

Standardization also requires defining stem size and nodal specification. Tea softwood cuttings commonly use semi-lignified branches at least 15 cm long, while apple rootstock cuttings were standardized at 20 cm length, 5~10 mm thickness, and 4~6 buds. *Tecoma* cuttings were trimmed to 10 cm and 0.5~1.0 cm diameter (Singh et al., 2021), and *Picea crassifolia* likewise performed well with softwood cuttings 0.5~1.0 cm in diameter. Single-node cuttings can maximize propagation efficiency, but they may root slowly or fail to produce shoots in some species (Schrader et al., 2026), whereas four-node terminal semi-hardwood cuttings are used successfully in camellia. Leaf retention is also critical. Leafy cuttings rooted and sprouted better than leafless cuttings in *Tecoma stans*, likely because retained leaves continued photosynthesis during propagation. For *T. hemsleyanum*, a practical standard is to use vigorous current-season or semi-lignified shoots of moderate thickness, retain a limited functional leaf area, and specify a stable range of node number, length, and diameter to balance carbon supply with water loss (Choudhary et al., 2024).

3.3 Collection, trimming, and rooting pretreatment of cuttings

The final step is the collection, trimming, and rooting pretreatment of cuttings before insertion. Clean handling begins at harvest: stock plants should be well hydrated, cuttings should be taken in the early morning, and tools and hands should be disinfected to reduce contamination. Several studies also used fungicidal sanitation before hormone treatment, including 0.2% Bavistin for 10 min in *Tecoma stans* and Rizolex at 3 g/L for 5 min in fig cuttings (Singh et al., 2021). Trimming is usually standardized around the basal node, because nodes are common sites of adventitious root formation, and basal cut pattern can influence rooting depending on species (Mohammed et al., 2020). In tea, excess leaves 3~5 cm above the base were removed before sticking in perlite, while general greenhouse guidance recommends each cutting retain several leaves rather than becoming excessively leggy. Pretreatments that wound the basal region can improve rooting in some species by stimulating root initials or enhancing auxin responsiveness. Basal longitudinal or unilateral wounding was applied successfully in fig, apple rootstock, and camellia, and wounded apple cuttings showed better root and shoot parameters than unwounded ones. The effect is not universal, however, because bottle brush showed no wounding effect by itself (Hameed and Adil, 2019).

Auxin pretreatment is the most consistent rooting intervention, but concentration and application method must be standardized by species and cutting type. Quick-dip basal treatments are widely used, including 15 s in apple rootstock, short basal dips in fig, talc formulations in *Tecoma stans*, and 5 min immersion or 15 s basal dip in camellia. IBA repeatedly outperformed or matched other auxins, with optimal reported concentrations of 1 000 mg/L in catalpa (Quan et al., 2022), 2 000 ppm in apple rootstock, and 0.4% IBA in *Tecoma stans* (Singh et al., 2021). Auxin combinations can further improve rooting in some species, as in magnolia with NAA:IBA (2:1) and fig with wounding plus IBA and NAA. Because *T. hemsleyanum* needs a reproducible nursery protocol, its cuttings should be harvested from hydrated elite mother plants, disinfected, trimmed to a fixed nodal and leaf standard, optionally wounded at the base, and subjected to a calibrated IBA-based quick-dip treatment before insertion into the rooting substrate.

4 Optimization of Key Techniques for Rooting of Cuttings

4.1 Selection and optimization of rooting substrates

The rooting substrate should first satisfy the physical requirements of water retention plus aeration, because adventitious rooting responds strongly to pore structure, oxygen availability, and moisture balance rather than to any single substrate ingredient (Hoover et al., 2025; Saini et al., 2025). Across species, mixed media often outperform single materials when they balance these properties, as peat+perlite outperformed perlite alone in Caucasian whortleberry and cocopeat+perlite (1:1) gave optimum rooting in carnation (Zheng et al., 2020; Yazar et al., 2025). Similar advantages appear in woody and succulent systems, where perlite-cocopeat (1:1) gave the best juniper protocol and sand:perlite or sand:vermiculite supported the highest rooting percentage and root number in *Pedilanthus tithymaloides* (Abass et al., 2024). In chrysanthemum, vermiculite+perlite (1:1) supported the best response under the optimal auxin-temperature combination, again indicating that porous, well-aerated mixtures are broadly favorable for cutting propagation (Ghimire et al., 2022).