VERDENAL Thibaut (2021): Nitrogen dynamics and fertilization use efficiency in *Vitis vinifera* : carry-over effects of crop limitation

Abstract

As an essential element for plant development, nitrogen (N) is used extensively since the twentieth century to increase production, although only 30–40% of the fertilizer is used by the crops. The rest of the fertilizer is usually lost to the environment. It is therefore essential to improve N use efficiency by the plant to minimize our ecological footprint. During wine production, N in grapes is also involved in alcoholic fermentation and in the development of aroma compounds, which both affect the quality of the wine. To prevent N deficiency in grapes, foliar N supply is usually applied at the beginning of fruit ripening in the form of urea. However, there is no universal recipe for optimal results. N metabolism in plants is fundamentally affected by environmental conditions and by our cultural practices, such as soil management, training systems, or vineyard inputs. Understanding the impact of these influencing factors allows us to better orient our technical choices with the objectives of quality and sustainability.

This thesis focuses on a common practice in viticulture, that is, crop limitation. It consists of removing grapes before the beginning of ripening to favor the maturation of the remaining fruits. We evaluated the impact of crop limitation on N distribution in the plant and on the efficiency of fertilization. For this purpose, a wide gradient of fruit load was set up in a homogeneous plot of Chasselas (Vitis vinifera), and foliar N was provided as ^{15}N-labelled urea. Isotope labelling identified the N in the fertilizer and provided a dynamic picture of its distribution in the plant over two consecutive years.

The close relationship between fruits and roots in the maintenance of plant N balance was highlighted.

Leaf gas exchange rates were reduced in response to lower yield conditions, reducing C assimilation and increasing intrinsic water use efficiency. Fruit N concentration remained unchanged regardless of crop load. Moreover, the fruit amino acid profile varied with crop load, thus potentially affecting fruit aromas. Interestingly, the amino acids most affected by crop load were not the same as those

affected by foliar N supply. The presence of fertilizer N in the plant in the following year had no carry-over effect on the plant vigor or grape N composition. Fertilization efficiency greatly varied in relation to crop load, with higher uptake rates under high-yield conditions. A significant amount of N was released by the plant into the soil during the fall and winter and was then assimilated again in the following year. N partitioning depended on both N species and N origin, either from the perennial reserves (mainly amino N) or from the seasonal uptake (mainly nitrate and ammonium). These findings demonstrate the impact of plant balance on fertilization efficiency and will contribute to the improvement of cultural practices in perennial crops.