

Research Insight

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Analysis of the Mechanisms by Which Shading Environment Affects the Growth and Medicinal Quality Formation of *Tetrastigma hemsleyanum*

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Abstract This study explores the mechanisms by which shading environments affect the growth and medicinal quality formation of *Tetrastigma hemsleyanum*. *T. hemsleyanum* is an important medicinal vine in China, and its tuberous roots and aerial parts are rich in bioactive compounds, including flavonoids, polysaccharides, and phenolic acids, which have medicinal development value due to their anti-inflammatory, antioxidant, immunomodulatory, and antitumor activities. With the decline of wild resources and the increasing demand for artificial cultivation, achieving high-yield and high-quality production of *T. hemsleyanum* through light environment regulation has become a key issue in its standardized cultivation and industrial development. This study analyzes the ecological habits and low-light adaptation basis of *T. hemsleyanum*, elucidates the effects of shading on morphogenesis, biomass accumulation, photosynthetic pigments, photosynthetic efficiency, antioxidant systems, carbon-nitrogen metabolic balance, and the accumulation of flavonoids, polysaccharides, and phenolic compounds, and further discusses the roles of light signal perception, signal transduction pathways such as COP1-HY5, key enzyme genes, and transcription factor regulation in medicinal quality formation. Existing studies indicate that *T. hemsleyanum* exhibits obvious shade-adaptive characteristics, and approximately 67%~70% shading is generally beneficial for maintaining relatively high net photosynthetic rate, stomatal conductance, and leaf function, while also promoting vine growth, leaf expansion, and tuberous root development. In contrast, strong light or excessive shading may inhibit photosynthetic efficiency and disrupt carbon assimilation and biomass allocation. In the future, shading intensity, light quality regulation, cultivation model optimization, and multi-index quality evaluation systems should be integrated to establish standardized shading cultivation techniques suitable for different ecological regions and growth stages of *T. hemsleyanum*, thereby providing a theoretical basis for resource conservation, high-quality medicinal material production, and industrial utilization.

Keywords *Tetrastigma hemsleyanum*; shading environment; photosynthetic physiology; secondary metabolism; medicinal quality

1 Introduction

Tetrastigma hemsleyanum is a high-value Chinese medicinal vine, and both its roots and aerial parts are widely used. With increasing market demand and intensified overharvesting, the utilization of *T. hemsleyanum* resources is rapidly shifting from wild collection to artificial cultivation (Hu et al., 2021). Its medicinal quality largely depends on light-sensitive secondary metabolites; therefore, shading management has become a key issue in standardized and high-quality production (Zhang et al., 2021). Traditionally, *T. hemsleyanum* has been used to treat fever, pneumonia, asthma, hepatitis, rheumatism, and other inflammatory and infectious diseases, and it is known in folk practice as a “natural plant antibiotic” (Ji et al., 2020). Modern studies have identified more than 140 compounds in this species, among which flavonoids and polysaccharides are representative active components, exhibiting antitumor, anti-inflammatory, antioxidant, immunomodulatory, and antipyretic activities. Total flavonoids from the roots of *T. hemsleyanum* can inhibit colorectal tumor growth and regulate gut microbiota (Han et al., 2023), while polysaccharides from the roots and aerial parts show significant antitumor, antipyretic, and immunomodulatory effects in vivo. These findings indicate that *T. hemsleyanum* is a potential resource for developing novel antitumor and immunomodulatory products and also provide strong impetus for its industrial development.

For medicinal plants, light environment regulation is a core agronomic measure that simultaneously affects biomass and secondary metabolite accumulation (Zhang et al., 2021). In many medicinal plants, shading or light