

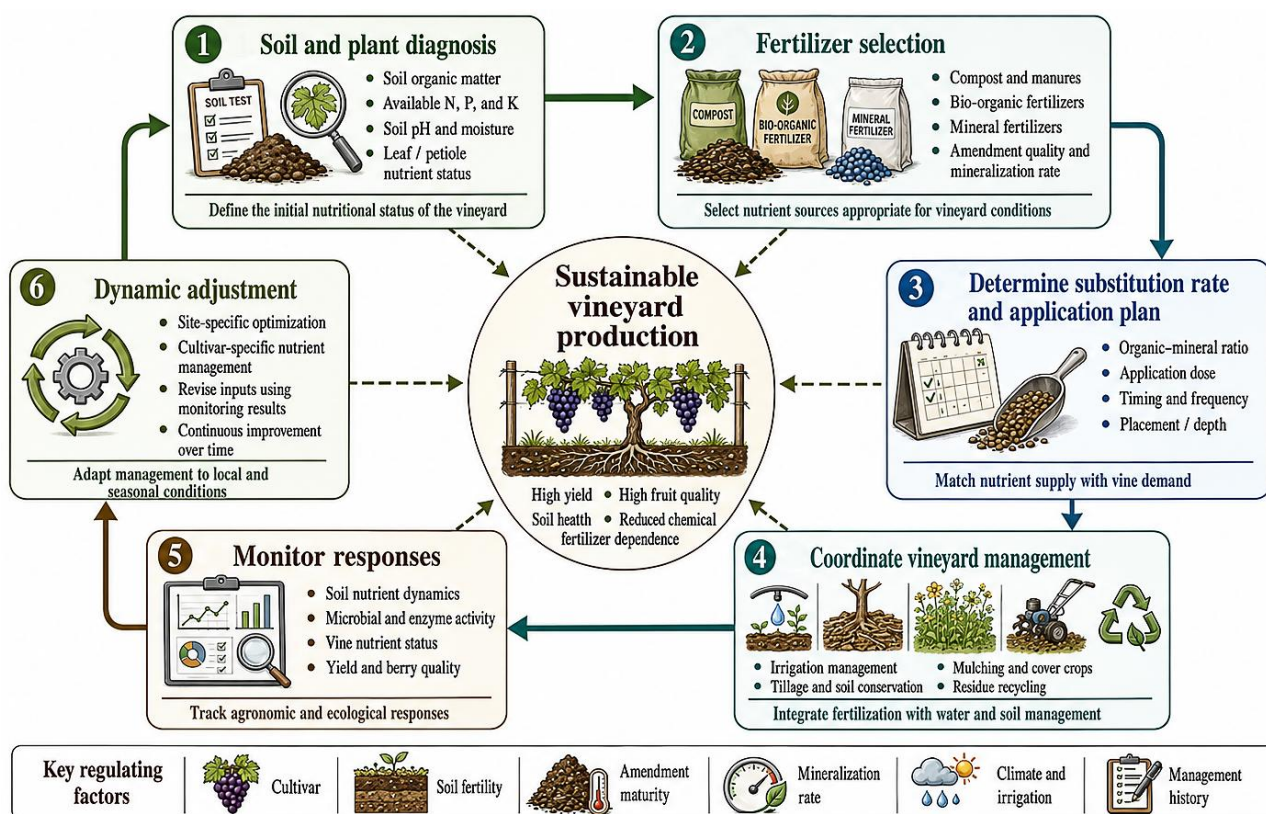


Figure 3 Integrated organic nutrient management framework for sustainable vineyard production

8 Conclusions and Future Research Directions

Existing studies indicate that the role of organic fertilizers in vineyards extends beyond simple nutrient supplementation and contributes to the overall improvement of soil health. Plant residues and other organic amendments can increase soil organic matter and nutrient levels, enhance microbial and enzymatic activities, improve soil water and aeration conditions, and strengthen agroecosystem resilience. Combined application of organic and mineral fertilizers can also promote grape yield formation while maintaining favorable soil properties, with available nitrogen, available potassium, and soil enzyme activities showing relatively close associations with yield responses.

Organic fertilization is beneficial for grape yield and fruit quality, although responses vary among cultivars and growing conditions. In 'Shine Muscat' grape, reducing nitrogen application by 20%-30% while supplementing with organic fertilizer increased yield, sugar-acid ratio, vitamin C content, and economic returns, with the 0.8N + OF treatment showing particularly favorable performance. Some studies have also reported that organic cultivation can enhance antioxidant activity and increase flavonoid and phenolic contents in seedless grapes. However, other studies have found higher yields under conventional fertilization or no significant effects of organic fertilizers on most quality traits of Syrah grapes, indicating that the effectiveness of organic fertilization is strongly dependent on cultivar and environmental conditions.

Current research is also constrained by factors such as soil conditions, climate, cultivar, and management practices. Soil temperature, moisture, initial fertility, texture, and pH can all influence organic fertilizer mineralization, nutrient uptake, and the resulting agronomic effects. Fertilization strategies should therefore be dynamically adjusted according to soil testing, plant nutritional status, and actual management conditions. Long-term field experiments in vineyards remain limited, and many studies have lasted only 2-3 years, which is insufficient to fully evaluate the long-term ecological and production effects of organic fertilization.