4.2 Seedling quality grading and health assessment

Seedling grading should convert these measurements into operational classes that distinguish plantable from unqualified nursery stock. Citrus grading studies show that classification can be built from a larger measured dataset and then simplified into a few key indicators that are practical in production (Wang et al., 2026). In annual grafted *Citrus aurantium* seedlings, plant height, scion diameter, and branch number were used to establish three quality grades, and seedlings below the third-grade threshold were considered unqualified (Xu et al., 2020). This provides a useful example of how citrus nursery measurements can be translated into operational grades, but the numerical thresholds of *Citrus aurantium* should not be used directly as fingered citron standards. More broadly, plant height, stem or ground-line diameter, and root system condition are commonly used grading indicators, while integrated indices such as sturdiness quotient, shoot:root ratio, and Dickson quality index can reduce error from relying on a single trait (Robonen et al., 2023).

Health assessment should accompany grading because a morphologically large seedling is not necessarily a healthy or field-ready one (Grossnickle and MacDonald, 2018; De Melo et al., 2018). Physiological assessment methods such as root growth potential, cold hardiness, stress resistance, water relations, nutrient status, and root electrolyte leakage provide information on transplant performance that morphology alone can miss, although they are more time-consuming and are used less often operationally. Nursery quality control should therefore screen for root deformities, abnormal shoot-to-root ratios, low photosynthetic competence, cellular stress, and poor hydration status, because these problems can occur even where seedlings appear acceptable externally (Kamanga et al., 2026). A relative water content above about 75% has been associated with better leaf water status and drought tolerance in other seedling-quality studies; this value can serve only as a physiological reference and should not be treated as a fingered citron grading threshold. Nursery assessment is also valuable for preventing disease spread and qualifying plant material in trade, so fingered citron grading should integrate morphology, physiology, and sanitary inspection into one standard evaluation process (Mataruga et al., 2023).

4.3 Hardening, lifting, and transportation of seedlings

Before seedlings leave the nursery, hardening is used to improve tolerance to transplant stress, especially in dry or exposed planting environments. In nursery practice, seedlings are often water stressed and then gradually weaned under shade before transport so they become less vulnerable to drought after planting. Evidence on drought hardening is mixed overall, but field studies show that it tends to improve survival and growth as site aridity increases, while benefits are reduced when a long delay occurs between hardening and transplanting (Puértolas et al., 2024). Hardening therefore needs to be linked closely to the expected field site and planting schedule rather than applied as a fixed routine (Guimarães et al., 2024). In addition, nursery practices such as watering, shading, fertilization, root pruning, suitable growing media, and short-day or storage protocols all influence the final transplant quality of planting stock (Kamanga et al., 2026).

Quality can decline substantially between lifting and planting if seedlings are exposed to desiccation, extreme temperatures, rough handling, root loss, or prolonged storage. These stresses often occur in combination, and the cumulative effects of desiccation and storage appear especially harmful, making careful lifting, packing, and rapid delivery essential. European nursery surveys similarly identify unsuitable transport and handling during shipping and planting as a common cause of declining seedling quality (Mataruga et al., 2023). For fingered citron seedlings, lifting should retain as much of the functional root system as possible, avoid mechanical injury, and keep roots moist and shaded during grading, bundling, loading, and transport, because root morphology and physiological condition are closely tied to successful establishment after transplanting (Grossnickle and MacDonald, 2018).

5 Standardized Orchard Establishment and Planting Techniques for Fingered Citron

5.1 Site selection and soil improvement

Site selection for fingered citron should begin with climatic and topographic suitability, because this species is sensitive to mismatched environments and its current planting problems have been linked directly to inadequate suitability analysis. For fingered citron, the dominant environmental variables identified across habitat modeling