

Feature Review

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Effects of Organic Fertilization on Soil Health, Nutrient Uptake, and Fruit Quality of Grapevine

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Abstract Excessive or long-term reliance on chemical fertilizers in grape production can lead to declines in soil organic matter, nutrient imbalances, and weakened microbial functions, thereby constraining the sustainable development of vineyards. This study systematically examines the effects of organic fertilization on the “soil-grapevine-fruit” system, with particular emphasis on soil health, nutrient uptake, vine growth, yield, and fruit quality. The results indicate that organic fertilizers can increase soil organic matter and the availability of nutrients such as nitrogen, phosphorus, and potassium, improve soil porosity, aggregate stability, and water-holding capacity, and enhance microbial abundance and related enzyme activities. Appropriate substitution of chemical fertilizers with organic fertilizers can also promote root development and nutrient uptake, while increasing grape yield, the sugar–acid ratio, and the contents of vitamin C, phenolic compounds, and antioxidants. However, these effects vary depending on fertilizer type, substitution rate, soil conditions, grape cultivar, and climate. Overall, the combined application of organic and mineral fertilizers is more effective than either fertilization strategy alone, as it can maintain grape yield and fruit quality while improving soil ecological functions. These findings provide a theoretical basis for reducing chemical fertilizer inputs, improving fertilizer-use efficiency, and developing sustainable nutrient management strategies in vineyards.

Keywords Grapevine; Organic fertilization; Soil health; Nutrient uptake; Fruit quality; Sustainable production

1 Introduction

Grapevine is an important fruit crop worldwide, and berry composition directly influences the market value of table grapes and the quality of wine (Zhu et al., 2022; Kaya et al., 2024a). In grape cultivation, nutrient management is closely related not only to yield but also to vegetative growth and berry composition, thereby affecting the gap between actual and potential productivity (James et al., 2023). Soil chemical properties and vineyard management practices also influence the balance between vegetative and reproductive growth, which is essential for maintaining stable long-term production (Cataldo et al., 2021). Therefore, sustainable nutrient management has become a key strategy for simultaneously maintaining grape yield, fruit quality, ecosystem functions, and stress resilience (Cataldo et al., 2021; Zhu et al., 2022).

Long-term dependence on chemical fertilizers has also caused considerable agronomic and environmental problems. Excessive or imbalanced application of mineral fertilizers can alter vine vigor and fruit composition while reducing soil biological functions and the activities of enzymes involved in nutrient cycling (James et al., 2023; Visconti et al., 2024). Continuous application of inorganic fertilizers alone may also lead to declines in soil organic matter, soil acidification, nutrient imbalance, salinization, and environmental pollution (Bhatt et al., 2019; Wu et al., 2024). In vineyards, inappropriate management can similarly result in soil compaction, erosion, and biodiversity loss, ultimately reducing grape yield and quality (Cataldo et al., 2021; Kaya et al., 2025). Prolonged fertilization may also reshape soil microbial communities and reduce the abundance of beneficial microorganisms positively associated with grape productivity (Li et al., 2024; Visconti et al., 2024). Therefore, improving nutrient-use efficiency is more important than simply increasing fertilizer inputs.