Journal of the American Pomological Society 59(3):153-160 2005

Sources of Variation in Maturation Soluble Solids of Three White Grape Cultivars

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Abstract

On vines of 'Vidal blanc', 'Seyval blanc' and 'Pinot Gris' exposed and shaded clusters were harvested and berry weight and soluble solids determined on individual berries of a random 30-berry sample from each cluster. Delaying harvest to optimum maturity of 'Vidal blanc' and 'Seyval blanc' decreased the variability and shifted the distribution of berries with higher soluble solids. There was little difference in range of concentration of soluble solids between early and mature harvests of 'Pinot Gris'. Berries from exposed clusters of all cultivars had higher soluble solid concentrations than shaded clusters. The sources in variation in soluble solids of 'Vidal blanc' were 31% due to berry to berry, clusters 28% and 41% vines. Soluble solids variation of 'Seyval blanc' were as follows: berries 22%, clusters 69%, and vines 9%. Variation in soluble solids for 'Pinot Gris' were as follows: berries 34%, clusters 18% and vines 48%. Based on these sources of variation, a table of sampling protocols is provided to insure 95% confidence in soluble solids half width intervals of 0.5, 1.0 or 2.0% for each cultivar.

Introduction

The maturation of grapes is the result of a complex series of biochemical transformations which are affected by weather, cultivar and vineyard cultural practices. Optimum maturity depends on the style of wine to be made, as well as the genetic influence imparted by the cultivar. As harvest approaches, a sample is taken in the vineyard and analyzed for soluble solids, pH and titratable acidity. Often a 100- to 200-berry sample is recommended (1,4,5). Kasimatis and Vilas (5) reported that 10-cluster samples gave the same precision as two 50-berry samples for detecting differences of 1.0°Brix. It is critical that this sample be a true prediction of the maturity in the vineyard.

The composition of berries can differ with their position on the rachis, the location of the cluster on the vine, location of the vine in the vineyard, degree of sun exposure, age of the vine, pruning system etc.(2,6,8,9). In an oral presentation of the 1996 cool climate symposium, Zelma Long showed that wine quality was not only influenced by the mean value of soluble solids, but also by the variation with the highest quality wine occurring when the variation in soluble solids was small. She showed large differences between 'Chardonnay' and 'Cabernet Sauvignon' in the berry sample size required to accurately predict must composition differences by cultivar. Carroll et al. (3) showed that when variation in maturity around the mean value was large, overripe and unripe flavors are present in the wine. They demonstrated that wines made from grapes of optimum ripeness were considered superior to those from the under-ripe or over-ripe grapes. Since we had difficulty in correctly predicting must soluble solids from a standard berry sample, the present studies were initiated to determine the primary sources of variation. Was the variation primarily among vines, cluster exposure, berry to berry or harvest

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Salaries and research support provided in part by state and federal funds appropriated to the Ohio Agricultural Research and Development Center, The Ohio State University and through funds provided by the Ohio Grape Industries Program. Manuscript No. HCS 04-03.

date? 'Vidal blanc', 'Seyval blanc' and 'Pinot Gris' were selected as important white wine cultivars in the Midwest.

Materials and Methods

The following grape cultivars located in adjacent vineyards at Horticulture Unit II in Wooster, Ohio, were used in this study: 'Vidal blanc' own rooted vines planted in 1981, spaced 3 x 4.5m, trained as a bilateral cordon, pruned leaving 40 buds on 5-bud canes, thinned at bloom to one cluster per shoot; 'Seyval blanc' own rooted vines planted in 1981, spaced 2.5 x 3m, trained as a bilateral cordon, pruned leaving 40 buds on 5-bud canes, thinned at bloom to one cluster per shoot; 'Pinot Gris' vines on C-3309 rootstock planted in 1994, spaced 1.25 x 3m, trained as a Geneva Double Curtain, leaving 25 buds on 5-bud canes and not hand-thinned.

In the fall of 1995, 20 vines of each cultivar were selected for uniformity and two exposed clusters and two shaded interior clusters were tagged on each vine. Harvests were made at early maturity defined as 1-2% soluble solids below optimum maturity and the second sample taken at optimum maturity. The clusters were weighed, all berries were counted and removed. A 30-berry sample from each cluster was chosen at random and weight and juice soluble solids determined on each berry (Atago digital refractometer, PR101, Misco, Cleveland, OH)

Approximate minimal sample size protocols were devised for estimating % soluble solids. The first step in this process was to compute the components of variance due to plant, cluster, and berry size by fitting a nested model to the data. In this model berries were nested within cluster, clusters within plant and plants within date. Date was modeled as a fixed effect and this mixed model analysis was computed using proc Mixed in SAS. The estimated components were then used to compute the minimum sample needed to get estimates of the % soluble solids concentration that would be within 0.5%, 1% or 2% soluble solids of the true % soluble solids value a reasonable amount of the time. Confidence intervals of 95% are used as the basis for these estimated sample sizes.

With some assumptions about the model and the computation of estimated components of variation, this "reasonable" amount of time would be 95%. However, the clusters were chosen to maximize the amount of variation due to exposure to sunlight. If sunlight has an effect, this will result in estimates for cluster variation that are larger on average than if the assumption of randomness were true. The result will be sample sizes that are too large in general, but more so for cluster than for vines and berries. Hence, the values in Table 1 will be conservative and might be expected to provide even better than expected results in comparable vineyards. The values in Table 1 were calculated as follows: let the variance of an estimate due to vines be σ_v^2, the variance due to clusters be σ_c^2, and the variance due to berries be σ_b^2. If v is the number of vines, c the number of clusters and b the number of berries then the variance of an estimate of vineyard % soluble solids would be given by

$$\sigma_{estimate}^2 = \frac{\sigma_v^2 + (\sigma_c^2 + \sigma_b^2/b)/c.}{v}$$

A 95% confidence interval for this estimate is then given by

$$y \pm t_{v-1,.95} * \sqrt{\frac{(\sigma_v^2 + (\sigma_c^2 + \sigma_b^2/b)/c)}{v}}$$

The goal is to find values of v, c and b such that the right hand term, or C.I. half width, is less than the target value, say 1.0% soluble solids. If c is chosen large enough then $(\sigma_c^2 + \sigma_b^2/b)/c$ can be made as small a positive number as we might want. Therefore the half width will be at least

$t_{v-1,0.95} \sqrt{} (\sigma_v^2 / v.$ (1)

The smallest value of v is determined such that (1) is less than the target value. This requires an iterative process since when v is changed, $t_{v-1,.0.95}$ changes as well.

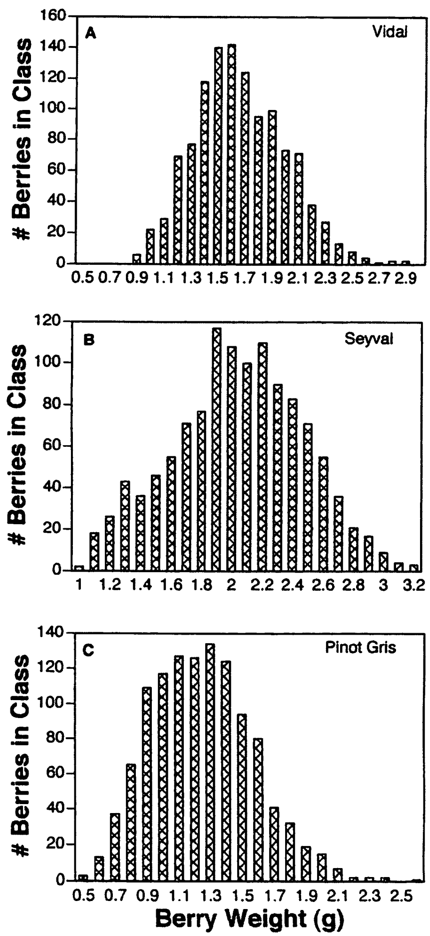
Once this minimum number of vines is determined the minimum value for the number of clusters such that the half width is still smaller than the target value is calculated noting that if b, the number of berries, is large enough the term σ_b^2/b can be made as small as needed. The final step is to calculate the smallest value for b given these minimum values of v and c. Since the values for b might be quite large, c is increased by 1 several times which should give smaller values for b. This is done until nothing more is gained.

The same was then done for vines to decrease the number of clusters and berries. For a given number of vines, such as v + 1, the new c was calculated and used to calculate the new b. Then several values of c were used to decrease the number of berries as before.

Results and Discussion

Berry weight of 'Vidal blanc' ranged from 0.8g to 3.0 g with most of the berries weighing between 1.2 and 2.1g (Fig. 1A). Berries of 'Seyval blanc' were larger ranging from 1.0 to 3.2g with the largest concentration between 1.7 and 2.5g (Fig. 1B). 'Pinot Gris' had the smallest berries of these three cultivars ranging from 0.5 to 2.5g with most between 0.8 and 1.5g (Fig. 1C). The distribution of all cultivars appeared to be a normal bell-shaped curve. Trought and Tanneck (7) reported for 'Pinot noir' and 'Cabernet Sauvignon' no effect of position in the cluster on berry size or soluble solids and did report that berry size was reduced when berries had no seeds or only one seed. These small berries had higher soluble solids, but berries with 2 or more seeds did not differ in soluble solids. Berry size was positively related to pedicel cross-sectional area and xylem and phloem. Unfortunately, we did not count seed numbers, but most berries were observed to have multiple seeds. Pearson correlation coefficients between berry size and % soluble solids were calculated for the whole data set and also for all possible subsets (31) produced by combinations of levels of cultivar, exposure

Figure 1. Distribution of berry weight in clusters of 'Vidal blanc' (A), 'Seyval blanc' (B) and 'Pinot Gris' (C).



and date. The most significant correlation coefficient was -0.40 and while most were negative as expected, all were close to 0. None were of a magnitude that would suggest that % soluble solids could be usefully predicted by berry size.

Box plots are a fairly common way of displaying data, especially when the desire is to look at a distribution of values or to compare distributions of values. The box has for its ends the 25 and the 75 percentiles or 1st and 3rd quartiles. An additional line divides the box at the 50th percentile or median. The plot also contains lines or "whiskers" that extend from the box and represent the extent of the data values. These lines are limited to 1.5 times the length of the box. All data beyond this limit are given a special character suggesting that they are extreme and may need a second look. The data for harvest date shows that for 'Pinot Gris' delaying harvest did not shift the box to higher soluble solids (Figure 2). However, with both 'Seyval blanc' and 'Vidal blanc', mature harvest shifted the box to higher soluble solids and reduced the range of the data values.

Exposed clusters for all three cultivars tended to have higher soluble solids than shaded clusters with the greatest difference with 'Seyval blanc' (Figure 3). The range of soluble solids was shorter and had fewer extreme values for 'Seyval blanc' than the other two cultivars which appeared similar. Wolpert et. al. (8) found with 'Vidal blanc' that clusters exposed to sun light had a greater effect on soluble solids than training systems, pruning severity, shoot origin or cluster thinning.

In Table 1, combinations of sampling protocols are presented to give 95% confidence that the sample you take will provide the correct soluble solids at interval half widths of 0.5, 1.0 or 2.0% soluble solids for these three cultivars. It is very clear that the sample for all cultivars must be larger, as the interval half width is reduced. In talking to winemakers, generally a 1.0% half width would be acceptable and would not require significant changes in winemaking techniques.

The actual estimate of the variance components with standard errors (Table 2) show that although estimates were used the very large sample size provided adequate results. The upper 95% confidence limits for the variance components are not much larger than their estimates due to the large sample size used. The 95% C.I. half widths can be recalculated using these upper 95% confidence limits for the variance components and the values from Table 1. When this is done for 'Vidal blanc' and 'Pinot Gris' instead of 1% soluble solids the largest actual half width is 1.22%. Under this worst case scenario 'Seyval blanc' half widths using suggested sample sizes with just one vine are quite large. But the suggested sample sizes using 4 to 5 vines result in half widths from 1.21% to 1.51%.

The difference in sources of variation (Fig. 4) is clearly shown in the sampling protocols. For example, the uniformity of the vines of 'Seyval blanc' in this vineyard indicate that a single-vine could be used as long as 30-38 clusters on that vine are sampled, since cluster-to-cluster variation was responsible for 69% of the variation. However we suggest sampling 4 or more vines with fewer clusters per vine (see Table 1) as vines in other vineyards might not be as uniform. With 'Vidal blanc' and 'Pinot Gris' it was most important to increase the number of vines in the sample since this was the largest source of variation in soluble solids (41 and 48%, respectively), followed by number of berries per cluster.

These results clearly show that sampling schemes should differ among cultivars to insure optimum prediction of must soluble solids. Wolpert and Howell (8) also found that sampling techniques should differ between 'Vidal blanc' and 'Concord' if precise estimates of soluble solids were to be achieved.

Figure 2. Box plot showing the influence of harvest date on the distribution of individual berry soluble solids for three cultivars.

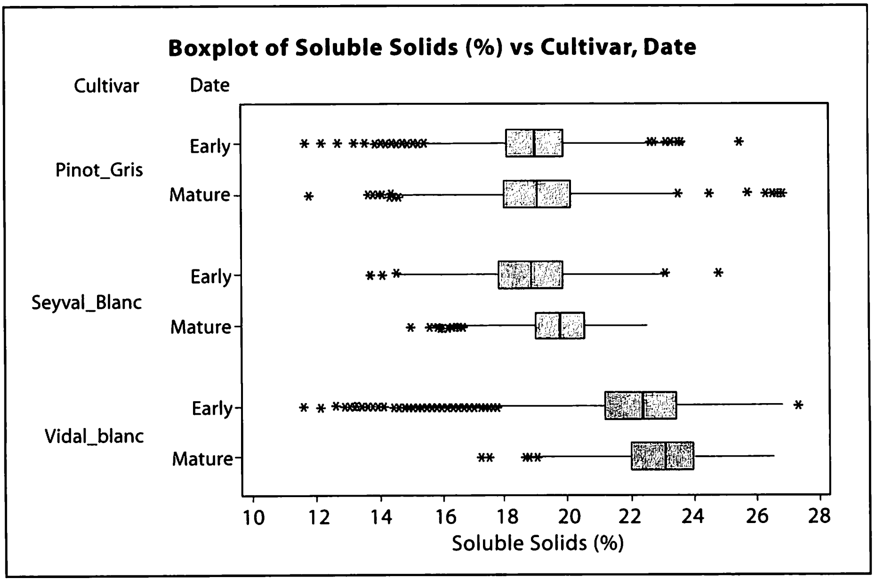


Figure 3. Box plot showing the influence of cluster exposure at the mature harvest on the distribution of soluble solids for three cultivasr.

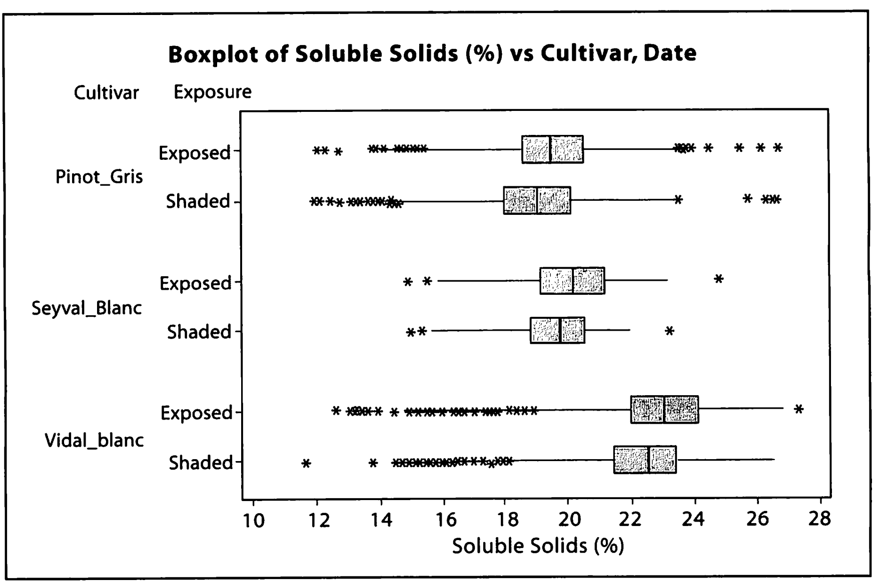


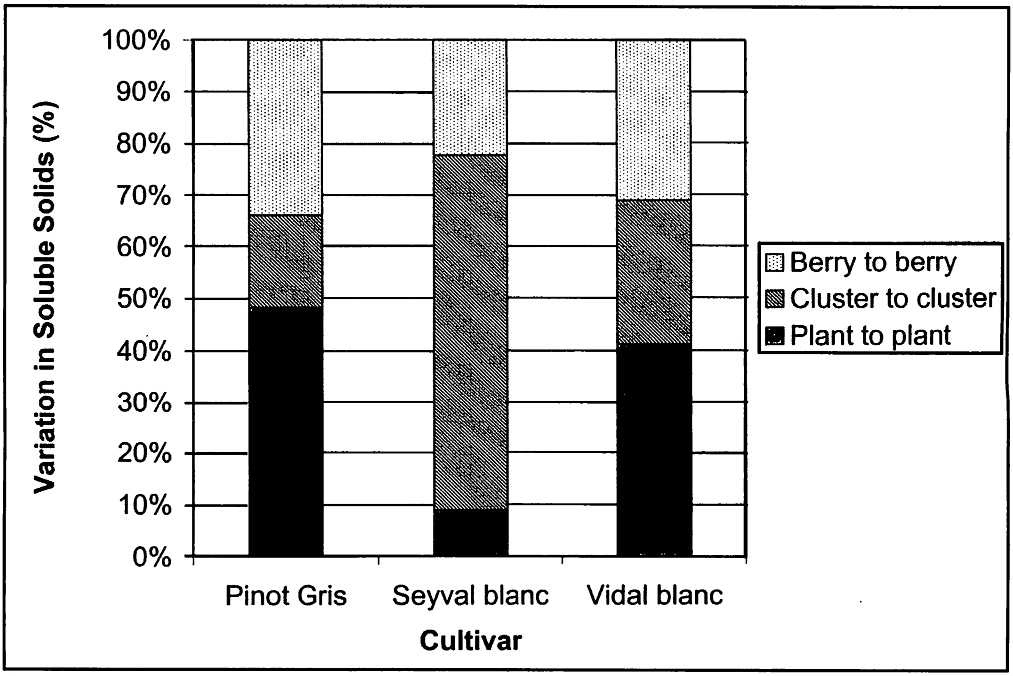
Table 1. Approximate minimal sample size protocols to provide 95% confidence that the soluble solids in the sample will represent the soluble solids concentration of the must of three white wine cultivars at three interval half-widths.

Interval half-width (% soluble solids)	Vidal blanc			Seyval blanc			Pinot Gris		
	Vines Berries	Clusters		Vines Berries	Clusters		Vines Berries	Clusters	
0.5	29	59	59	6	40	22	25	10	15
	29	61	21	6	42	5	25	11	8
	30	14	29	7	15	7	26	5	11
	30	16	6	7	17	2	26	7	3
	31	8	23	8	9	11	27	3	22
	31	10	4	8	11	2	27	5	3
	32	6	9	---	---	---	---	---	---
	32	8	3	---	---	---	---	---	---
	33	5	5	---	---	---	---	---	---
	33	7	2	---	---	---	---	---	---
	33	9	1	---	---	---	---	---	---
1.0	10	5	15	1	30	38	8	24	69
	10	7	3	1	32	4	8	26	17
	11	3	4	1	34	2	9	2	22
	11	5	1	1	38	1	9	4	2
	12	2	4	4	8	3	10	1	42
	12	4	1	4	10	1	10	3	1
	13	2	2	5	4	2	---	---	---
	13	4	1	5	7	1	---	---	---
2.0	5	2	3	1	5	3	4	4	7
	6	1	2	1	7	1	4	6	2
	7	1	1	1	9	1	5	1	2
	8	1	1	1	11	1	5	3	1
	8	3	1	1	13	1	6	3	1

Table 2. Estimates of variance components, standard errors and the upper 95% confidence limits for the three cultivars.

	Pinot Gris			Seyval blanc			Vidal blanc		
	Var comp.	Std. error	Con. limit	Var comp.	Std. error	Con. limit	Var comp.	Std. error	Con. limit
Vine	1.40	0.39	2.05	0.19	0.27	0.63	1.70	0.54	2.59
Cluster	0.52	0.13	0.73	1.47	0.33	2.01	1.14	0.27	1.58
Berry	0.99	0.03	1.04	0.48	0.01	0.50	1.29	0.04	1.35

Figure 4. Distribution of the variation in soluble solids due to vines, clusters and berries of ‘Vidal blanc’, ‘Seyval blanc’, and ‘Pinot Gris’ grapes.



Literature Cited

1. Amerine, M.A. and E.B. Roessler. 1958. Methods for determining field maturity of grapes. Amer. J. Enol. and Vitic. 9:37-40.
2. Cahoon, G., M. Ellis, R. Williams, L. Lockshin. 1991. Grapes: Production, Management and Marketing. Ohio State Univ. Bull. 815, Pub. Office Ohio State Univ., Columbus, OH 43210.
3. Carroll, D.E., W.E. Ballinger, W.F. McClure, and W.B. Nesbitt. 1978. Wine quality versus ripeness of light-sorted Carlos Muscadine grapes. Amer. J. Enol. Vit. 29:169-171.
4. Jackson, D. and D. Schuster. 1994. The production of grapes and wine in cool climates. Gypsum Press. Christchurch, New Zealand.
5. Kasimatis, A. and E.P. Vilas. 1985. Sampling for degrees Brix in vineyard plots. Amer. J. Enol. and Vitic. 36:207-213.
6. Trought, M.C.T. 1996. The New Zealand Terriors: Sources of variation in fruit composition in New Zealand vineyards. In Proc. of the Fourth Internat. Symp. on Cool Climate Enol. and Viticult. T. Henick-Kling et al. (Eds.) pp. I, 23-27. N.Y. State Agric. Exp. Sta. Geneva.
7. Trought, M.C.T. and S.J.C. Tannock. 1996. Berry size and soluble solids variation within a bunch of grapes. In Proc.of the Fourth Internat. Symp. on Cool Climate Enol. and Viticult. T. Henick-Kling et al. (Eds.) pp. I, 70-73. N.Y. State Agric. Exp. Sta. Geneva.
8. Wolpert, J.A., G.S. Howell, and T.K. Mansfield. 1983. Sampling Vidal Blanc Grapes. I. Effect of training system, pruning severity, shoot exposure, shoot origin, and cluster thinning on cluster weight and fruit quality. Amer. J. Enol. and Vitic. 34: 72-76.
9. Wolpert, J.A. and G.S. Howell. 1984. Sampling Vidal Blanc Grapes. II.. Sampling for precise estimates of soluble solids and titratable acidity of juice. Amer. J. Enol. and Vitic. 35: 242-246.

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