exudates, nutrient shifts, enzyme changes, and pathogen enrichment interact over time in perennial peony systems. In replanted peony, growth and flowering decline progressively, while soil pH, nutrients, enzyme activities, and microbial diversity decrease and harmful genera rise as beneficial taxa such as *Bacillus* fall (Li et al., 2023). Broader medicinal-plant syntheses point to the same three main drivers-microbial community change, nutrient imbalance, and allelopathic effects-and emphasize that rhizosphere plant-soil-microbe interactions are the core system where obstacles develop (Liao and Xia, 2024). Yet a key complication is that not all continuous cropping systems inevitably deteriorate; some long-term systems can become more suppressive or self-repairing, which means years of continuous planting alone do not explain obstacle formation.

Future development should focus on green control technologies grounded in mechanism rather than blanket soil replacement or chemical intervention. Reviews across medicinal plants support soil amendments, crop rotation, and intercropping as effective directions because they can increase beneficial microorganisms and improve fertility and nutrient availability. In *P. lactiflora*, rhizosphere studies show that secondary metabolite accumulation is linked to microbial communities and is shaped by soil water, precipitation, pH, and biotic factors such as *Alternaria*, while microbial networks in the rhizosphere are more complex and cooperative than in bulk soil (Wu et al., 2025). This supports future strategies based on microbiome screening, synthetic beneficial communities, and soil ecological regulation, especially since recent long-term monoculture work in another crop showed that suppressive microbiomes can be rebuilt and even mimicked through designed inoculation. For peony, the next step is to connect replant years, root exudate chemistry, microbial food-web structure, and quality outcomes in long-term field experiments so that green prevention targets can be defined precisely rather than descriptively (Liao and Xia, 2024).

6.3 Need for establishment of intelligent production systems and standardized management models for *Paeonia lactiflora*

There is also a clear need to establish intelligent production systems and standardized management models for *P. lactiflora*, because current production still depends heavily on local experience, fragmented propagation methods, and inconsistent environmental control. Standardized regeneration systems have advanced rapidly: mature embryo culture achieved high germination, shoot induction, and rooting rates, and optimized rooting protocols improved root architecture and survival of embryo-derived shoots (Zhu et al., 2026). These advances solve part of the seedling bottleneck, but they do not yet constitute a farm-scale standardized management model that links germplasm screening, nursery propagation, field deployment, environmental monitoring, and harvest timing across production regions (Wang et al., 2022). The need is especially urgent because *P. lactiflora* is temperature-sensitive, and protected cultivation studies show that changes in soil and air temperature can shift harvest timing substantially while also affecting quality and disease pressure.

Future development should therefore promote a digital, standardized perennial management platform that combines cultivar-specific thresholds with real-time sensing and decision support. Precision-agriculture research shows that AI, IoT, remote sensing, and automated systems can collect real-time soil, crop, and environmental data, support irrigation and input decisions, and reduce labor and environmental costs. Integrated smart systems have already reached high predictive accuracy for crop selection and yield forecasting and can save substantial irrigation water through sensor-driven fuzzy control, which indicates that similar architectures are feasible for peony production zones (Saha et al., 2025). The main constraints are dataset integration, scale-up cost, connectivity, and farmer training, so future peony research should pair digital trials with unified phenological indicators, soil-health standards, and operational protocols to build a truly standardized intelligent production model.

7 Conclusions and Perspectives

Optimization of cultivation models is essential for improving the production efficiency of *Paeonia lactiflora*, as its growth is highly influenced by temperature, winter chilling requirements, and regional climatic conditions. Multi-criteria evaluation studies in low-latitude regions have identified ‘Qihua Lushuang’, ‘Hang Baishao’, ‘Meiju’, ‘Hongpan Tuojin’, and ‘Bo Baishao’ as highly adaptable germplasm resources, highlighting the importance of elite cultivar selection as the foundation for cultivation model optimization. Among them, ‘Hang