



Nitrogen nutrition status of the vine: correlation between N-tester and SPAD chlorophyll indices

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Knowledge of the nitrogen nutrition status of the vine is essential for long-term management of its nutrition with the aim of producing high-quality grapes. Measurement of the chlorophyll index is a fast, non-destructive and relatively inexpensive method that provides a good approximation of the nitrogen nutrition status of the vine during the growing season. Several chlorophyll meters are available on the market, each using its own measurement unit. With the aim of popularizing the use of chlorophyll meters, the interpretation thresholds of the SPAD index, measured on the vine at the veraison stage, have been established from correlation with the N-tester index, for which the thresholds are already known.

Estimate of the nitrogen nutrition status of the vine

The first visible symptoms of nitrogen deficiency are poor vegetative growth of the vine and pale green-yellow coloration of the canopy, due to lower chlorophyll content (Figure 1). Depending on the severity of the deficiency, bud fertility and crop yield can also be greatly reduced over years. In terms of grape quality, the must at harvest can have very low levels of assimilable nitrogen (<140 mg/L), affecting both the kinetic of the alcoholic fermentation and the development of wine aromas. White and rosé wines are particularly sensitive to nitrogen deficiency. Knowledge of the nitrogen nutrition status of the vine is thus essential for long-term management of its nitrogen nutrition with the aim of producing high-quality grapes¹.



FIGURE 1. Symptoms of nitrogen deficiency in the vineyard: weak shoot growth and pale green-yellow coloration of the canopy. Phenological stage: flowering, Chasselas, 2022.

Measurement of the total nitrogen in the soil is not a reliable indicator of nitrogen availability for the vine. Soil analysis does not reflect the kinetics of mineralization over time, which varies widely with environmental conditions. A soil can thus be rich in organic nitrogen, without it being assimilable by the vine. However, there are now several reliable methods to estimate the nitrogen nutrition status of the vine

1/ Visual observation of deficiency symptoms remains the simplest method to implement. Strong vigor, a dense canopy and a high yield are generally indicators of high nitrogen nutrition status.

2/ Petiole and/or leaf blade analysis is quite expensive and can be difficult to interpret². It is more generally used to confirm visual observation of the plant.

3/ Measurement of the assimilable nitrogen content in the must at harvest is the most appropriate method. Detection of nitrogen deficiency in the must makes it possible to plan nitrogen nutrition management of the vine for the following year. It varies strongly depending on environmental conditions and vineyard management techniques³.

4/ Indices have been developed for more or less direct estimation of the nitrogen nutrition status of the plant⁴. Estimation of the chlorophyll concentration in the leaves, generally based on indirect and non-destructive measurements, provides a reliable, fast and inexpensive approximation of the nitrogen nutrition status of the vine during the growing season.

Chlorophyll content and chlorophyll index

The green color of the canopy, and its yellowing in the presence of nitrogen deficiency, correlate very well with its chlorophyll content⁴. The relationship between chlorophyll and nitrogen content in leaves varies considerably between species, but remains stable within species⁵, such as *Vitis vinifera*, thus making measurement of the chlorophyll index an appropriate method for estimating nitrogen nutrition in the vine. Chlorophyll meters are widely used for diagnostic purposes to guide nitrogen management by monitoring the nitrogen nutrition status of foliage in many crops through rapid, non-destructive measurements. Various portable models are available, such as the N-Tester (Yara, Oslo, Norway), the SPAD 502 (Konica Minolta, Nieuwegein, Netherlands) and the Dualex (Force A, Orsay, France). Measurement of the chlorophyll index during the growing season faithfully reflects the variation in the nitrogen content of the canopy depending on the grape variety and the phenological stage (Figure 2).

Taking account of the sampling method is also essential for reliable use in the vineyard. Estimation of vine nitrogen nutrition status by measuring the chlorophyll index is usually performed at veraison.

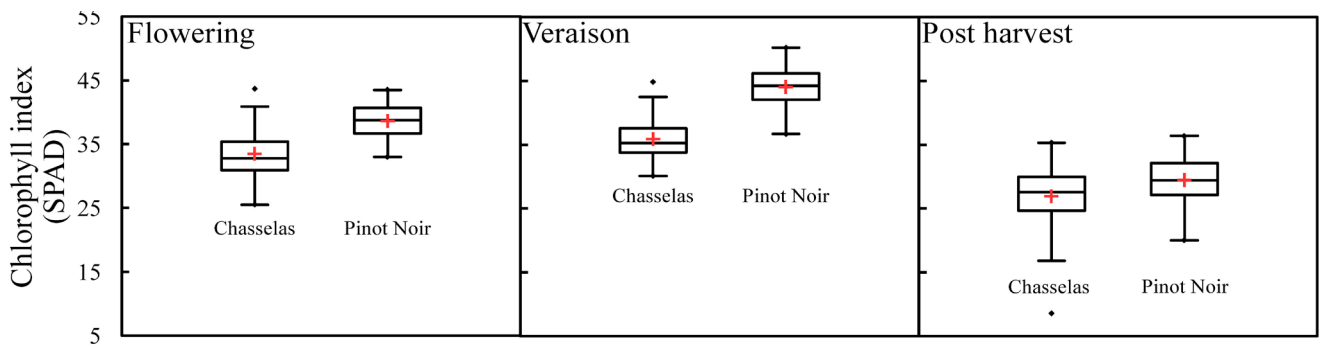


FIGURE 2. Variability of the chlorophyll index (SPAD) as a function of the phenological stage and the grape variety. ($n = 500$; source: Agroscope, Switzerland).

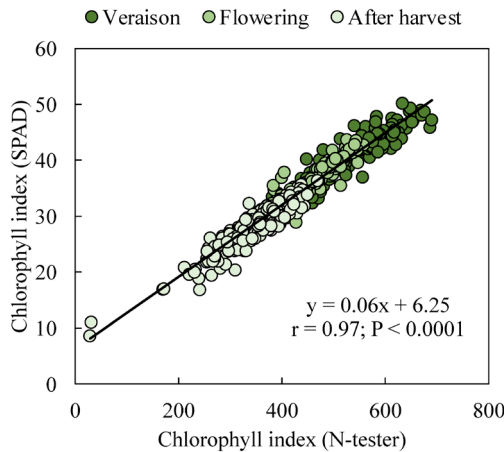


FIGURE 3. Correlation between N-tester and SPAD chlorophyll indices. The measurements were made at three phenological stages on Chasselas and Pinot Noir ($n = 500$; source: Agroscope, Switzerland).

when the nitrogen content is highest, by sampling healthy adult leaves in the bunch zone. It is not recommended to carry out measurements at other points in the season due to increased data fluctuation: at the start of the season because of the younger age of the leaves and possible symptoms of iron chlorosis; at the end of the season because of possible mineral deficiency symptoms (magnesium and potassium among others), or because of strong pressure from fungal diseases (drying out of the leaf blades) or in case of severe water deficit during the summer (yellowing of leaves at the base of the shoots). Thresholds for interpreting vine nitrogen nutrition status using the chlorophyll index are currently insufficient or even non-existent for some chlorophyll meters. Ideally, thresholds should be available for each grape variety and each phenological stage.

N-tester/SPAD conversion

The chlorophyll meters on the market use different indices. Interpretation thresholds are available for measurements made with the N-Tester at veraison for the grape varieties Chasselas, Pinot Noir and Gamay⁶ (Table 1). With the aim of popularizing the use of these

instruments, measurements were made at Agroscope in Switzerland to establish the correlation between the N-tester and SPAD indices (Figure 3). In 2022, 500 measurements were made in parallel using the N-tester and SPAD, at three phenological stages on Chasselas and Pinot Noir. The vines were Guyot trained. The measurements were taken on the main leaves in the median area of the canopy. This showed excellent correlation ($r = 0.97$; $P < 0.0001$) and a linear regression that allowed conversion of the existing interpretation thresholds for the N-tester (Figure 3, Table 1). ■

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- 1 Bell, S.-J., & Henschke, P. A. (2005). Implications of nitrogen nutrition for grapes, fermentation and wine. *Australian Journal of Grape and Wine Research*, 11, 242-295. <https://doi.org/10.1111/j.1755-0238.2005.tb00028.x>
- 2 Delas, J. (2010). La fertilisation de la vigne : contribution à une viticulture durable. 2e édition. Eds Feret, 165 pp
- 3 Spring, J. L., Verdenal, T., Zufferey, V., & Viret, O. (2012). Nitrogen dilution in excessive canopies of Chasselas and Pinot noir cvs. *J. Int. Sci. Vigne Vin*, 46(3), 233-240. <https://doi.org/10.20870/oenone.2012.46.3.1520>
- 4 Friedel, M., Hendgen, M., Stoll, M., & Löhnertz, O. (2020). Performance of reflectance indices and of a handheld device for estimating in-field the nitrogen status of grapevine leaves. *Australian Journal of Grape and Wine Research*, 26(2), 110-120. <https://doi.org/10.1111/ajgw.12424>
- 5 Xiong, D., Chen, J., Yu, T., Gao, W., Ling, X., Li, Y., Peng, S., & Huang, J. (2015). SPAD-based leaf nitrogen estimation is impacted by environmental factors and crop leaf characteristics. *Scientific Reports*, 5(1), 13389. <https://doi.org/10.1038/srep13389>
- 6 Spring, J. L. & Jelmini, G. (2002). Nutrition azotée de la vigne : intérêt de la détermination de l'indice chlorophyllien pour les cépages chasselas, pinot noir et gamay. *Revue Suisse Vitic. Arboric. Hortic.* 34, 27-29.

TABLE 1. Thresholds for interpretation of the chlorophyll index (N-tester and SPAD) of the canopy measured at veraison (main leaves of the bunch zone) for three grape varieties.

Assessment of the nitrogen supply	N-tester			SPAD*		
	Chasselas	Pinot Noir	Gamay	Chasselas	Pinot Noir	Gamay
very low	<420	<460	<380	<31	<34	<29
low	420–460	460–500	380–430	31–34	34–36	29–32
normal	460–540	500–580	430–530	34–38	36–41	32–38
high	540–570	580–620	530–580	38–40	41–43	38–41
very high	>570	>620	>580	>40	>43	>41

*The SPAD thresholds were calculated from the N-tester thresholds established by Spring and Jelmini (2002).