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Nutrient composition of leaves and fruit juice of grapevine as affected by soil and nitrogen fertilization

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Abstract

Effects of soil type and nitrogen (N) fertilizer–application rates on the nutrient composition of grapevine (*Vitis vinifera* L. cv. Riesling) leaves during a growing cycle were compared with the composition of the resulting grape juice. Grapevines were planted in 75 L containers that had been installed in a vineyard and filled with three different vineyard soils (loess, shell lime, and Keuper). Four typical levels of N fertilizer (40, 80, 120, and 160 kg N ha^{-1}) were applied. Elemental composition of mature leaves sampled seven times during the growing cycle as well as of the extracted grape juice was analyzed. The time of sampling affected all measured elements (C, N, Ca, K, P, Mg, S, Fe, Zn, Mn, and B) in the leaves. Nitrogen-fertilizer rate affected the concentrations of all elements except Ca and Mg, while the soil type had significant effects on elemental composition of the leaves with the exception of N, B, and Ca. Soil type had a significant effect on K, S, Mn, and B in the grape juice. Increasing rates of N fertilizer increased C concentration in the grape juice significantly and affected its elemental composition similar to the effects in leaves. This may be explained with the role of leaves as the source for supplying the grapes during ripening *via* phloem transport. Cluster analysis for the elemental composition of soils, leaves, and grape juice revealed no consistent relationships indicating that other soil characteristics in addition to the mineral concentration influence the elemental composition of grapevine leaves and grape juice.

Key words: elemental composition / grape juice / grapevine / leaves / nitrogen-fertilizer rate / soil type

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1 Introduction

Along with climatic conditions, soil type and nutrient supply are important determinants of quantity and quality of yield of agricultural plants. An integrated view of agricultural management aims to decrease inputs while maintaining or increasing yield quantity and quality (*Vance*, 2001; *Jeuffroy* et al., 2002). Knowledge of the minimum fertilizer input that will result in the desired yield quantity and/or quality is of special interest (*Gastal* and *Lemaire*, 2002). Aside from economic considerations, fertilizer use has ecological implications, too. For example, the leaching of nitrate from vineyards drastically increased as nitrogen (N)-fertilizer inputs increased (*Müller*, 1993), which subsequently led to high levels of nitrate in groundwater. In the case of grapevine, the impact of climate, soil, and crop management on the quality of the end product—wine—is the subject of extensive discussion (*Jackson* and *Lombard*, 1993; *Keller*, 2005). The effects of N supply on grapevine N metabolism, N transport, and accumulation, as well as growth and yield has been the subject of a number of investigations (*Bell* et al., 1979; *Kannenberg*, 1990; *Müller*, 1991, 1993; *Keller* et al., 1995; *Keller*, 2005).

In viticulture, analysis of the chemical composition of leaves is an important management tool (*Kannenberg*, 1990). The nutrient status of leaves will directly affect total biomass production including the allocation of mineral nutrients to the fruits. *Pate* (1980) concluded that for C, N, and K, the supply of fruits by phloem is more important than by xylem. In grapes, it was shown by *Lang* and *Düring* (1991) that during ripening, at the time of breakdown of cellular compartmentation, import *via* phloem increased drastically. However, during these processes there are a number of transporter-mediated steps that will influence the quantity and the distribution of nutrients in the plant. Therefore, it is unclear if the soil's "mineral signature" will be reflected in the leaves or fruits.

In the present study, the effect of mineral composition of soils, derived from different geological formations, and of N fertilizer–application rates on the elemental composition of grapevine leaves was investigated during an entire vegetation period and compared with the elemental composition of the grape juice. To avoid climatic effects, soils were collected and filled into pots in which grapes were grown in a vineyard under the same environmental conditions and management. The aim of this study was to identify correlations between the elemental composition of soils, the grapevine leaves, and the corresponding juice.

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