

best combination was 2-3-year-old cuttings treated with 1 000 mg/L IBA for 10 s. More broadly, auxin type and concentration are repeatedly decisive: IBA is widely recognized as an effective rooting auxin, concentration often has the strongest effect among hormone variables (Sun et al., 2023), and excessively high levels can damage tissues and impair rooting. Species-level optima still differ, with 2 000 ppm IBA performing best in chrysanthemum (Ghimire et al., 2022), 50 ppm NAA for 30 min in *Valeriana jatamansi* (Gautam et al., 2021), and 3.0 mmol/L IBA accelerating rooting in young *Andrographis* cuttings (Hossain et al., 2021).

Environmental control is equally important because light, temperature, water status, substrate aeration, and mineral nutrition modify auxin activity, carbohydrate supply, and tissue competence for root initiation (De Almeida et al., 2017). Rooting improves when carbohydrate status is maintained, and higher light during early cultivation can offset carbohydrate depletion in cuttings, whereas low light and poor photosynthetic recovery restrict root formation (Druege et al., 2019). Light quality also matters: far-red promoted rooting in medicinal cannabis when supplied during the initial 7 d, while blue had no significant effect in that experiment. Temperature interacts strongly with auxin responses, with 25°C repeatedly supporting better root number and length than cooler or warmer conditions in chrysanthemum and tomato experimental systems (Guan et al., 2019; Ghimire et al., 2022). Substrate effects are species-dependent but often substantial: hemp rooting varied markedly across media, with substrate composition exerting the greatest effect in that study (Campbell et al., 2021), and grape cuttings rooted best in perlite or coarse-particle substrates that improved aeration (Zheng et al., 2025). Cutting diameter, leaf retention, stem wounding, humidity, season, and mother-plant health also modify rooting success by changing transpiration, endogenous hormone supply, and carbon availability.

### 3 Selection and Pretreatment of Cutting Materials

#### 3.1 Selection of elite mother plants and cultivation of cutting materials

The first prerequisite for standardized cutting propagation is the selection of elite mother plants with stable phenotype, strong vegetative vigor, and high regenerative capacity, because poor stock-plant management directly lowers cutting quality. Vegetative propagation is valuable precisely because it preserves true-to-type traits from the stock plant, so the quality of the donor plant determines the quality uniformity of the seedling population (Quan et al., 2022). Mother-plant physiological status is a major determinant of rooting success, and reviews across fruit and woody crops identify it alongside cutting type, season, substrate, and hormones as a core source of variation (Saini et al., 2025). Age is especially important: hazelnut formed vigorous one-year shoots most intensively from 4-7-year-old mother plants, while younger bushes allocated more growth to plant establishment and older bushes produced weaker shoots (Savina et al., 2025). In *Picea crassifolia*, cuttings from 15-year-old healthy ortets showed better rooting performance than material from younger or older donor trees, indicating that optimal donor age is species-specific but biologically meaningful. Mother-plant origin also matters: tissue-culture-derived eucalyptus stock plants produced cuttings with higher rooting success and superior early growth than conventional mother-bed sources.

Elite mother plants should therefore be maintained under conditions that preserve juvenility, sanitation, and repeated shoot production. Greenhouse guidance emphasizes that healthy stock plants can tolerate frequent harvest, but they must be fully hydrated before cutting collection, and early-morning harvest is preferred because tissues are more turgid. Keeping stock plants in a juvenile state can increase the number of harvestable propagules across successive cutting rounds. Controlled mother-plant systems also improve phytosanitary quality and propagule homogeneity: soilless strawberry mother plants reduced soil-contact contamination risk and increased the quality and uniformity of propagules, while micropropagated mother plants showed substantially higher propagule output than in vivo stocks. For *T. hemsleyanum*, this supports establishing a dedicated mother-stock garden composed of disease-free, vigorous elite clones, managed with rejuvenation pruning, adequate water and nutrition, and protected cultivation to produce uniform juvenile shoots for repeated cutting collection (Morresi et al., 2025).