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Regulatory Effects of Nursery Mode and Canopy Closure on the Establishment Survival Rate of *Tetrastigma hemsleyanum* and Delineation of the Optimal Closure Range

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Abstract To clarify the regulatory factors affecting the establishment survival rate of *Tetrastigma hemsleyanum*, cutting propagation experiments and field establishment trials were conducted to compare survival performance under different nursery modes and canopy closure conditions. The results demonstrated significant differences in survival rates among the three nursery modes, with container substrate cultivation showing significantly higher survival than direct field cuttings. Establishment survival also differed significantly across canopy closure levels, exhibiting a unimodal response pattern along the closure gradient. Quadratic regression analysis indicated that the predicted maximum survival rate occurred at a canopy closure of approximately 0.67. Based on comprehensive statistical analyses and trend fitting, the optimal canopy closure range for the establishment of *T. hemsleyanum* was determined to be 0.6–0.7. These findings provide quantitative support for understory cultivation management of *T. hemsleyanum*.
Keywords *Tetrastigma hemsleyanum*; Establishment; Nursery mode; Canopy closure; *Survival rate*

1 Introduction

Tetrastigma hemsleyanum Diels et Gilg is a perennial climbing vine belonging to the Vitaceae family and is one of the important medicinal resource plants in southern China. Its tuberous roots are rich in polysaccharides, flavonoids, and various bioactive compounds, exhibiting considerable pharmacological potential in anti-inflammatory, antitumor, and immunomodulatory applications. With increasing market demand and continuous depletion of wild populations, artificial cultivation has become an essential approach for ensuring sustainable resource utilization. Within the cultivation system, establishment represents the critical transition from nursery production to subsequent field management. The survival rate during this stage directly affects planting costs, population structural stability, and future yield potential. Forest ecological studies have demonstrated that the seedling establishment phase often constitutes a demographic bottleneck in regeneration processes, where high mortality restricts the transition of individuals to stable populations (Chang-Yang et al., 2021; Stone et al., 2025). Under closed canopy conditions, seedlings may persist in the understory for extended periods, yet only a small proportion successfully overcome early survival constraints, thereby influencing community structure and regeneration trajectories (Lin et al., 2014). Therefore, improving establishment survival is a prerequisite for large-scale cultivation and stable production.

T. hemsleyanum is commonly distributed along forest edges or in open woodland environments and is considered a typical understory-adapted species. Canopy closure, as a structural indicator of canopy coverage, directly regulates understory light intensity, light quality, and microclimatic conditions. Under closed canopies, light availability may decline to 10%~15% of full sunlight, substantially affecting seedling photosynthetic performance and carbon balance (Zhou et al., 2023). Shade-tolerant or semi-shade-tolerant species generally exhibit higher light-use efficiency under moderate diffuse light, whereas excessive irradiance may induce photoinhibition and severe shading may reduce net photosynthetic rates due to insufficient light availability (George and Bazzaz, 1999; De Lombaerde et al., 2020). Variations in canopy gap size and openness can markedly alter early seedling survival conditions; however, increased light availability may simultaneously promote rapid expansion of