Microbial biomass C and N are therefore indispensable complementary indicators, capturing the living pool of microbial cells that mediate nutrient cycling. In multi-cropping and organic vegetable experiments across Europe, microbial C and N (Cmic, Nmic) increase under diversified cropping and higher organic inputs, and their stoichiometric ratios (Cmic/Nmic, Cmic/TOC) are used to infer shifts in nutrient limitation and carbon stabilization potential (Figure 1) (Trinchera et al., 2022). Global analyses reveal that the relationship between microbial diversity and biomass is strongly governed by soil carbon, underscoring how management-driven changes in organic matter, including biofertilizer use, cascade into microbial standing stocks and functions (Bastida et al., 2021; Schnecker et al., 2023). Consequently, integrating soil respiration with microbial biomass C and N provides a powerful set of indicators to evaluate how biofertilizers influence both the intensity and efficiency of microbial activity in vegetable production soils.

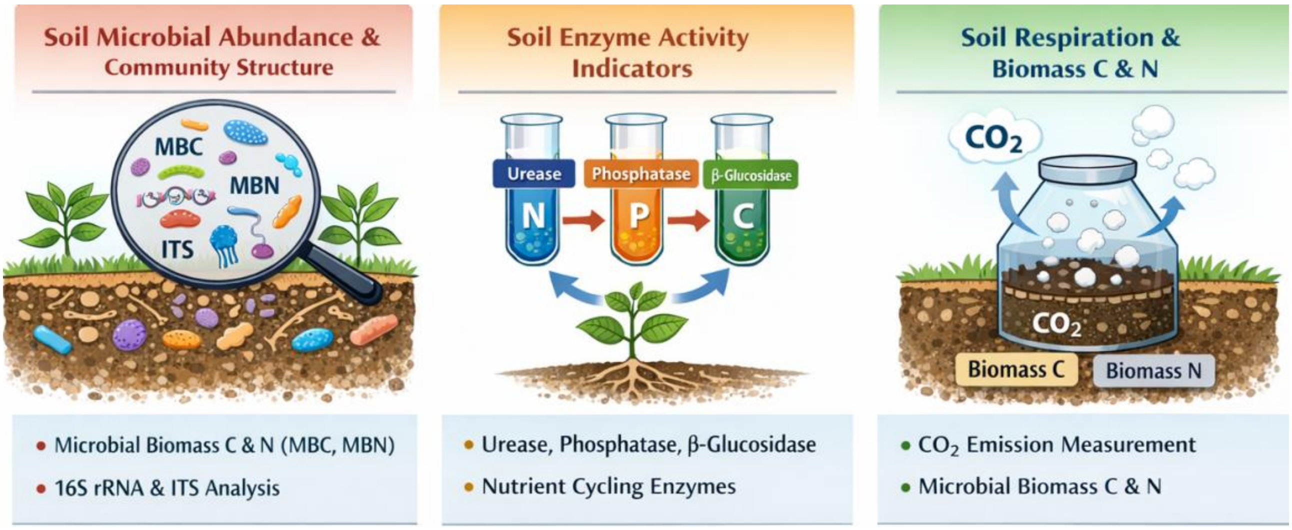

Figure 1 Evaluation indicators of soil biological activity in vegetable production systems

4 The Impact of Biofertilizers on Soil Microbial Community Structure

4.1 Changes in microbial diversity

Biofertilizers frequently alter α-diversity (richness and evenness) and β-diversity (community dissimilarity) of soil and rhizosphere microbiota in vegetable and other cropping systems. In greenhouse cucumber, different biofertilizers applied to soil or substrate significantly modified bacterial and fungal diversity over the season, with distinct community trajectories between fertilized and unfertilized treatments (Wu et al., 2022). In maize, Bacillus-based biofertilizers generally increased rhizosphere bacterial richness and diversity relative to the control, although consortia of multiple strains sometimes reduced overall diversity, suggesting a directional enrichment of specific functional taxa at the expense of community evenness (Wang et al., 2021; Zhang et al., 2025).

Patterns are not universally positive for diversity, underscoring that biofertilizers reshape communities rather than simply “add” diversity. A Bacillus bio-organic fertilizer applied to pakchoi reduced both bacterial and fungal diversity compared with unfertilized soil, while strongly shifting composition and enriching particular beneficial groups (Tao et al., 2020). Actinobacterial biofertilizers containing Streptomyces spp. likewise altered fungal community composition and co-occurrence networks across several crops without consistently increasing bacterial or fungal α-diversity, indicating that functional reassembly can occur even when richness is stable (Li et al., 2022; Zhao et al., 2022). These results highlight that diversity responses depend on formulation, dosage, and substrate, but shifts in β-diversity and taxonomic structure are almost ubiquitous following biofertilizer application.

4.2 Regulatory roles of dominant functional microbial groups

A central ecological effect of biofertilizers is the enrichment or suppression of dominant functional groups that drive nutrient cycling and plant health. Bacillus- and Trichoderma-amended biofertilizers increase the relative abundance of plant-beneficial bacteria and fungi, including Bacillus, Rhodanobacter, Massilia, Trichoderma, and