

of GA₃, about 4.90 °C, and a 1:1 sand-to-Huangjiang-slag substrate ratio (Gou et al., 2026). Temperature, light, water, and nitrogen are recognized as core environmental signals controlling dormancy and germination through interaction with ABA and GA pathways.

Light and moisture conditions further modify germination performance. Dark treatment increased *P. sibiricum* seed germination relative to illumination, and soaking seeds in 35~40 °C lukewarm water for 18~24 h raised germination to 93.33%, indicating that both light exclusion and improved imbibition can facilitate dormancy release. Hormonal regulation mediates much of this environmental response: cold stratification for more than 70 days significantly alleviated dormancy, ABA remained high during dormancy, and exogenous GA₃ and 2-coumarate promoted germination while 6-BA and GA₃ enhanced corm growth. Transcriptomic and metabolomic evidence likewise indicates that ABA helps maintain dormancy whereas GA₃, JA, and IAA rise during seed coat penetration and promote germination-associated processes (Gou et al., 2026). After emergence, rhizome growth and quality remain sensitive to habitat conditions: *P. sibiricum* is commonly distributed in moist and cool forest or shrub environments, artificial and wild plants examined in Fujian grew under high precipitation, 82% relative humidity, and moderate annual temperature (Cheng et al., 2023), rhizome fresh weight and polysaccharide content decline with soil acidification, and poor performance is associated with rhizospheric pathogens such as *Fusarium* (Shi et al., 2024), including field-reported root rot beginning in the rhizome and reaching a disease index of 70% in Gansu plantations.

3 Rhizome Propagation Technology System

3.1 Division and whole-rhizome propagation methods and their characteristics

Rhizome propagation is a core propagation pathway for *Polygonatum sibiricum* because seed propagation is constrained by a long juvenile cycle and deep epicotyl dormancy, whereas rhizome-derived plants reach harvestable rhizomes in about 3~4 years rather than 5~6 years from seed (Meucci et al., 2024). Natural rhizome propagation is still inherently slow, which is why conventional field multiplication based on whole rhizomes or larger bud-bearing pieces remains reliable but inefficient for rapid scale-up (Tejera-Nieves and Walker, 2023). In *Polygonatum* germplasm, some cultivars form one or multiple branch buds adjacent to the renewal bud in the next growth season, and multi-bud rhizome types usually have larger rhizome segments and are more favored in cultivation, which gives whole-rhizome propagation an advantage for maintaining strong early vigor and varietal traits (Lubbe et al., 2023). Comparative metabolomic work also found that artificially cultivated plants with multiple rhizome buds had phytochemical profiles generally comparable to wild types, supporting the production value of clonal rhizome-based multiplication (Figure 1) (Cheng et al., 2023).

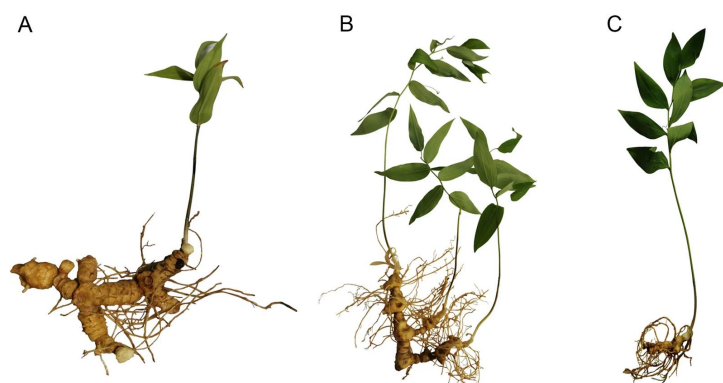


Figure 1 The photos of the rhizomes of *P. sibiricum* from the artificial cultivation with multiple rhizome buds (A), the wild-type with multiple rhizome buds (B), and the wild-type with single rhizome bud (C)

The main advantage of whole-rhizome propagation is that it preserves a more complete storage organ and therefore tends to maintain stronger nutrient reserves, bud viability, and transplant buffering capacity, while the main disadvantage is the low multiplication coefficient and the sacrifice of more commercial rhizome material per seedling (Meucci et al., 2024). Division propagation increases the propagation coefficient by cutting the rhizome into bud-bearing units, but its performance depends on retaining viable buds and sufficient storage tissue around