https://doi.org/10.20870/IVES-TR.2021.4852

Leaf area management affects grape nitrogen content

>>> Grape nitrogen content at harvest plays a decisive role in the kinetics of alcoholic fermentation and in the formation of wine aromas, particularly in the case of white wines. Viticultural practices have evolved considerably in recent decades towards less use of herbicides and more grass cover. In this context, nitrogen deficiencies in musts have been observed repeatedly in certain vineyards. How can vineyard management be adapted to take account of this competition for nitrogen? <<<

Background to the study

The presence of certain forms of nitrogen in grape must at harvest is necessary to ensure a smooth fermentation and has an influence on the final quality of the wine. In white winemaking, a must is considered deficient if it contains less than 140 mg/L of yeast assimilable nitrogen (ammonium + amino acids)[1]. Fermentation is then slowed down and may even stop before the complete conversion of sugars into alcohol. Amino acids are also involved in the formation of wine aroma compounds[2]. Wines made from nitrogen-deficient musts are often less aromatic and taste more bitter and astringent. Addition of 10–20 kg/ha of urea on the leaves at veraison is often suggested as a temporary solution to correct the yeast assimilable nitrogen content in grapes[3]. However, this solution is prohibited in organic farming and undesirable in a context of limiting inputs in the interest of more sustainable production. It is essential to adapt cultivation practices to promote accumulation of nitrogen in the grapes.

Several studies have shown the impact of the ratio between the vine leaf area (source) and crop load (sink) on the carbon metabolism, and more precisely the link between the photosynthetic activity of the leaves and the accumulation of sugars in the grapes[4, 5]. But the leaf-to-fruit ratio also influences the nitrogen content of the vine and particularly the grapes. A ten-year study showed the strong impact of canopy management on the nitrogen content of the vine by varying the trimming height (between 60 cm and 140 cm) in Guyot-pruned Pinot Noir and Chasselas vines[6]. Less intense trimming induced greater canopy height and resulted in a decrease in the nitrogen content of the vine, comparable to a dilution of nitrogen in the volume of the biomass. In some years, the excessive leaf area even caused yeast assimilable nitrogen deficiency in the must, despite the good availability of nitrogen in the soil[6]. Oversized canopy (+31 % dry matter) led to a decrease in the total nitrogen concentration throughout the plant (−17 %), and more

Canopy height trial on the Chasselas grape variety at Agroscope, Pully.

particularly a decrease in the yeast assimilable nitrogen concentration in the must (−53 %)[5].

Trial

A trial was set up in the Agroscope experimental vineyard in Pully, Switzerland, to show the impact of the trimming height on the nitrogen composition of the must at harvest and on nitrogen fertilization efficiency. In a uniform plot of Chasselas, two variable factors were put in place: fertilization (two levels: an unfertilized control and addition of 20 kg/ha of leaf urea at veraison), and canopy height (three levels, 80, 120 and 150 cm). Canopy height was controlled by varying the trimming height. The trial was repeated for four consecutive years (2013–2016). The musts were analyzed at the time of harvest. The exposed leaf area (in m^2) was estimated in August on a fully developed canopy, using the following formula:

Exposed leaf area = [(2 × height + width) × (1 − % porosity)] / inter-row width.

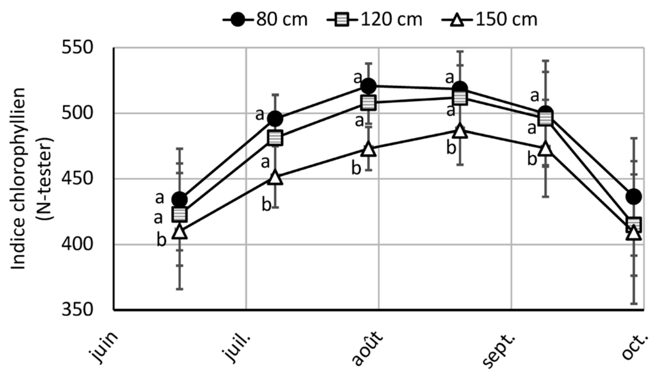

Figure 1. Change in the leaf chlorophyll index (Yara N-Tester) during the growing season as a function of canopy height. Mean values over four years.

The set-up and launch of IVES Technical Reviews are supported by the LabEx COTE via its Transfer and valorization call for projects.
The translation of this article into English was offered to you by Moët Hennessy.

Results

The exposed leaf area varied from 1.1 m^2 (80 cm foliage height) to 2.0 m^2 (150 cm height). The average yield was constant at 1.3 kg/m^2 regardless of the canopy height. The leaf-to-fruit ratio thus varied between 0.9 m^2/kg (80 cm) and 1.5 m^2/kg (150 cm). The chlorophyll index – an excellent indicator of the foliage nitrogen content – was lower as from flowering in the 150 cm variant (Figure 1). Leaf analyses (limbs + petiole) at veraison confirmed a significant drop in nitrogen content in the 150 cm variant (1.9 % of the dry matter compared with 2.1 % in the 80 cm variant).

Insufficient canopy height delayed ripening of the grapes at harvest: the must of the 80 cm foliage variant had an average sugar content of 18 °Brix (approximately 180 g/L), that is a significant reduction of 0.5 °Brix (approximately 5 g/L) compared with the 150 cm variant. These musts also had an average malic acid content of 2.8 g/L, a significant increase of 0.3 g/L. Regarding the nitrogen in the must, the 80 cm variant had 252 mg/L of yeast assimilable nitrogen compared with only 164 mg/L in the 150 cm variant (Figure 2). The canopy height did not influence fertilization efficiency: the addition of leaf urea resulted in an average increase in yeast assimilable nitrogen of 57 mg/L in the must at harvest, whatever the canopy height (Figure 2).

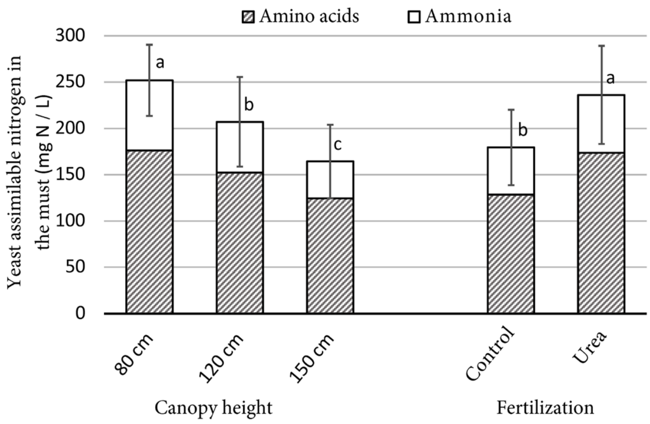

Figure 2. Yeast assimilable nitrogen content in the must at harvest, as a function of foliage height and the addition of leaf urea at veraison. Mean values over four years.

Correlations between the variables are shown in Figure 3A. The leaf area was strongly correlated with the sugar content of the must and negatively correlated with the nitrogen in both the plant (leaf nitrogen) and the must (yeast assimilable nitrogen). As shown in Figure 3B, the different treatments (canopy height × fertilization) could be distinguished according to must composition and canopy height. The main distinction was linked to both the vintage and the grape maturity. A second distinction within each vintage was linked to the canopy height and nitrogen supply. The impact of leaf fertilization was low compared with the impact of vintage and trimming height.

Conclusion

The leaf-to-fruit ratio is an essential criterion for the physiological balance of the plant, for both carbon and nitrogen. The canopy height did not influence the efficiency of leaf fertilization.

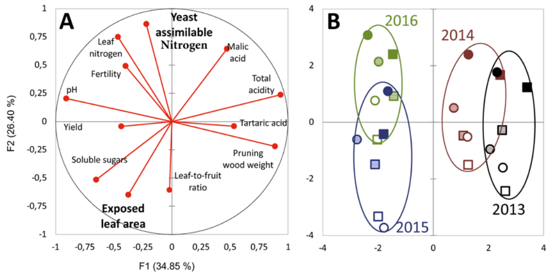

Figure 3. Results of principal component analysis (PCA) on the parameters related to vegetative growth and must composition at harvest (mean values over four years). Figure 3A describes the correlations between variables: the yeast assimilable nitrogen in the must is negatively correlated with the leaf area of the vine. Figure 3B shows the similarities between observations. Circle = leaf urea addition; square = unfertilized control; blank = 150 cm canopy; hatched = 120 cm; filled = 80 cm.

Nevertheless, a leaf-to-fruit ratio < 1.0 m^2/kg was not sufficient to guarantee a proper grape maturity each year. Conversely, a leaf-to-fruit ratio > 1.5 m^2/kg resulted in a moderate yeast assimilable nitrogen deficiency in the must. The leaf area had no influence on the amount of nitrogen assimilated by the plant. The amount of nitrogen in the plant therefore remained constant and hence its concentration was reduced in the volume of the biomass. In the temperate climate of the Swiss vineyard, a leaf-to-fruit ratio of 1.0–1.2 m^2/kg is therefore recommended to guarantee full grape maturity, a suitable must nitrogen concentration and a sufficient nitrogen refill by storage organs. Good canopy management represents a sustainable solution that limits nitrogen deficiency in the must while minimizing the need for fertilization. ■

Thibaut Verdenal, Vivian Zufferey, Mélanie Huberty, Claire Melot, Ágnes Dienes-Nagy, Jean-Laurent Spring

Agroscope, 1009 Pully, Suisse

1 Verdenal T, Dienes-Nagy Á, Spangenberg JE, Zufferey V, Spring JL, Viret O, Marin-Carbonne J, van Leeuwen C. Understanding and managing nitrogen nutrition in grapevine: a review. *Oeno One.* 2021, 55, 1-43.

2 Bell SJ, Henschke PA. Implications of nitrogen nutrition for grapes, fermentation and wine. *Austr. J. Grape Wine Res.* 2005, 11, 242-295.

3 Hannam KD, Neilsen GH, Neilsen D, Midwood AJ, Millard P, Zhang Z, Thornton B, Steinke D. Amino acid composition of grape (*Vitis vinifera L.*) juice in response to applications of urea to the soil or foliage. 2016. *Am. J. Enol. Vitic*, *67*, *47-55*.

4 Kliewer WM, Dokoozlian N. Leaf area/crop weight ratios of grapevines: influence on fruit composition and wine quality. *Am. J. Enol. Vitic.* 2005, 56, 170-181.

5 Verdenal T, Spangenberg JE, Zufferey V, Lorenzini F, Dienes-Nagy A, Gindro K, Spring JL, Viret O. Leaf-to-fruit ratio affects the impact of foliar-applied nitrogen on N accumulation in the grape must. *J. Int. Sci. Vigne Vin.* 2016, 50, 23-33.

6 Spring JL, Verdenal T, Zufferey V, Viret O. Nitrogen dilution in excessive canopies of Chasselas and Pinot noir cvs. *J. Int. Sci. Vigne Vin.* 2012, 46, 233-240.