



Changes in norisoprenoid levels with long-term nitrogen fertilization in different vintages of *Vitis vinifera* var. Riesling wines

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In: South African Journal of Enology and Viticulture. 28(1):17-24. 2007.

- Norisoprenoids are important compounds that contribute to the aroma of wines. Examples of norisoprenoids are **β -ionone** and **β -damascenone**, which contribute intense fruity aromas; **TDN** (trimethyl-dihydro-naphthalene), which contributes the typical kerosene, or petrol, note in wines (in high concentrations, TDN may be considered a defect); and **actinidol** and **vitispirane**, which contribute other complex aging aromas. Chardonnay contains many types of norisoprenoids, whereas Riesling has fewer.
- Both *temperature* and *sunlight* are known to have an effect on norisoprenoid concentrations. For example, when Riesling is grown in a cool climate, TDN is usually perceived only after 6 years of aging, whereas in hot areas, TDN can accumulate much earlier and stronger. Similarly, grapes exposed to direct sunlight produce higher TDN than those grown in the shade. However, prior to this study, nothing was known about the effect of *nitrogen fertilization* of vineyards on the concentrations of norisoprenoids in the resultant Riesling wines, so these German authors decided to look into it.
- The experiment took place in the Rheingau, Germany, in 1996, 1997 and 2003. The vineyard, on a loamy, sandy soil, was Riesling planted on 5C in 1977, and trained to one vertical cane. The vineyard had a permanent cover crop every second row. The treatments were **0, 30, 60, 90, and 150 kg of nitrogen per hectare per year** (ammonium nitrate, 27% N). There were 4 replications per treatment. The winemaking was on a small scale (10 L), and after bottling, the wines were stored at 14°C.
- The authors measured the levels of norisoprenoids in each fertilization treatment through “SBSE-GC/MS”, a powerful analytical tool used to quantify and identify aroma compounds in wines. The first part of the name (SBSE) stands for “*stir bar sorptive extraction*”, in which aroma compounds are gradually adsorbed onto a specialized stirring bar in the wine sample. The second part of the name refers to “*gas chromatography/mass spectrophotometry*”, in which the aroma compounds trapped on the stir bar are desorbed and subsequently identified, based on their mass and retention time. Besides measuring norisoprenoid concentrations in the wines, the authors measured N levels in the leaf tissue and in the soils of each treatment.
- **Effect of nitrogen on vine performance and juice composition.** Fertilized vines could be easily separated visually from unfertilized vines in growth, foliage surface and leaf color. Unfertilized vines had 25% less pruning weight and 18% less yield. Juice Brix and TA were not affected by fertilization. But, as expected, N concentration in the must was significantly higher in the fertilized treatments. The most apparent effect of N fertilization was in the concentration of leaf N, with unfertilized leaves showing much lower N levels, clearly indicating a nitrogen deficiency.

- **Effect of nitrogen on norisoprenoid levels.** The effect varied, depending on the individual norisoprenoid. N fertilization led to lower TDN concentrations, whereas actinidol and β -damascenone concentrations (desirable) increased with fertilization. Vitispirane content was not affected. β -ionone concentration (violets) was below the level of detection.

- **Correlations.** When the authors subjected their data to Principal Component Analysis, they found that much of the variation in norisoprenoid content was correlated with “storage time” (first principal component). The second principal component correlated well with the parameters “temperature” and “sunshine”. Overall, N fertilization was not well correlated with norisoprenoid content and was not explained by principal component analysis. On the other hand, the correlation between “yield” and norisoprenoid content was highly significant. Brix and TA, in contrast, were poorly correlated with norisoprenoid content.

- In the discussion, the authors point out that, despite the lack of direct effect of N fertilization on norisoprenoid content mentioned above, there may be an indirect effect due to the increased leaf size and shade of the fertilized vines. Similarly, N levels may have affected norisoprenoid content indirectly through an effect on berry size and skin surface, where norisoprenoid precursors (carotenoids) are located.

In summary, TDN, responsible for the kerosene-like aroma in Riesling wines, decreased with nitrogen fertilization. In contrast, the positive aroma compound β -damascenone increased with nitrogen fertilization. The authors found that colder years with less sunshine hours caused TDN to decrease, and β -damascenone to increase. Most norisoprenoid concentrations (TDN, actinidol, vitispirane) tended to increase with increased bottle aging. So, even though the mechanism of the effect of nitrogen fertilization on norisoprenoids is still not fully explained by this research, it is now assumed that it can influence the aroma profile of Riesling and, possibly, other varieties.

Author: Bibiana Guerra, Editor: Kay Bogart. This summary series funded by J. Lohr Vineyards & Wines.