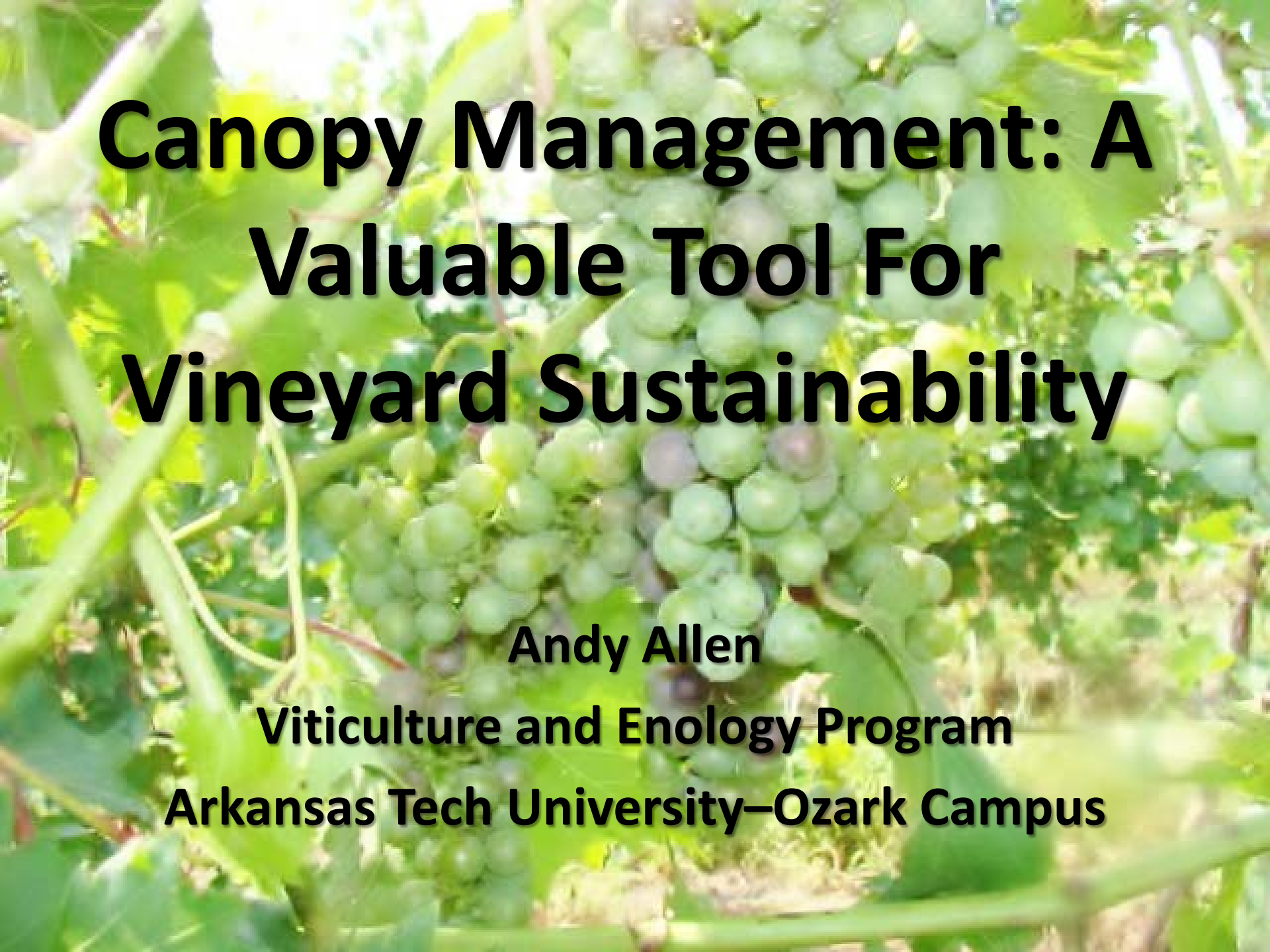

# Canopy Management: A Valuable Tool For Vineyard Sustainability

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# Recommended sustainable winegrowing practices

- Canopy management – purpose is to create more open canopy with improved microclimate in fruiting zone
  - Balanced pruning
  - Shoot thinning
  - Shoot positioning
  - Leaf removal
  - Hedging
  - Crop load adjustment

# Benefits of canopy management

Improving the canopy microclimate to permit more light and air penetration into fruiting zone:

- Reduces disease pressure
- Improves spray penetration
- Allows more efficient photosynthesis
- Improves fruit composition
  - Improves color
  - Reduces levels of methoxypyrazines
  - Improves development of flavor and aroma compounds
  - Improves sugar and acid composition

# Effects of canopy management practices and fungicide applications on Botrytis bunch rot and yield of Chenin blanc grapevines in California in 1985.

| | Control | Shoot thinning | Leaf removal | Hedging |
|---|---|---|---|---|
| | Incidence (% diseased clusters) | | | |
| Sprayed | 46.8 | 47.0 | 16.9 | 44.1 |
| Nonsprayed | 55.0 | 42.9 | 23.9 | 47.4 |
| Mean | 50.9 | 44.9 | 20.4* | 45.7 |
| | Severity (% rot per cluster) | | | |
| Sprayed | 9.3 | 11.3 | 1.69 | 8.05 |
| Nonsprayed | 15.3 | 10.2 | 2.85 | 9.08 |
| Mean | 12.3 | 10.7 | 2.27** | 8.56* |
| | Yield (tons per acre) | | | |
| Sprayed | 8.19 | 4.84 | 7.59 | 6.54 |
| Nonsprayed | 5.39 | 5.17 | 7.31 | 6.32 |
| Mean | 6.79 | 5.00* | 7.45 | 6.43 |

From: Gubler, et al. 1987. Control of Botrytis bunch rot of grape with canopy management. Plant Disease 71:599-601.

# Effect of one- and two-sided leaf removal on composition of Cynthiana juice and wine in three seasons in Arkansas.

| Year and treatment | Soluble solids (%) | pH | Titratable acidity | Tartaric acid (g/L) | Malic acid (g/L) | Total red pigment color |
|---|---|---|---|---|---|---|
| **1997** | | | | | | |
| None | 21.9 a | 3.58 a | 14.2 a | 6.3 a | 7.4 a | 100 b |
| East side | 22.1 a | 3.53 a | 13.6 a | 6.2 a | 6.8 a | 121 a |
| Both sides | 22.1 a | 3.48 b | 12.5 b | 6.0 a | 6.5 a | 125 a |
| **1999** | | | | | | |
| None | 22.9 a | 3.83 a | 10.1 a | 8.0 a | 5.8 a | 124 b |
| East side | 23.1 a | 3.84 a | 10.4 a | 8.2 a | 5.4 a | 157 a |
| Both sides | 22.4 a | 3.84 a | 10.3 a | 8.0 a | 5.3 a | 169 a |
| **2000** | | | | | | |
| None | 21.2 b | 3.85 a | 11.2 a | 7.0 a | 6.2 a | 18 b |
| East side | 21.8 a | 3.82 a | 10.3 b | 6.9 a | 5.2 b | 25 a |
| Both sides | 22.1 a | 3.79 a | 10.3 b | 6.8 a | 4.5 b | 24 a |

From: Main and Morris, 2004. Leaf-removal effects on Cynthiana yield, juice composition, and wine composition. Amer. J. Enol. Vitic. 55:147-152.

# Shoot thinning

- Should be done when shoots are 2”-6” in length
- Remove shoots from “non-count” positions
- Improves canopy density
  - Reduces shoot density, leaf layer number
  - Increases proportion of canopy gaps, exterior leaves
- Reduces crop load

# Shoot positioning

- Goal is to re-orient shoots into position appropriate for trellis/training system
- Should be done when shoots are long enough to remain in place after positioning but before tendrils attach to neighboring shoots
- May require more than one pass through vineyard
- Improves environment around fruiting/renewal zone
- Has benefits for other vineyard management tasks

# Leaf removal

- Should be done between fruit set and pea-size
- Remove 2-6 leaves per shoot in the fruiting zone
- Improves canopy microclimate by reducing leaf layer number
- Possibly the most beneficial canopy management practice
  - Can improve fruit composition and color
  - Can reduce bunch rots
  - Can improve spray deposition and coverage in fruiting zone

# Influence of leaf removal on development of bunch rot in winegrapes in Missouri in 1992.

| Treatment | Incidence | Severity |
|---|---|---|
| Vignoles | | |
| Leaf removal | 13.8* | 15.0* |
| Control | 28.7 | 25.1 |
| Seyval blanc | | |
| Nonsprayed | | |
| Leaf removal | 28.3* | 27.3* |
| Control | 42.8 | 31.2 |
| Sprayed | | |
| Leaf removal | 17.4* | 20.5* |
| Control | 34.1 | 32.1 |

From: English, et al. 1993. Leaf removal for control of Botrytis bunch rot of wine grapes in the Midwestern United States. Plant Disease 77:1224-1227.

# Hedging

- Done on low-cordon systems to prevent shading by overhanging shoots
  - Done when majority of shoots begin to cascade
- Done on high-cordon systems to facilitate undervine management
  - Done when majority of shoots reach the ground

# Crop load adjustment

- Helps maintain balance between vegetative/reproductive growth
- Promotes fruit ripening, vine health
- Done for large- or medium-clustered varieties,
- Based on shoot length at fruit set
  - If shoot length is less than 8” – remove all clusters
  - If shoot length is greater than 8” but less than 20” – retain only 1 cluster
  - If shoot length is greater than 20” – retain 2 clusters

Effects of canopy and crop load management practices on yield and fruit composition of Chambourcin grapevines trained to a high-wire single curtain trellis.

| Treatment | Yield Per Acre (tons) | Average Cluster Number | Average Cluster Wt (g) | Average Berry Wt (g) | Average Berries/ Cluster | Soluble Solids (%) | pH | Titratable Acidity (g/L) |
|---|---|---|---|---|---|---|---|---|
| **SP+LR** | 9.7 a | 85.79 a | 150.16 efgh | 2.03 ab | 74.92 cdefg | 21.1 fg | 3.41 g | 7.29 a |
| **CONTROL** | 9.3 a | 91.25 a | 135.73 h | 1.99 b | 68.51 g | 20.8 g | 3.41 g | 7.26 a |
| **LR** | 9.1 a | 81.92 a | 147.42 efgh | 2.07 ab | 71.40 efg | 21.4 efg | 3.38 g | 7.20 abc |
| **SP** | 8.6 ab | 84.00 a | 137.58 gh | 2.02 ab | 67.98 g | 21.1 fg | 3.43 fg | 7.19 abc |
| **ST** | 8.3 abc | 64.84 b | 174.30 abc | 2.08 ab | 83.92 abc | 22.1 def | 3.53 cde | 6.98 abcd |
| **ST+LR** | 7.1 bcd | 56.58 bcd | 168.38 bcd | 2.17 a | 77.85 bcdef | 23.1 bcd | 3.50 def | 6.80 def |
| **ST+SP+LR** | 7.0 cd | 56.67 bcd | 164.08 bcde | 2.18 a | 75.18 cdefg | 23.0 cd | 3.53 cde | 6.87 cdef |
| **ST+SP** | 6.4 de | 59.25 bc | 145.89 fgh | 2.10 ab | 69.46 fg | 22.6 de | 3.46 efg | 6.86 bcdef |
| **SP+CT** | 6.1 def | 51.50 cde | 159.42 cdef | 2.10 ab | 75.92 cdefg | 24.3 ab | 3.54 bcde | 7.08 abcd |
| **CT** | 5.7 defg | 46.42 de | 163.00 bcde | 2.07 ab | 79.04 abcde | 24.0 abc | 3.56 bcd | 7.25 ab |
| **CT+LR** | 5.0 efgh | 41.79 ef | 160.28 cdef | 2.04 ab | 78.75 abcde | 24.9 a | 3.58 abcd | 6.95 abcde |
| **SP+CT+LR** | 4.8 fgh | 41.42 ef | 154.11 defg | 2.12 ab | 72.92 defg | 24.5 a | 3.57 abcd | 6.88 bcdef |
| **ST+CT+LR** | 4.62 fgh | 32.92 f | 188.55 a | 2.16 a | 87.19 a | 25.0 a | 3.65 a | 6.60 ef |
| **ST+CT** | 4.3 gh | 32.25 f | 178.06 ab | 2.09 ab | 85.56 ab | 24.5 a | 3.59 abc | 7.11 abcd |
| **ST+SP+CT+LR** | 4.0 h | 31.67 f | 167.21 bcd | 2.05 ab | 81.54 abcd | 24.7 a | 3.63 abc | 6.52 f |
| **ST+SP+CT** | 3.7 h | 29.04 f | 169.02 bcd | 1.97 b | 86.02 ab | 24.8 a | 3.63 abc | 6.74 def |

| Training system | | | | |
|---|---|---|---|---|
| **Issue** | **Category 4** | **Category 3** | **Category 2** | **Category 1** |
| 27. Is trellis training system appropriate for the vine size in each block? | Trellis training system accommodates the vine size of your vines, providing an open canopy with moderate exposure of the fruit zone to light and air without requiring leaf removal. | Trellis training system accommodates the vine size of your vines, providing an open canopy with moderate exposure of the fruit zone to light and air but requires leaf removal. | Trellis training system reduces excessive canopy density, but shading of the fruit zone still occurs even with leaf removal. | Trellis training system does not compensate for excessive vine size; the fruit zone is very shaded and fruit composition negatively impacted. **Or** High inputs of labor for canopy management are required to maintain an open fruit zone. **Or** Provides more canopy space than the vine can fill due to inadequate vine size. |
| **Notes:** The vineyard is developed with soil type, vigor of variety and rootstock, and crop load goals in mind. It is recommended that a viticulture extension advisor or professional consultant be involved in this decision making process, as the best management practice to apply will require customization and extensive knowledge of the vineyard and site. | | | | |

| Shoot density and thinning | | | | |
|---|---|---|---|---|
| **Issue** | **Category 4** | **Category 3** | **Category 2** | **Category 1** |
| 28. Have shoots been thinned so that they grow at a proper density? | A shoot density of 4 to 6 shoots per foot of canopy was achieved without extensive shoot thinning. | Where necessary, shoots were thinned to 4 to 6 shoots per foot of canopy. If possible, non-count shoots should be preferentially eliminated. | Shoot thinning was done but not to the recommended level. | Excessive shoot density exists but no shoot removal was performed, resulting in a dense shaded canopy. |
| **Notes:** Shoot removal can be performed shortly after budburst. However, if shoot removal is performed before most buds have pushed, not all shoots will be visible. If shoots become longer than 15 inches, shoots become difficult to remove without tearing. Several shoot thinning methods have been established in commercial vineyards. Three common methods that have become more widely adopted include removing all shoots carrying no fruit (unless needed for renewal), removing all non-count shoots and retaining a certain number of shoots per linear length of canopy (generally 4 to 6 shoots/foot). Depending on the desired crop load of the vineyard, fruiting shoots may not need to be removed. For example, if the number of clusters per vine has been assessed prior to shoot thinning and the cluster count is estimated to be inadequate to meet the yield goal for the vineyard, then you should keep every shoot with a cluster. | | | | |

| Shoot positioning | | | | |
|---|---|---|---|---|
| **Issue** | **Category 4** | **Category 3** | **Category 2** | **Category 1** |
| 29. Are shoots positioned to reduce shading? | Shoot positioning was done three times in the correct way for the trellis training system and timing was optimal (see notes). | Shoot positioning was done three times but without optimal timing. | Some shoot positioning was done (one to two times) to reduce shading. | No shoot positioning was performed, resulting in a densely shaded canopy. |
| **Notes:** Positioning of shoots requires the shoots to be forced in the direction intended for the trellis system. Shoots are separated, untangled and, depending on the trellis, tucked up between foliage wires or positioned down to hang from the cordon. For the vertical shoot positioned trellis (VSP), positioning shoots is generally required when shoots are 12 to 18 inches (2 weeks pre-bloom), 24 to 36 inches (fruit set), and 2 to 3 weeks after fruit set. In high-wire trellis systems, downward shoot positioning is performed when shoots are long and heavy enough to remain in place after positioning but before shoots and tendrils become intertwined and attached to adjacent shoots. This typically occurs when shoots are between 18 to 24 inches in length. | | | | |

| Leaf removal | | | | |
|---|---|---|---|---|
| **Issue** | **Category 4** | **Category 3** | **Category 2** | **Category 1** |
| 30. Are leaves removed as necessary for healthy clusters? | No leaf removal is necessary. The cluster zone is at least 50% exposed to light (clusters have some exposure to the canopy exterior) and allow free air movement. | Leaves around the clusters were removed shortly after bloom to improve light penetration and air ventilation of the clusters. | Leaf removal sometimes done or very lightly done to minimize costs. **Or** Leaf removal done on vines with inadequate shoot growth, resulting in sunburn or reduced sugar accumulation. | Appropriateness of leaf removal was not assessed. |

**Notes:** Pulling leaves at the end of fruit set best establishes the beneficial effects of an open canopy and tends to be more beneficial than removal later in the season. Late leaf removal in warm climates can often cause sunburn on the fruit, as berries need time to acclimate to warm weather conditions. Three widely accepted methods include the following (in order of severity): removing basal leaves of shoots carrying fruit; removing leaves in the proximal fruit zone of the trellis system (12-inch window depending on the variability of the vineyard); and removing leaves of nodes below, adjacent and above the grape clusters. Generally, a more severe leaf pulling treatment may be required in more vigorous vineyards, where lighter treatments can be applied in less dense canopies that still require manipulation. Pulling leaves on both sides of the canopy can be detrimental to fruit quality as pulling leaves on the afternoon sun side of the canopy can lead to excessively high berry temperatures due to direct sun exposure. Therefore, pulling leaves on the west side of north/south row orientations should be avoided if clusters will receive direct sun exposure during the warmest periods of the day.

| Balanced vine growth | | | | |
|---|---|---|---|---|
| **Issue** | **Category 4** | **Category 3** | **Category 2** | **Category 1** |
| 31. Are vines maintained for balanced growth? | Pruning, crop load management, irrigation and cover crop are successfully adjusted to keep vines in balance (see notes). | Growth stops around véraison, but leaves are large and shoots are longer than 54 inches or 22 nodes. | Vines are too vigorous, but growth is greatly slowed after the beginning of véraison. | Vines are too vigorous and strong growth continues after véraison; or vines are very weak, and many shoots are shorter than 36 inches or 18 nodes. |
| **Notes: Balanced vine** growth is the goal for creating high quality fruit and exceptional wines. Partridge (1925a-c) and Dry et al. (2005) stated that a balanced vine was a natural balance between vegetative growth or canopy and fruit yield. If vines are balanced (due to proper trellis, spacing, cover crop, irrigation and fertilization), then shoot positioning, shoot removal, leaf removal etc. are unnecessary. Shoot tips have stopped growing by véraison; shoots are 36 to 54 inches long; and 50% of the fruit is visible. Nearly all clusters should be visible from the canopy exterior. The fruit should see some sunlight during the day, but not directly for long periods of time. Exterior leaves make up 80 to 100% of the leaves; 25% gaps in the canopy; leaves are functional through harvest (leaves are not yellow or beginning to senesce); lateral shoots are rare; leaves are layered between one and two leaves deep; 20 to 22 nodes per cane, or 12 "functional" leaves per cluster; four to five shoots per foot of cordon. | | | | |

| Yield to pruning ratio | | | | |
|---|---|---|---|---|
| **Issue** | **Category 4** | **Category 3** | **Category 2** | **Category 1** |
| 32. Is the yield to pruning weight ratio (**Ravaz Index**) monitored? | Yield to pruning weight ratio is monitored. **And** Adjustments are made to maintain the ratio range from 4 to 10 by crop load adjustment, trellis retrofitting, differential pruning of dormant vines and irrigation management. | Yield to pruning weight ratio is monitored. **And** An attempt is made to reach the ratio range from 4 to 10 by irrigation management. | Yield to pruning weight ratio is monitored. | Yield to pruning weight ratio is not monitored. |
| **Notes:** Generally, a 4 to 10 ratio is a good range in regards to maintaining balanced vines. However, a 5 to 8 ratio may be a more accurate range for balance, depending on the cultivar and trellis system. Use a spring scale to measure and record the weight of all the live, mature one-year-old wood pruned from the vine. | | | | |

| Canopy microclimate | | | | |
|---|---|---|---|---|
| **Issue** | **Category 4** | **Category 3** | **Category 2** | **Category 1** |
| 33. Is the canopy microclimate and shoot-tip length carefully monitored? | The canopy microclimate and shoot-tip length is monitored and recorded by an objective method (see notes) at various points throughout the growing season and corrective action is taken as needed. | The canopy microclimate and shoot-tip length is monitored by an objective method at various points throughout the growing season. | The canopy microclimate and shoot-tip length is monitored by casual observation. | The canopy microclimate and shoot-tip length is not monitored. |
| **Notes:** Some canopy microclimate monitoring methods include **point quadrat analysis** to assess foliage density, visual rating of canopy characteristics and measurement of photosynthetically active radiation in the fruit zones. See Smart and Robinson (1991) for further details. | | | | |

| Thin crop | | | | |
|---|---|---|---|---|
| **Issue** | **Category 4** | **Category 3** | **Category 2** | **Category 1** |
| 34. What are the methods and timing of crop thinning? | Cluster thinning is done at fruit set and is based on shoot length. | | Cluster thinning is not done to reduce crop load.<br>**But**<br>Clusters lagging in maturity are removed at véraison. | Cluster thinning is not done. |
| **Notes:** Cluster thinning is the removal of excess fruit clusters to help manage crop load and prevent overcropping. Fruit cluster thinning can be done at any time after fruit set; to get the most benefit from cluster thinning, however, it should be done at fruit set. Small-clustered cultivars such as Vignoles or Norton are generally not cluster-thinned unless they are young and still undergoing canopy development. With moderate- to large-clustered cultivars it is recommended to follow the **2-1-None rule:** At fruit set, if the shoots are greater than 24 inches in length, **retain 2 clusters**. If shoots are between 12 and 24 inches in length, **retain 1 cluster**. If they are less than 12 inches in length, **retain no clusters (None).** | | | | |

| Estimating yield | | | | |
|---|---|---|---|---|
| **Issue** | **Category 4** | **Category 3** | **Category 2** | **Category 1** |
| 35. How are yields estimated? | Yield estimates are determined by counting clusters on several representative vines using historic cluster weight data from the block. | Yield estimates are determined by counting clusters on several representative vines but records of historic cluster weight data by block are not kept. | Yield estimates are determined by visual assessment of crop weight per vine. | Yield estimation is not done. |

**Notes:** Yield is assessed by counting the average number of clusters present per vine on a representative sample of vines. In blocks with uniform vine size a sample population of approximately 20 vines should generate fairly accurate results. If the vines are non-uniform, however, the sample population should be increased to perhaps 30 to 40 vines, or the block divided into homogenous sample areas to improve accuracy. Representative vines may be selected at random, or through a sequential selection process (every 20th vine, for example). While it's true that cluster weights for a given variety will vary annually, they remain an efficient method of estimating potential yield. Long-term records collected from individual vineyard blocks over time improve accuracy of this estimation strategy, and thus, provide the rationale for measuring cluster weights (by cultivar) at harvest every year.