Improved nutrient uptake under organic fertilization is mediated by both direct changes in root architecture and indirect regulation through the rhizosphere microbiome (Figure 2). These two pathways interact to increase the effective nutrient-absorbing surface and convert poorly available soil nutrients into forms more readily accessible to grapevine roots.

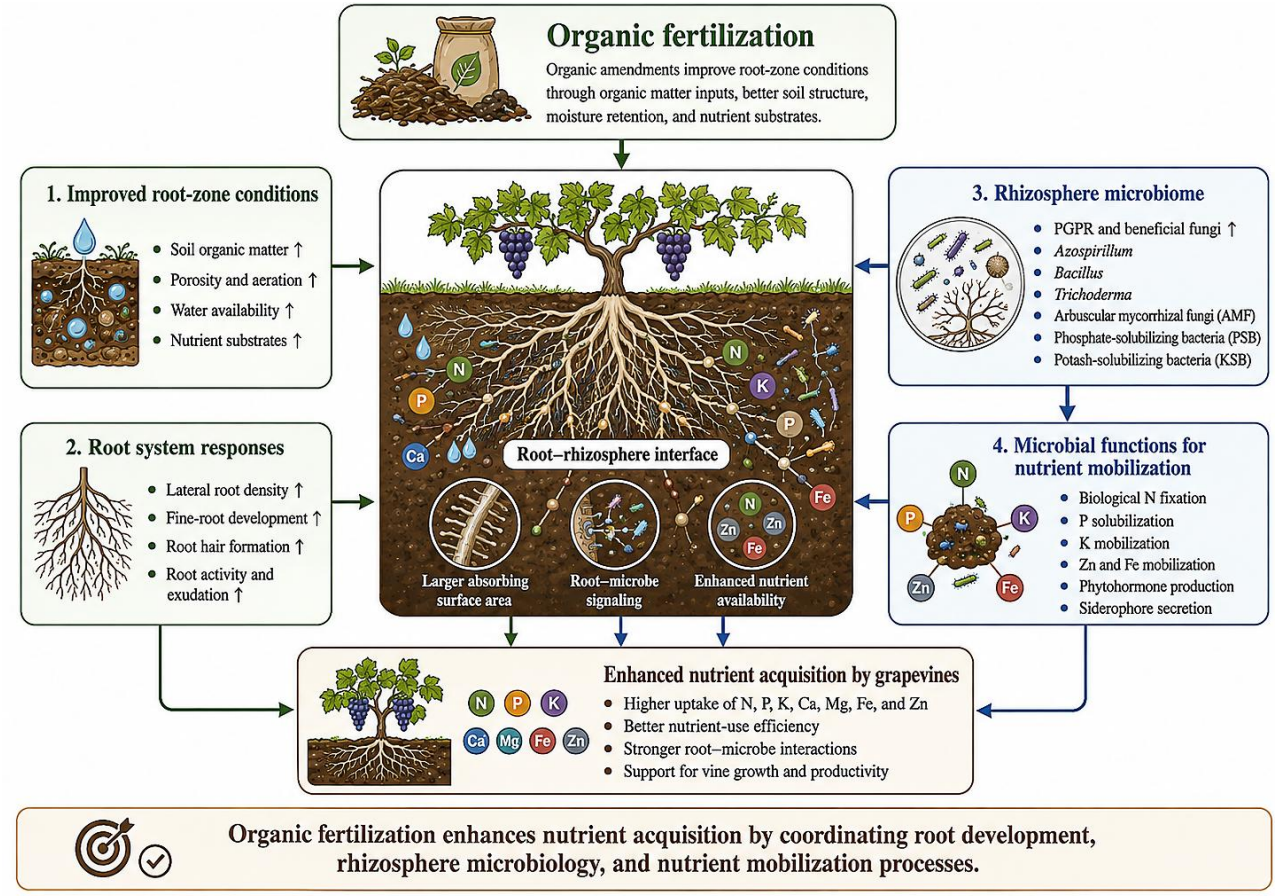

Figure 2 Root–rhizosphere mechanisms underlying nutrient acquisition under organic fertilization

5 Effects of Organic Fertilization on Grapevine Growth and Yield Formation

5.1 Effects on vegetative growth

When nutrient release is synchronized with grapevine demand, organic fertilization generally promotes shoot growth, leaf area expansion, and canopy development. Chen et al. (2023) found that, in drip-irrigated seedless white grapes, combined organic and inorganic fertilization increased new shoot length by 3.16%-11.88% and leaf midrib length by 7.35%-15.15% compared with inorganic fertilization alone. In Flame Seedless grapes, partial replacement of mineral nitrogen with compost, biofertilizer, or humic acid increased leaf area, pruning wood weight, and total chlorophyll content (Abd EL-Rahman et al., 2021). Similar improvements were also observed over three consecutive growing seasons when mineral nitrogen was partially replaced with organic and biological nitrogen sources (Alsalhy et al., 2021). Compared with the 100% mineral nitrogen treatment, Red Roomy grapevines under partial substitution treatments developed longer shoots, more leaves, and larger leaf areas. Bio-organic fertilizers also promoted grapevine seedling growth, allowing seedlings to reach the target shoot size 1-4 weeks earlier (Liu et al., 2024; El-Salhy et al., 2025). In a terraced Cabernet Sauvignon vineyard, compost application promoted vegetative growth relative to chemical fertilization, while in semiarid tropical vineyards, organic fertilization improved soil conditions and increased crop yield under adverse environmental conditions (Lucchetta et al., 2023; Fracetto et al., 2024).