and that soil properties and climate are closely associated with atractylenolide accumulation, while biomass and quality may be regulated by partly independent environmental networks (Lee et al., 2025). Regional comparison also shows that rhizosphere microbial structure, organic matter decomposition, pH, and enzyme-related soil characteristics are closely linked with the quality formation of *A. macrocephala* (Zhou et al., 2025). In medicinal plants more broadly, rhizosphere microecology directly or indirectly affects growth, metabolic regulation, and active ingredient accumulation, and medicinal plant production is especially sensitive to changes in soil fertility and biological properties because quality formation is inseparable from secondary metabolism (Wang et al., 2022; Rostaei et al., 2024). Therefore, for the Baizhu industry, fertilizer management must satisfy dual production goals: maintaining rhizome biomass while promoting the synthesis and accumulation of pharmacodynamically important compounds.

In practice, however, the pursuit of higher yields in medicinal plant cultivation has often led to excessive dependence on chemical fertilizers, and this strategy is increasingly recognized as unsustainable. Across medicinal plant systems, long-term or excessive chemical fertilizer use causes soil compaction, acidification, nutrient imbalance, decline of soil organic matter, and deterioration of microbial diversity and abundance (Wang et al., 2022; Su et al., 2025). Excessive chemical fertilizer application has also been linked to soil degradation in *Pinellia ternata* cultivation, where yield reduction and disease pressure were associated with deteriorated physicochemical properties, nutrient imbalance, and unfavorable shifts in the soil microflora.

In *Salvia miltiorrhiza*, lack of scientific fertilization guidance and excessive chemical fertilizer use directly reduced the content of tanshinones in roots, demonstrating that fertilization can impair not only soil health but also medicinal quality (Ji et al., 2025). Similar concerns appear in other medicinal crops: overuse of agrochemicals in *Polygala tenuifolia* compromised both soil health and medicinal quality, while continuous chemical fertilizer use in Chinese herbal medicine systems has promoted disease occurrence and inferior quality compared with bio-organic alternatives (Huang et al., 2024). Although chemical fertilizer can contribute substantially to crop yield and provides rapid nutrient release, its low use efficiency, with more than 50% of applied nitrogen reportedly not absorbed by crops, means that high-input cultivation often brings ecological costs without proportionate gains in sustainable productivity (Rostaei et al., 2024).

This review examines the mechanisms underlying the effects of organic fertilizer substitution for chemical fertilizers on the growth environment, yield formation, and quality accumulation of *Atractylodes macrocephala*, aiming to provide a theoretical basis for sustainable and green cultivation of medicinal plants. Organic fertilizer substitution can improve soil conditions, enhance nutrient-use efficiency, promote microbial activity, and regulate the formation of medicinal quality. Previous studies have shown that in *Pinellia ternata* cultivation, replacing 75% of chemical fertilizer with organic fertilizer increased yield by 44.93% without reducing alkaloid content; in *Codonopsis pilosula* production, bio-organic fertilizer improved emergence rate and yield while reducing disease incidence; and in *Polygala tenuifolia* cultivation, partial substitution with microalgae fertilizer increased underground biomass and active compound content. In addition, organic fertilizer substitution has demonstrated beneficial effects on improving soil fertility, maintaining yield, and enhancing quality in crops such as maize, *Saposhnikovia divaricata*, senna, *Prangos ferulacea*, tea, and *Salvia miltiorrhiza*.

However, the effectiveness of organic fertilizer substitution is influenced by crop species, soil conditions, fertilizer sources, and application methods, and it does not always outperform chemical fertilization under all conditions. Therefore, this review systematically analyzes the effects of organic fertilizer substitution for chemical fertilizers on soil environment, yield formation, quality accumulation, and ecological benefits of *Atractylodes macrocephala*, aiming to clarify its underlying mechanisms and provide a theoretical foundation for the development of green cultivation practices and scientific fertilization strategies for *Atractylodes macrocephala*.