Summary 22

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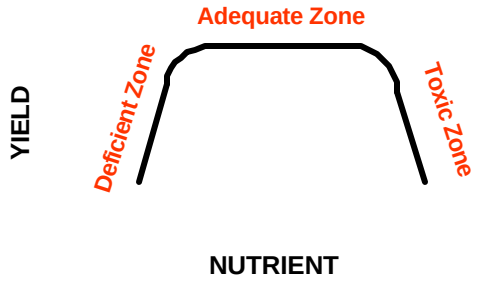
Title: **"Critical plant tissue values and application of nutritional standards for practical use in vineyards"**

By: J. Robinson

In: Proceedings of the Soil Environment and Vine Mineral Nutrition Symposium. P. Christensen and D.R. Smart (Eds.), pp 61-68. American Society of Enology and Viticulture, Davis, CA. 2005.

This is a very practical, down-to-earth review of different techniques of plant tissue analysis and their suitability for vineyards, from an Australian perspective.

- For many annual, herbaceous crops it has been possible to develop specific yield response curves for individual nutrients using pot and field experiments. These curves have always followed an inverted-U shape. That is, they show a **deficient zone**, where yields are low, followed by a plateau or **adequate zone**, where yields are maximal, and finally a **toxic zone**, where yields start declining again.



- In perennial, woody crops like grapevines, where responses are much more variable, response curves have been difficult to develop. We can only approximate these curves by relying on database information from productive vineyards in which nutrient status has been associated to a visual quality assessment, as well as deficiency and toxicity symptoms from pot trials.

- A compromise often needs to be made when choosing **what plant tissue** is best for sampling. 1) Nutrients that are *mobile* (tend to move from older leaves -where symptoms appear- towards the growing tip) are best sampled from older leaves. Examples are nitrogen (N), phosphorus (P) and potassium (K). 2) *Immobile* nutrients (do not move around the plant phloem, and show deficiency symptoms in the growing tips or in the younger leaves) are best sampled from tips and young leaves. Examples are calcium (Ca), zinc (Zn) and iron (Fe). Most plant analyses use a compromise method of sampling, where a plant part is pre-selected and then it is assessed whether both mobile and immobile nutrients are in reasonable supply.

- Another important compromise is **when to sample**. Nutrients change in concentration depending on the vine physiological stage. Even within the same physiological stage, large differences were detected based on vintage. For example, Christensen showed important differences in N levels in the leaves of

Thompson Seedless four years in a row, despite being sampled at the same stage and having received the same fertilization program. It was then noted that these changes were smaller and less troublesome around *bloom.*

- **Variety and rootstock** combination is a third factor that has an important effect on nutrient composition. As an example, the article reproduces a table where varieties have been classified according to their ability to accumulate N. A second table classifies rootstocks according to their scion petiole K concentration.

- Finally, **contamination** from foliar nutrients and pest management sprays is another complicating factor that needs to be taken into consideration. Acid-washes of sampled tissues have been recommended to remove most of a potential contaminant (even though it's never clear how much of the contaminant remains).

- There are 4 tissue analysis approaches currently used in Australia: 1) petioles sampled at bloom, 2) sap analysis, 3) leaf blades (lamina) sampled early, and 4) leaf blades sampled at veraison.

- 1) **Petioles sampled at bloom.** Widely used in California, this technique was found by the author to give the most sensible interpretation of vineyard nutrient status in a comparative study. One point of dissatisfaction among Australian growers is that the nitrogen standards used with this method seem too high. The author agrees and notes that the Californian standards for N were developed from studies on Thompson Seedless vines, where high yields were important. With winegrapes, growers often limit yield by pruning, shoot thinning, fruit thinning, etc, so the vine probably needs much lower concentrations of N than those deemed necessary for maximum yield. The author points out that visual observation of vigor is often the best indicator of N requirements.

- 2) **Sap analysis**. This is a new technique that is gaining favor in Australia. It still lacks agreed-upon standards. Samples for analysis can easily be collected at different times of the year to take account of fluxes in nutrients. The author expects working standards to be developed soon.

- 3) **Leaf blades sampled early.** This technique is in response to growers' complaints that normal petiole analysis sampling times (bloom) yield results too late. The concern of the author with this technique is that samples are taken at a time when nutrient fluxes are at a peak. The risk is that, instead of gaining information about true deficiencies or toxicities, we might just pick up normal vine developmental nutrient changes, or the impact of very variable spring weather conditions.

- 4**) Leaf blades sampled at veraison**. This method is mostly used when an earlier sampling date was missed, or when we are trying to diagnose a particular problem that we have observed in the vineyard.

- The author, who runs a tissue analysis service, next offers some insight into their operation. He uses an outside, contracted lab that dries, grinds, and analyzes the samples, and forwards the results to him. At the time of interpreting the results for the client, all of the following are taken into account: possible contaminations, fertilizer program, grower's assessment of vigor, vine appearance, grower comments, and winemaker comments on the previous season's grape quality. In the author's experience, contamination from sulfur (S) is often expected, and furthermore, petiole S readings seem to depend on the time that has lapsed since the last S spray. Unexplained low Ca, or high manganese (Mn), are normally indicators of acid soil; and high Mn can sometimes mean waterlogged conditions. The author emphasizes that plant tissue analyses should always be used together with visual observations.

- The author points out that, in a 1978 survey of nutrient values in vineyards in South Australia, they had only an electronic calculator to assess all their data. Today it is possible to collect detailed management

data, wine-quality data, and soil data, and study their interrelationships using sophisticated software. He also sees a great future in precision viticulture to help establish the relationship between plant nutrient levels and plant performance.

The following table summarizes info from various tables presented in this paper.

Nutrient	Adequate levels in petioles [a]	Adequate levels in leaf blades [b]	Comments
N	0.8-1.1 %	3.0-5.0 %	Vigor or leaf color may be more reliable
P	0.25-0.5 %	0.25-0.4 %	
K	1.8-3.0 %	1-1.8 %	There are large differences in petiole levels between varieties
Ca	1.2-2.5 %	1.2-2.8 %	
Mg	>0.4 %	0.3-0.6 %	
Na		<0.1 %	
Cl		<0.8 %	
Fe	>30 mg/kg		Dust contamination likely. Leaf symptoms are a more useful diagnostic aid
Cu	6-11 mg/kg	10-100 mg/kg	Fungicide contamination likely
Zn	>26 mg/kg	35-60 mg/kg	Fungicide contamin ation likely
Mn	30-60 mg/kg	30-200 mg/kg	Fungicide contamination likely
B	35-70 mg/kg	30-200 mg/kg	

[a] Petioles from basal leaves opposite clusters at bloom. One petiole per 100 vines.

[b] Leaf blades from basal leaves opposite clusters at bloom.

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