

photosynthetic product supply and underground assimilate allocation. At present, direct studies on the relationship between shading and tuberous root enlargement in *T. hemsleyanum* remain limited, and existing research has mainly focused on changes in aboveground photosynthesis under different light intensities (Hu et al., 2021). Current data indicate that unsuitable light environments, such as strong light, high temperature, and low humidity, reduce photosynthetic activity and slow plant growth in *T. hemsleyanum*, thereby indirectly limiting carbohydrate supply to the roots (Xu et al., 2018). In contrast, 67%~70% shading can maintain relatively high maximum net photosynthetic rate and quantum efficiency, creating favorable conditions for sustained assimilate production and its storage in tuberous roots (Dai et al., 2009).



Figure 1 The aerial part (A), root tuber (B) and raw herb (C) of *T. hemsleyanum*

Studies on other medicinal plants with storage organs help explain the possible biomass allocation patterns of *T. hemsleyanum* under different shading regimes. In shade-responsive species, moderate shading generally increases total biomass more effectively than full sunlight or deep shading, and may also increase root or storage organ biomass (Liang et al., 2022; Xue et al., 2023). Comprehensive studies of biomass allocation have shown that plants under environmental stress or resource limitation often allocate a relatively greater proportion of biomass to underground parts, thereby increasing the root-shoot ratio. However, this does not necessarily mean improved medicinal yield, because increased underground allocation may be accompanied by damage to aboveground photosynthetic structures and a decline in total biomass (Qi et al., 2019). In medicinal herbaceous plants, light shading may reduce the root-shoot ratio while increasing leaf biomass and total yield; in contrast, high light and dense planting may promote biomass allocation to roots, but at the expense of restricted aboveground growth (Ahmed et al., 2024). In storage tuber crops such as potato, simulated shading promotes stem elongation but reduces tuber yield, indicating that excessive shading may redirect assimilates from storage organs toward stem elongation (Gómez-Ocampo et al., 2023).

Therefore, from the perspective of medicinal material production, an ideal shading environment should not simply promote stem and leaf growth, nor should it simply increase the root-shoot ratio. Instead, it should maintain a dynamic balance between aboveground photosynthetic structure formation and underground medicinal organ accumulation. *T. hemsleyanum* likely has an optimal shading range close to the 67%~70% shading level identified in photosynthetic performance studies. Within this range, aboveground assimilation and underground storage processes can be well coordinated, thereby simultaneously supporting vigorous vine growth and effective tuberous root enlargement. In contrast, both strong light stress and excessively deep shading may lead to unfavorable biomass allocation and reduced medicinal yield. Therefore, in *T. hemsleyanum* cultivation, shading intensity should be reasonably controlled according to different growth stages so as to maintain good vegetative growth while ensuring tuberous root formation and medicinal yield improvement.