines should be measured in a given vineyard block. This can be done by selecting three locations in the vineyard or a given block and flagging 10 consecutive vines in each location (10 vines x 3 areas = 30 vines total).

Alternatively, you may choose to sample 5 consecutive vines in 5 different locations in your vineyard (5 x 5 = 25 vines). In either case, you should measure a minimum of 20 vines per vineyard block.

From our research, we have found that a minimum of 20 measurements are needed to determine differences based on this leaf area template. Be sure you make note of the vine rows and locations to be measured in your notes and on your vineyard map. It is best to flag the trunk of the vines to be measured for easy identification in the block (Figure 3).

It is important to know areas in the vineyard where there are specific growth concerns when outlining your sampling areas.

Reference vine sections should be positioned spatially throughout the vineyard block and include separate sampling locations for these variable areas

Figure 3. Flagging trunks of reference vines with plastic flagging tape helps in identifying these vines for later measurements. (Photo: Patricia A. Skinkis, © Oregon State University)

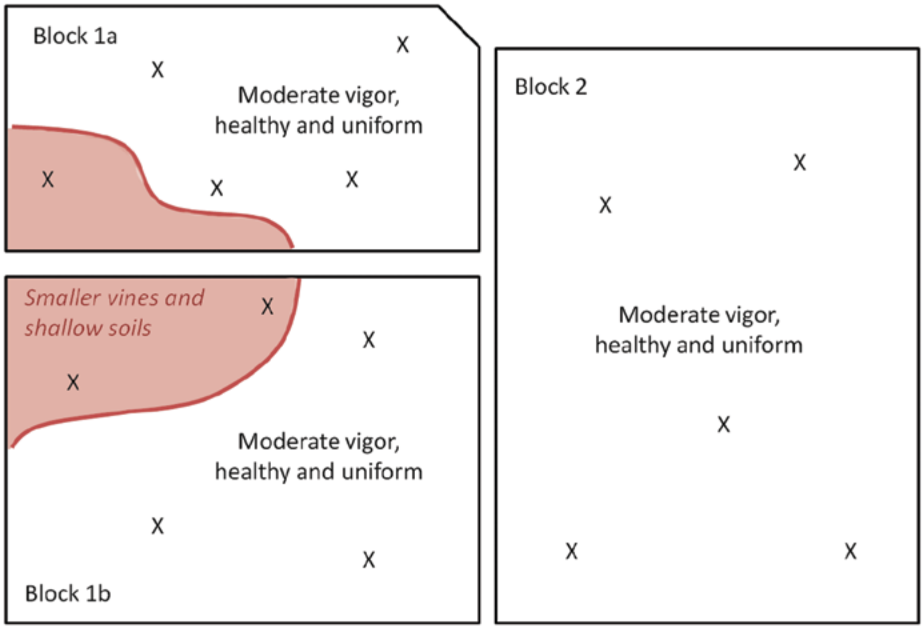

Figure 4. An example of a vineyard map where reference vine sections are identified with an X. This map represents large vineyard blocks where sections are distributed spatially throughout each vineyard block to capture the variability. Because of the larger vineyard size, the vineyard manager chose to use five 5-vine sections to estimate the leaf area across the vineyard. Samples are taken within the weak areas of each block and noted as separate from healthy areas.

(See Figure 4 for an example). In some cases, you may not know that there are areas with growth differences until you begin monitoring your blocks more closely, and you can use sampling results to assign a value to your observations on the vineyard map. Once you begin management of these problem areas, annual measurements of the same vines will help you identify if your management practices have altered vine size and productivity. It is important to return to your reference vines for other key measurements (i.e. yield and pruning weights) throughout the year and in subsequent years to track how your management practices are impacting vine growth or yield. When identifying reference vines, do not choose end vines or edge rows as these vines are often more vigorous than the remainder of the vineyard block.

Step 3: Measure leaf area

Use the reference vines that you identified in Step 2 to measure leaf area. You will not measure all leaves on a given vine but rather one selected shoot within each vine on each of your reference vines. The data will then be used to calculate average vine leaf area.

1. Count the number of shoots on each reference vine and record on your data sheet. This information is needed for the final calculation of vine leaf area.

2. Randomly select one normal-looking shoot on each reference vine to measure leaf area using the template. Avoid measuring shoots that arise from renewal spurs or the head of the vine as these shoots can often be larger and longer than the average shoots on the vine.

3. Start by measuring the shoot length with the flexible measuring tape and recording it on your data sheet. Be sure to record units that you are using in your data sheet.

4. Next, use the template to match each leaf on the shoot to the respective category, making sure to center the leaf on the best-fitting circle (Figure 5) rather than putting the base of the petiole on the point where all concentric circles meet. Record a tally on the data sheet for the number of the category that best

Figure 5. When measuring the size of each leaf, center the whole leaf on the respective circle to determine size as shown. The circle that best fits the leaf size should be recorded on the data sheet. For example, the leaf shown above should be recorded as a category 2 leaf. (Photo: Patricia A. Skinkis, © Oregon State University)

corresponds with the circle that represents the size of the leaf. Measure leaf size starting from the base of the shoot and work upward toward the shoot tip. Be sure to measure leaf area of all primary leaves on the shoot and any leaves that are on lateral shoots.

TIP

- Having two people collect these data will make this process more efficient. One person measures the leaf area and reads the category out loud as they move up the shoot. The second person records the numbers as the measuring person calls out numbers.

5. Repeat this process on the remaining reference vines.

After you get a bit of experience matching up the leaf size on the template, you will become more efficient at estimating leaf size without holding the template up to every leaf. However, be sure to keep the template with you to periodically calibrate your eyes to the size of the leaf and the template over time.

Step 4: Using the data

Now that you have your data, enter it into a spreadsheet by adding up the tally marks that were made for each leaf size category. The spreadsheet should look similar to the data collection form provided in this protocol, but it will also include some calculations. First, you will want to determine the total leaf area for each measured shoot. To do this, create an equation that multiplies the number of leaves in each category by the reference leaf area from Table 1. Here is an example using the mean leaf area for all 6 cultivars:

(# Size 1 Leaves) x 37.2in^2 + (# Size 2 Leaves) x 25.8 in^2 + (# Size 3 Leaves) x 19.1 in^2 + (# Size 4 Leaves) x 13.0 in^2 + (# Size 5 Leaves) x 6.4 in^2 + (# Size 6 Leaves) x 3.2 in^2
=Total shoot leaf area

Once you make the equation, you can easily use it within your spreadsheet to calculate leaf area for each shoot you measured, and you will use this data to estimate whole vine leaf area by multiplying the number of shoots per reference vine. From there, you can calculate the average vine leaf area for each block or vineyard. A series of equations (Table 2) can be used to determine a number of other vine growth measurements that are useful for comparing vigor across vines with different canopy height and spacing. The stepwise calculations are described below:

- **It is easiest to work with your leaf area** data in square feet, so consider the conversion of your shoot leaf area to square feet before calculating whole vine leaf area.

- **Convert your shoot leaf area** to whole vine leaf area to help you make further calculations and compare leaf area averages across vineyard blocks. Use the average leaf area of consecutive vines multiplied by the number of shoots on each of the consecutive vines to generate estimates per sampling location.

- **At harvest, collect yield weights** per vine from the reference vines. This enables you to calculate the vine balance metrics for those vines with paired data, including leaf area, yield and pruning weight. All three components can be used to calculate vine balance, including leaf-area-to-fruit ratio and yield-to-pruning-weight ratio (known as crop load or Ravaz Index).

- **Whole vine data is often less important** to growers who are managing vineyard blocks and not individual vines. So, you can convert your whole vine leaf area to leaf area per linear foot of row. This now allows you to compare vine leaf area across vineyard blocks.

- **Leaf layer or density of the canopy** can be determined by considering the distribution of your leaf area within the canopy. This requires that you take a measure of your canopy surface area. This can be done by measuring the length and height of a “face” of your canopy. This is easy to do on VSP vines given that most are trained and hedged into a box. The leaf area within the canopy is then divided by the canopy surface area to give an estimate of leaf layer in the canopy. More dense canopies have more layers of leaves. It is recommended that a well-balanced vine of moderate vigor will have 1.5 leaf layers.

Table 2. Conversions and calculations for using leaf area data

Potential Calculations	Equation/Conversion
Convert leaf area units from in^2 to ft^2	144 in^2 = 1 ft^2
Calculate whole vine leaf area from shoot leaf area	(shoot leaf area ft^2) x (# shoots per vine)
Calculate leaf area: yield from reference vines	(whole vine leaf area – ft^2) / (whole vine yield – lb)
Leaf area calculated on a linear basis	(whole vine leaf area)/(vine spacing in-row)
Canopy surface area	(vine spacing in-row - ft) x (shoot length - ft)
Determine leaf area density (leaf layer number)	(whole vine leaf area ft^2)/(canopy surface area ft^2)

Step 5: Interpreting the data

Once you have made all desired calculations, you can compare your data to the leaf-area-to-yield ratio generally recommended for quality fruit production (0.8 to 1.2 m^2/kg, 3.9 to 5.9 ft^2/lb fruit). Keep in mind that your vineyard may require a different leaf area to fully ripen the fruit depending on climate and cultivar. Based on research in Oregon, cool climate production regions such as the Willamette Valley require nearly 3-fold more leaf area than California for ripening Pinot noir in vertical-shoot-positioned canopies (2.25 to 3.25 m^2/kg, 11.0 to 15.9 ft^2/lb fruit). Also keep in mind that more leaf area is not always best — too much leaf area and too little yield may result in reduced fruit quality.

The various data that you collect can be used to better quantify your areas of high or low vigor that require different management practices to bring the vines into better balance and achieve better uniformity across the vineyard.

Keeping records of leaf areas, along with other measurements of vine growth and productivity, such as pruning weights and yields, will help you determine how management practices are affecting your vineyard and what you can do in the future to improve the overall vine health and production longevity.

For more information about how to manage your vineyard for balance, see *The Role of Canopy Management in Vine Balance,* available at http://extension.oregonstate.edu/catalog/.

Data collected by: ____________________ **Date:** __________ **Page** _____ **of** _____

				Place a tally in the appropriate box for the leaf size of each leaf on the shoot selected for measurement.					
Vineyard or Block ID	**Vine ref #**	**# shoots/ vine**	**Shoot Length (in)**	**Size 1 Leaves**	**Size 2 Leaves**	**Size 3 Leaves**	**Size 4 Leaves**	**Size 5 Leaves**	**Size 6 leaves**
	1								
	2								
	3								
	4								
	5								
________	6								
	7								
	8								
	9								
	10								
	1								
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	10								

Procedure: *Count the number of shoots on the reference vine. Randomly select one normal-looking shoot to measure leaf area on that vine. Match the leaf up to the template, record the best-fit category for each leaf, starting from the base of the shoot moving to the shoot tip. Measure all leaves on that shoot. Have a helper record the numbers as you call them out by placing a tally mark into the respective categories. Spaces are available for 10 consecutive vines per section of a given vineyard.*

Literature cited

Kliewer, W.M. and N.K. Dokoozlian. 2005. Leaf area/crop weight ratios of grapevines: influence on fruit composition and wine quality. *American Journal of Enology and Viticulture* 56: 170–181.

Further reading

For more general information on leaf area and canopy management, please see *eViticulture* (http://eViticulture.org), an online Extension resource in viticulture.

For other publications in this canopy management series, please see the following:

Skinkis, P.A. 2013. *Understanding Vine Balance: An Important Concept in Vineyard Management*. EM 9068. Corvallis, OR: Oregon State University Extension Service.

Skinkis, P.A. 2013. *How to Measure Dormant Pruning Weights Of Grapevines*. EM 9069. Corvallis, OR: Oregon State University Extension Service.

Vance, A.J., A. Reeve, and P.A. Skinkis. 2013. *The Role of Canopy Management in Vine Balance*. EM 9071. Corvallis, OR: Oregon State University Extension Service.

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