highlighting that microbial inoculants enhance plant access to soil and fertilizer nutrients, particularly under suboptimal resource conditions, thereby supporting more vigorous crop growth for a given external input level.

System-level vegetable experiments further confirm that more active soil microbial communities translate into improved crop performance. In an intensified organic vegetable rotation using plant-based fertilizers, cover crops, and reduced tillage, β-glucosidase and dehydrogenase activities and potential N mineralization were markedly higher than under common practice, and these improvements in microbial activity coincided with 1.3-2.7-fold increases in marketable yields and greater plant N uptake without increasing N leaching risk (Hefner et al., 2023). A broader systematic review on microbial activity and nutrient cycling likewise concluded that most studies report microbial-driven enhancement of soil fertility and crop productivity, supporting the view that managing soil microbes is a powerful lever for sustaining growth in intensive systems such as vegetable production (Bayu, 2024).

6.2 Promoting effects on vegetable yield

Across crops and environments, biofertilizers consistently promote yield, with particularly strong effects documented for vegetables. A comprehensive Chinese meta-analysis found that biofertilizers increased yields for 21 of 23 crops, with vegetables such as Chinese cabbage and ginger showing gains of roughly 36-39%, attributing these responses to improved nutrient availability, better root growth, and reduced disease incidence (Pei et al., 2025). A global synthesis of field trials reported average yield increases of around 8-20% depending on climate, and showed that combinations of N-fixers, P-solubilizers and mycorrhiza are especially effective when soil phosphorus is not severely limiting, underscoring that yield benefits depend on matching microbial traits to soil conditions.

Vegetable-focused experiments under greenhouse and field conditions provide more specific evidence for yield promotion and fertilizer savings. In lettuce and broccoli, treatments combining biofertilizer with full or reduced chemical fertilizer rates achieved total and marketable yields comparable to or higher than full mineral fertilization alone, indicating that biofertilizers can maintain productivity while allowing 50% reduction in chemical NPK inputs (Demir et al., 2023). For Swiss chard, vermicompost-functionally analogous to many bio-organic fertilizers-applied alone or with biochar increased yield by about 140% relative to untreated or biochar-only soils, demonstrating that biologically active organic amendments can match mineral N in supporting high productivity while simultaneously improving soil quality (Libutti et al., 2023).

6.3 Impacts on quality

Biofertilizers indirectly enhance vegetable quality by improving plant nutrition and reducing physiological imbalances such as excessive nitrate accumulation. In the Chinese field meta-analysis, biofertilizer application significantly increased vitamin C, protein, and carotenoid contents while decreasing nitrate concentrations by about 22%, indicating that microbial inoculants can shift the balance toward more nutrient-dense and safer produce across a wide range of crops (Pei et al., 2025). A review on biofertilizers and food security similarly reported crop yield increases of 10%-40% accompanied by higher protein, essential amino acids, and vitamins, emphasizing that microbially mediated nutrient mobilization often improves nutritional profiles rather than simply increasing biomass (Daniel et al., 2022).

Recent vegetable studies confirm these quality effects under practical cultivation scenarios. In tomato, brinjal, and okra, replacing part of the chemical fertilizer with diverse organic sources plus a microbial consortium increased soil microbial populations and improved nutritional, organoleptic, and nutraceutical attributes, including higher antioxidant contents, relative to conventional fertilization alone (Bhardwaj et al., 2025). In Swiss chard, vermicompost and its mixtures with biochar not only raised yield but also increased specialized metabolites and antioxidant activity, while keeping leaf nitrate within regulatory safety thresholds, illustrating that biologically enriched fertilization can simultaneously support high productivity, nutritional quality, and nitrate safety in leafy vegetables (Libutti et al., 2023).