

Broader orchid evidence supports using porous, moisture-buffering substrates with stable structure during acclimatization. Cocopeat gave the highest survival at 88.33% in one orchid study, coconut coir outperformed a sphagnum-charcoal-bark combination for seedling height and leaf number in another, and wood sawdust or coconut coir produced 100% early survival in a hardening experiment (Silva et al., 2017; Longchar and Deb, 2022; Han et al., 2025). For *Dendrobium* specifically, sterilized coconut husk supported 95% survival in *D. crumenatum*, tree fern supported 94.8% survival in *D. thyrsiflorum*, and *D. nobile* performed best in a mixed substrate of chopped coconut husk, brick, charcoal, and cocopeat. Together, these results suggest that *D. officinale* transplant substrates should prioritize bark- or coir-based materials with good drainage and moderate moisture retention, while local optimization remains necessary because performance differs by genotype and cultivation objective (Rachmawati et al., 2024).

## 7.2 Temperature, humidity, light, and ventilation management

Environmental management after transplanting should follow a gradual transition rather than an abrupt exposure to ambient conditions. In *Dendrobium*, acclimatization improves survival by progressively lowering relative humidity and increasing light, allowing plantlets to shift from heterotrophic or photomixotrophic growth to autotrophic growth while improving stomatal control and root function (Silva et al., 2017). More general orchid hardening guidance similarly recommends maintaining relative humidity near 95% at first, then gradually reducing moisture and nutrient supply while moving seedlings into shaded conditions, which promotes wax formation, thicker leaves, and more stable water relations (Zhang et al., 2022). In *D. officinale* domestication practice, greenhouse seedling training for about three months produced thicker leaves, darker color, stronger stems, more robust roots, and post-transplant survival above 98%, indicating that controlled environmental transition materially improves transplant success (Rachmawati et al., 2024).

Light and ventilation must be coordinated with seasonal temperature control because excessive heat and stagnant humidity increase stress and disease risk. A *D. officinale* cultivation study reported that plantlets were properly shaded, cooled, and ventilated during summer and autumn, linking these measures to improved growth quality under cultivation (Zhang et al., 2024). Orchid precision-greenhouse research further shows that intelligent environmental management can track growth status and support decisions on greenhouse factors, with recognition accuracy reaching 98.6%, which supports future refinement of temperature, humidity, light, and ventilation control in orchid nurseries. Physiological evidence also indicates that appropriate light and potassium treatments can increase anthocyanin content and that different cultivation modes affect active compound accumulation, so environmental management during recovery should aim not only at survival but also at maintaining medicinal quality (Zhang et al., 2024).

## 7.3 Disease prevention and management during the seedling recovery period

Disease prevention during the recovery period should begin with sanitation and microbial risk reduction because newly transplanted tissue-cultured seedlings are highly susceptible to pathogen attack. General acclimatization studies note that a major cause of mortality is the rapid exposure of aseptically raised roots to soil microbial communities, especially fungi, and sterilized soil is therefore often used at the beginning of establishment (Rachmawati et al., 2024). Post-bottle handling should include thorough washing to remove residual medium from the roots before planting, since retained medium can favor excess moisture and contamination (Silva et al., 2017). These sanitation steps fit *D. officinale* domestication systems, which explicitly treat post-bottle handling and post-field management as separate technical links within survival-oriented nursery management (Rachmawati et al., 2024).

Biological management also appears important for disease resistance and recovery vigor in *D. officinale*. *Mycena dendrobii* significantly enhanced survival and growth after transplanting, and proteomic analysis indicated that the induced proteins included defense-and stress-response proteins, supporting a disease-preventive role through improved stress tolerance rather than simple growth promotion alone. Other orchid mycorrhizal studies found that fungal symbiosis can raise antioxidant enzyme activity, improve drought and disease resistance, and increase root and leaf growth, biomass, and medicinal polysaccharides, although effects differ by fungal strain and development