

Figure 2 Challenges encountered in the cultivation and application of the herbaceous peony at low latitudes (Adopted from Wang et al., 2022)

Image caption: (A-H) High spring temperatures and high humidity caused stem bending, flower bud abortion and severe diseases; (I-K) High summer temperatures induced heat damage and premature withering of aboveground parts; (L, M) High autumn and winter temperatures caused insufficient chilling requirement and induced subsequent abnormal flowering and vegetative growth (Adopted from Wang et al., 2022)

5.2 Development of a green and efficient long-term continuous production system

A green and efficient long-term continuous production system should center on stable seedling supply, lower-input establishment, and rhizosphere-mediated quality regulation. Tissue culture and bio-nursery work directly address the chronic bottleneck of slow multiplication, which is especially important because medicinal peony production takes more than three years from rhizomes and more than six years from seed (Song et al., 2023). In the bio-nursery system, a 15/5℃ diurnal regime increased shoot proliferation, 6 mmol/L calcium improved post-transplant vigor, and 20℃ greenhouse acclimation after cold treatment improved plantlet establishment. Rooting can be further strengthened by 7 days dark plus 28 days light and by a modified half-strength medium with doubled calcium, IBA, putrescine, and coumarin, which produced 75% rooting and 8.3 roots per shoot (Zhu et al., 2026). These propagation advances make green long-cycle production more feasible by reducing loss rates at the nursery stage.

Long-term efficiency also depends on soil ecological stability, because replanting obstacles in *P. lactiflora* are strongly linked to declining pH, nutrients, enzyme activities, and beneficial microbes, alongside increases in harmful fungi and possible autotoxins such as benzoic acid (Xie et al., 2023). Rhizosphere studies show that root secondary metabolism is closely tied to microbial communities, and cultivar differences in paeoniflorin, phenolics, flavonoids, and antioxidant capacity track microbial differences as well (Wu et al., 2025). Green production should therefore combine organic matter and pH management with microbial optimization, especially because pH and alkaline phosphatase significantly shape rhizosphere communities and some cultivars enrich stress-tolerant growth-promoting bacteria (Zu et al., 2022). Quality-oriented green systems can also incorporate optimized harvest and processing: 4-year roots performed best overall, late September was the best harvest window in Tongliao, shade drying gave the highest quality, and low-temperature storage followed by washing, boiling, and 30℃ machine drying improved main active components in processed roots (Komatsu, 2024; Guo et al., 2026).