

2.2 Fundamental role of light intensity in the growth and development of *Tetrastigma hemsleyanum*

Light is one of the most important ecological factors in the growth and development of *T. hemsleyanum*. It not only provides energy for photosynthesis, but also acts as an environmental signal involved in regulating plant morphogenesis, substance accumulation, and metabolic activities. Suitable light intensity is beneficial for improving leaf photosynthetic efficiency, promoting organic matter synthesis and transport, and providing a material basis for vine elongation, leaf expansion, and tuberous root enlargement. Shading experiments have shown that light intensity is a key factor regulating the growth, photosynthesis, and pigment accumulation of *T. hemsleyanum*. Under different shading levels, leaf size and net photosynthetic rate (Pn) reach relatively high levels under approximately 67%~70% shading, whereas stronger light and excessive shading both reduce plant growth and carbon assimilation capacity (Dai et al., 2009; Xu et al., 2018). This suggests that *T. hemsleyanum* has a clear suitable range of light intensity, and that either excessively strong or insufficient light is unfavorable for its sustained growth and formation of medicinal organs.

Both excessively high and excessively low light intensity may adversely affect *T. hemsleyanum*. Under strong light conditions, leaf transpiration increases and plant water consumption accelerates. When accompanied by high temperature and insufficient soil moisture, this may easily lead to leaf wilting, scorching, or photoinhibition, thereby reducing photosystem stability and photosynthetic efficiency. Studies have shown that under full sunlight and low-shading conditions, electron transport rate and photochemical quenching in *T. hemsleyanum* are inhibited, while non-photochemical quenching increases, indicating that excessively strong light can induce photoinhibition and reduce light-use efficiency. Conversely, under long-term excessive shading or insufficient low-light conditions, although *T. hemsleyanum* can enhance low-light capture capacity by increasing chlorophyll a, chlorophyll b, and total chlorophyll contents and reducing the chlorophyll a/b ratio, the accumulation of net photosynthetic products remains limited due to insufficient photosynthetically active radiation (Dai et al., 2009). Light response curve studies also indicate that the net photosynthetic rate of *T. hemsleyanum* increases rapidly under moderate photon flux density, then tends to become saturated, and decreases under high-light conditions, while the suitable light saturation point and maximum net photosynthetic rate mainly occur under moderate shading conditions (Xu et al., 2018). Therefore, the effect of light intensity on *T. hemsleyanum* is clearly dual in nature, and the key lies in maintaining a dynamic balance among light energy utilization, carbon assimilation, and stress alleviation.

2.3 Significance of shading environment for adaptation to artificial cultivation

The shading environment has important ecological regulatory significance in the artificial cultivation of *T. hemsleyanum*. Since the natural habitat of *T. hemsleyanum* is mostly semi-shaded and humid, exposing artificially cultivated plants completely to strong light may easily create a mismatch between their ecological niche requirements and the cultivation environment. In recent years, with the decline of wild *T. hemsleyanum* resources and increasing demand for medicinal materials, artificial cultivation has expanded rapidly, making light environment management a core issue for sustainable production. Based on the fact that *T. hemsleyanum* naturally grows in forest environments and is sensitive to strong light, bionic cultivation has been considered an important approach to meeting medicinal material demand and improving cultivation adaptability (Xu et al., 2018). By using shading nets, trellises, understory intercropping, or intercropping with tall-stemmed crops, direct light intensity can be reduced, the proportion of scattered light can be increased, and the field microclimate can be improved, thereby creating a growth environment close to its natural habitat. Relevant studies suggest that shading measures capable of achieving approximately 67%~70% shading may be adopted in cultivation, because higher light intensity inhibits its photosynthetic activity and growth, while excessive shading restricts carbon assimilation (Dai et al., 2009).

From the perspective of production practice, the value of shading treatment lies not only in promoting the growth of *T. hemsleyanum*, but also in regulating the relationship between yield and quality. Under suitable shading conditions, *T. hemsleyanum* can affect the formation and accumulation of active components such as flavonoids, polysaccharides, and phenolic compounds by improving leaf photosynthetic function, maintaining antioxidant system activity, regulating carbon-nitrogen metabolism, and promoting secondary metabolic processes. Studies on