In terms of irrigation, integrating soil, plant, and meteorological data into closed-loop or model-based control systems can significantly improve water use efficiency compared with traditional open-loop scheduling methods (Bwambale et al., 2022; Gamal et al., 2025). Smart irrigation platforms based on cloud computing and IoT show that connecting multiple small-scale farms to a centralized data analysis system helps optimize water allocation and supports climate-adaptive agricultural production in water-scarce regions (Et-Taibi et al., 2024). For the waxberry industry, priority should be given to promoting cost-effective tools such as soil moisture sensors, simple weather stations, and mobile data platforms to support fertilization and irrigation decisions, rather than relying on high-end automated systems that are difficult for small farmers to maintain.

9.2 Expansion of eco-friendly orchard models

Moderately reducing nitrogen and phosphorus inputs in waxberry orchards can improve soil quality (e.g., slowing acidification and increasing organic carbon levels) without affecting yield or fruit quality, indicating that optimized fertilization can achieve both production and ecological goals.

Introducing ryegrass as a cover crop under the waxberry canopy can significantly increase fruit sugar, vitamin C, and flavonoid content, while also improving soil physicochemical properties, rhizosphere microbial community structure, and secondary metabolism, which overall benefits orchard ecosystem optimization (Li et al., 2023).

More broadly, plant growth-promoting microorganisms and biofertilizers are important components of sustainable orchard systems. When combined with organic amendments, conservation agriculture, and agroforestry practices, they can effectively promote nutrient cycling, improve soil health, and enhance system resilience (Freitas and Silva, 2022). Agroforestry systems based on fruit trees, which combine fruit production with crops or livestock and optimize resource use throughout the life cycle, are considered an effective approach to improving orchard sustainability. Model tools are already available to design such systems under different soil and climate conditions (Barbault et al., 2024). In major waxberry-producing regions, eco-friendly orchard models that integrate cover crops, reduced and precise fertilization, biofertilizer use, and structural diversification should be promoted to achieve both high-quality fruit production and low environmental impact.

9.3 Integration with agritourism and brand building

Agritourism centered on orchards has been shown to bring clear socio-economic benefits. It not only provides additional income for farmers and creates jobs, but also promotes environmental and cultural sustainability through visitor education and nature-based experiences. Participatory activities such as fruit picking, science popularization displays, and direct farm sales can significantly increase tourists' willingness to purchase local agricultural products (Brune et al., 2021). From a destination perspective, value co-creation in agritourism—through visitor participation, interaction, and "citizen behavior"—can significantly enhance the brand equity of rural tourism destinations via enjoyable experiences, meaningful experiences, and perceived value (Zhou and Chen, 2023).

Successful agritourism regions often rely on producer cooperation networks, shared marketing platforms, and recommendation mechanisms. Digital marketing tools such as social media, visual storytelling, and online reviews further strengthen the attractiveness of agritourism destinations and support personalized experiences (Kulikova et al., 2024). For the waxberry industry, combining orchard production with seasonal picking festivals, ecological orchard education activities, processed product tasting, and unified regional branding can simultaneously increase farmers' income and enhance the brand value of "high-quality waxberry."

9.4 Directions for orchard standardization improvement

Sustainable orchard systems based on clear principles of nutrient management and soil biodiversity have already provided a technical basis for developing standards in fertilization, cover crop use, biofertilizer application, and soil protection. With the rapid development of smart agriculture and IoT technologies, it is necessary to establish unified monitoring indicators, threshold settings, data formats, and decision rules, so that even simple systems can be connected to regional decision support and benchmarking frameworks (Ali et al., 2023).