environments with diffuse light, it can better maintain leaf water status and physiological activity. Shading experiments have shown that, as shading intensity gradually increases from full light to 30%~90%, chlorophyll and carotenoid contents in *T. hemsleyanum* gradually increase, while most photosynthetic parameters, such as net photosynthetic rate, stomatal conductance, transpiration rate, and maximum net photosynthetic rate, reach their peaks at approximately 70% shading and then decline. This indicates that excessive light inhibits photosynthetic activity and normal growth in *T. hemsleyanum* (Xu et al., 2018). Under lower light conditions, namely 10%~30% of full sunlight, plants under 15% sunlight show higher photosynthetic capacity and yield than those under 10% and 30% sunlight, further indicating that *T. hemsleyanum* is better adapted to moderate diffuse light environments and is not suitable for strong direct light conditions.

However, the low-light adaptability of *T. hemsleyanum* does not mean that it can remain in excessively shaded environments for long periods. If stand canopy closure is too high and understory light transmission is insufficient, the plants may show rapid vine elongation, but this growth is often characterized by etiolation, including thinner leaves, elongated internodes, reduced tissue firmness, and insufficient accumulation of photosynthetic products, ultimately affecting underground tuberous root enlargement. Conversely, if understory shading is insufficient, strong light and high temperature may cause leaf scorching, wilting, and damage to the photosynthetic system, reducing plant survival. Therefore, understory cultivation should create a diffuse-light environment suitable for *T. hemsleyanum* growth by pruning tree canopies, adjusting planting locations, and controlling stand density, so that plants can avoid strong light stress while obtaining sufficient photosynthetically active radiation.

From the perspective of yield and quality formation, suitable light conditions can promote coordinated growth between the aboveground and underground parts of *T. hemsleyanum*. Healthy leaves are the basis for photosynthate formation, and only when the aboveground parts maintain moderate growth can sufficient nutrient sources be provided for tuberous root enlargement and medicinal substance accumulation. Light quality also significantly regulates growth and biomass allocation in *T. hemsleyanum*. Experiments using different colored films showed that blue film promoted plant height growth, leaf expansion, specific leaf weight, and fresh root weight, and increased soluble amino acid content and chalcone isomerase activity, thereby improving yield. Red film reduced root biomass but enhanced phenylalanine ammonia-lyase activity and total flavonoid content, indicating a certain trade-off between vegetative growth and secondary metabolism under different spectral conditions (Bai et al., 2021). In vitro regeneration studies also showed that when light intensity increased from 50 $\mu mol \cdot m^{-2} \cdot s^{-1}$ to 200 $\mu mol \cdot m^{-2} \cdot s^{-1}$, shoot proliferation and chlorophyll content increased, suggesting that young tissues can utilize higher light levels when other stress factors are controlled (Pang et al., 2024). Therefore, in the understory ecological cultivation of *T. hemsleyanum*, the light environment should be dynamically regulated according to stand type, seasonal changes, and plant growth stage, so that light conditions can protect plants from strong light stress while meeting their needs for photosynthesis and substance accumulation.

6.2 Effects of soil fertility on tuberous root yield of *Tetrastigma hemsleyanum*

The main medicinal part of *T. hemsleyanum* is the underground tuberous root, and soil fertility directly affects root development, tuberous root enlargement, and yield formation. Loose, fertile, and organic matter-rich soils can provide good extension space and nutrient supply for the roots of *T. hemsleyanum*, which helps enhance root absorption capacity and promote nutrient transport to underground parts. Because understory soils accumulate litter over long periods, they usually have a certain humus foundation, which can improve soil structure and enhance water and fertilizer retention to some extent, thereby creating a suitable rhizosphere environment for tuberous root formation. Pot experiments have shown that both low and high additions of pyrolytic organic matter, namely biochar, can significantly increase plant height and fresh root weight in *T. hemsleyanum*. Compared with the unfertilized control, fresh root weight and total flavonoid content increased by 1.60~2.70 times (Jiang et al., 2023).

Soil fertility is reflected not only in nutrient content but also in comprehensive conditions such as soil aeration, water retention, microbial activity, soil enzyme activity, and pH. The study by Jiang et al. (2023) showed that the yield- and quality-enhancing effects of biochar were associated with increases in soil available nitrogen, available