# GRAPEVINE NITROGEN STATUS: CORRELATION BETWEEN CHLOROPHYLL INDICES N-TESTER AND SPAD

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## Abstract:

**Context and purpose of the study**

Knowledge of the nitrogen nutrition status of grapevines is essential for the sustainable management of their nutrition for the production of quality grapes. The measurement of the chlorophyll index is a rapid, non-destructive and relatively inexpensive method that provides a good approximation of the nitrogen nutrition status of the vine during the season. Interpretation thresholds are currently insufficient or non-existent for some chlorophyll meters. Ideally, they should be available for each variety and each phenological stage. In order to popularize the use of chlorophyll-meters, measurements were carried out at Agroscope in Switzerland to establish the correlation between the indices obtained by the devices N-tester and SPAD 502.

**Material and methods**

In 2022, 500 measurements were carried out with the two devices N-tester and SPAD 502 in parallel, at three phenological stages (flowering, veraison and post-harvest), on the two grape varieties chasselas and pinot noir. The vines were all trained in Guyot pruning. Each measurement consisted of 30 flashes of each device taken at the same locations on the main leaves of the fruit zone.

**Results**

Measurements from both devices showed an excellent correlation ($r = 0.97$; $P < 0.0001$) between SPAD and N-tester indices. Given the linear regression obtained ($y = 0.06x + 6.25$), the thresholds of the SPAD index measured on vines at veraison, for the interpretation of the nitrogen nutrition status, were calculated from the correlation with the N-tester index, whose thresholds are already known. It is not recommended to carry out measurements at other times of the season due to the greater fluctuation of the data due to the age of the leaves, the water status of the vine or the possible presence of disease symptoms (e.g., mildew, powdery mildew) or other deficiencies (e.g., iron, magnesium). These results allow scientists and growers to easily estimate the nitrogen status of the vine at veraison in the vineyard and, if necessary, to compare/convert the results of the two devices.

**Keywords**: Vine, Nitrogen, Chlorophyll, Thresholds, Fertilization.

## 1. Introduction

The first visible symptoms of nitrogen deficiency are poor vegetative development of the vine and pale green-yellow coloration of its foliage, due to a lower chlorophyll content (Figure 1). Depending on the severity of the deficiency and its carryover effects, the bud fruitfulness and the yield at harvest can also be strongly affected. In terms of grape composition, the must at harvest can have very low levels of yeast assimilable nitrogen (YAN < 140 mg/L), which affects both the alcoholic fermentation kinetics and the development of wine aromas. White and rosé wines are particularly sensitive to nitrogen deficiency. The knowledge of the vine's nitrogen nutrition status is therefore essential for a sustainable management of its nitrogen nutrition in order to produce quality grapes and wines (Bell and Henschke, 2005).

The measurement of total nitrogen in the soil is not a reliable indicator of nitrogen availability for the vine. Soil analysis does not reflect the dynamics of mineralization over time, which is extremely variable depending on environmental conditions. A soil can be rich in organic nitrogen, without it being assimilable by the vine. On the other hand, several reliable methods for estimating the nitrogen nutrition status exist to date:

1/ Visual observation of deficiency symptoms is the easiest method to implement. High vigor, dense canopy and high yield are generally indicators of high nitrogen nutrition status.

2/ Analysis of the petiole and/or leaf blade is relatively expensive and can be difficult to interpret (Delas, 2010). It is generally used to confirm a visual observation of the plant.

3/ The concentration of YAN in the must at harvest is the most relevant method. The observation of a nitrogen deficiency in the must makes it possible to anticipate the management of the vine's nitrogen nutrition the following year. It varies greatly according to environmental conditions and cultivation techniques (Spring *et al.*, 2012).

4/ Several indices have been developed to estimate, in a more or less direct way, the nitrogen nutrition status of the plant (Friedel *et al.*, 2020). The estimation of chlorophyll concentration in leaves, generally based on indirect and non-destructive measurements, allows a reliable, fast and inexpensive approximation of the nitrogen nutrition status of the vine during the season.

Green leaf color correlates well with chlorophyll content and with leaf yellowing symptoms related to nitrogen deficiency (Cerovic *et al.*, 2015). The relationship between leaf chlorophyll and nitrogen content varies considerably between species, but remains stable within a single species (Xiong *et al.*, 2015), such as *Vitis vinifera*, making the measurement of the chlorophyll index relevant for estimating nitrogen nutrition status in grapevines. 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 and non-destructive measurements. Various handheld models are available, such as the N-Tester (Yara, Oslo, Norway) and the SPAD 502 (Konica Minolta, Nieuwegein, Netherlands), each device using its own index. A trial was conducted in order to establish the correlation between the indices obtained by the N-tester and by the SPAD.

## 2. Material and methods

Site and plant material – The trial was conducted in 2022 on the experimental vineyard of Agroscope in Pully, Switzerland (46°30'47.4"N 6°39'59.3"E), on two cultivars, that is, chasselas planted in 2002 and 2007, and pinot noir planted in 2012, with a planting density of 1.5 × 0.8 $m^2$ (8’300 vines per ha). The vines were trained in a single Guyot system with seven shoots per vine.

Plant measurements – A total of 500 measurements of chlorophyll index were done using both N-tester and SPAD 502 simultaneously at three phenological stages (i.e., flowering, veraison and post-harvest). Both devices were calibrated at each startup following the instructions for use. Measurements with both devices were done on the same spots of main leaves (no laterals) in the fruit area of the canopy. Thirty flashes in average were required to obtain one measurement.

Statistical analyses – Data description was done with XLSTAT (version 2021.1.1). An ANOVA was done for each index separately, considering both the cultivar and the phenological stage as factors of variability. An overall

linear regression was established between the two indices SPAD and N-tester, as well as by cultivar and phenological stage.

## 3. Results and discussion

The measurement of the chlorophyll index during the season perfectly reflected the variation of the nitrogen content of the foliage according to the grape variety and the phenological stage (Figure 2). These results confirm the results from Friedel *et al.* (2020). As expected for both cultivars, the highest chlorophyll indices were measured at veraison, followed by flowering, and then post-harvest. At each of the three phenological stages, the chlorophyll indices measured on pinot noir were significantly higher than chasselas (Figure 2). An excellent overall linear regression was established ($y = 0.06x + 6.25$; $r = 0.97$; $P < 0.0001$) between the SPAD and N-tester indices (Figure 3). Correlations by cultivar and by phenological stage were all strong ($0.80 < r < 0.94$). Linear regressions between the two indices were similar for both cultivars ($y = 0.06x + 6.30$ for chasselas; $y = 0.07x + 4.95$ for pinot noir). This allowed the conversion of the already existing interpretation thresholds for N-tester into thresholds for SPAD (Table 1).

## 4. Conclusions

Measurements obtained with both devices showed an excellent linear regression between SPAD and N-tester indices. This allowed the determination of nitrogen status thresholds for SPAD 502 measurements on vines at veraison, based on the correlation with the N-tester index, whose thresholds are already known. These results allow scientists and growers to easily estimate the nitrogen status of grapevines at veraison in the vineyard and, if necessary, to compare/convert the results of the two instruments.

## 5. Acknowledgments

We would like to underline the conscientious work of the technical team of Agroscope for the maintenance of the experimental vineyard and the precious help of our trainees Nicolas Berud, Mathile Donaty and Mathilde Le Graët for the measurements in the field.

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**Figure 1:** Symptoms of nitrogen deficiency in the vineyard: poor shoot growth and pale green-yellow coloration of the foliage. Phenological stage of flowering, chasselas, june 2022, Changins, Switzerland.

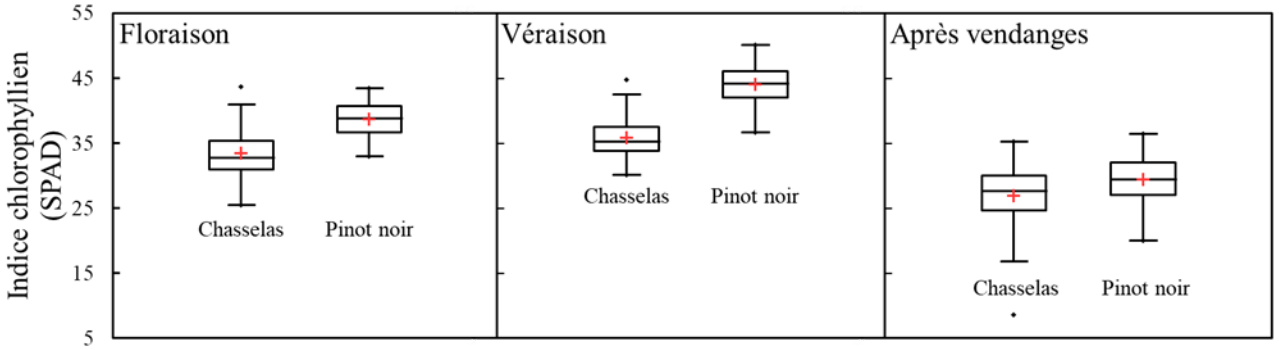


**Figure 2:** Variability of the chlorophyll index (SPAD) as a function of phenological stage and grape variety. (n = 500; Pully, Switzerland)

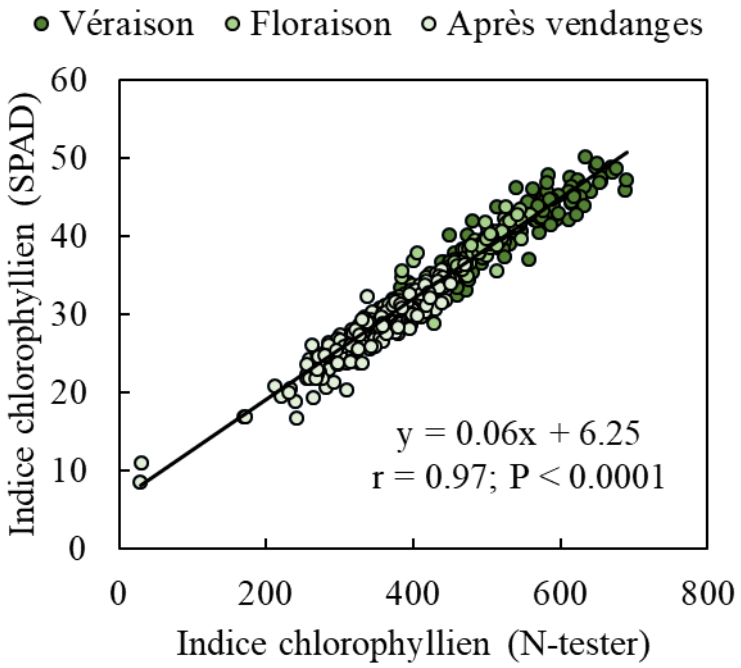


**Figure 3:** Linear regression between N-tester and SPAD chlorophyll indices. Measurements were performed at three phenological stages, on chasselas and pinot noir grapes (n = 500; Pully, Switzerland).

**Table 1:** Thresholds for the interpretation of the chlorophyll index (N-tester and SPAD) of the foliage measured at veraison (main leaves of the cluster area), on three grape varieties.

| Assessment of the level of nitrogen feeding | **N-tester** | | | **SPAD 502*** | | |
|---|---|---|---|---|---|---|
| | 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 |

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