2 Principles and Mechanisms of Eggplant Grafting

2.1 Graft compatibility and formation of vascular connections

Graft compatibility in eggplant depends on whether the scion and rootstock can heal into a single mechanically stable plant with continuous nonvascular and vascular connections, rather than merely surviving after grafting. Within Solanaceae, compatibility is often strongest in closely related combinations, and tomato-eggplant unions are a clear example of successful intrageneric heterografts in which substantial vascular reconnection supports long-term stability. The graft union forms through a sequence of wound healing events that includes tissue adhesion, vigorous callus proliferation, and later differentiation of new xylem and phloem across the interface (Habibi et al., 2022). During this process, phloem typically reconnects before xylem, and cell-to-cell communication is established through newly formed plasmodesmata, allowing the two partners to coordinate regeneration before the vascular system is fully restored (Tsaballa et al., 2021).

Compatibility is also expressed anatomically at the graft junction. In eggplant-related systems, a successful union is associated with degradation of necrotic layers, close linkage of callus cells, and strong integration between the callus bridge and the vascular network, whereas persistent mismatch at the junction signals functional imbalance (Kappel et al., 2024). Practical assessments therefore often use affinity indices based on the relative diameters of the graft partners, because a balanced junction is more likely to support effective transport of water and nutrients through the developing vascular system (Argento et al., 2023). Incompatibility can be immediate or delayed, and delayed incompatibility is especially important because plants may survive for weeks or longer before mechanical weakness and transport failure become obvious. Molecular work indicates that incompatible unions show disrupted vascular strand reconnection and perturbed expression of key vasculature-related genes, while successful union formation depends on regulators such as SlWOX4 and cell-wall remodeling genes including XTH family genes that sustain callus growth and xylem bridge formation.

2.2 Rootstock characteristics and their functional roles

Rootstock choice is central to eggplant grafting because the rootstock largely determines the belowground capacity for water capture, nutrient uptake, stress tolerance, and resistance to soil-borne pathogens (Musa et al., 2020). In practice, wild *Solanum rootstocks* and selected tomato hybrids are widely used because they can confer higher vigor, stronger root systems, and greater resilience than self-rooted plants. Anatomical traits of the rootstock are one major basis of these functional effects. In grafted eggplant, rootstocks with larger xylem widths and higher cortex cell numbers were associated with higher yield, while *Solanum rootstocks* also showed larger root volume or xylem area than self-rooted plants or some commercial tomato rootstocks (Kappel et al., 2024). These findings indicate that rootstock-mediated differences in sap flow and tissue organization help regulate the later performance of the scion by shaping transport efficiency from the seedling stage onward.

The functional role of the rootstock becomes especially clear under stress. Under deficit irrigation, grafted eggplants developed greater canopy vigor, root proliferation, water and nutrient uptake, and photosynthetic capacity than non-grafted controls, which translated into lower yield loss and higher water productivity (Wakchaure et al., 2025). This supports the broader view that rootstocks do not simply anchor the plant, but actively regulate scion growth, flowering, fruit set, and stress resistance through whole-plant integration (Liu et al., 2025). Rootstocks also contribute indirectly by modifying the rhizosphere environment and disease pressure. In eggplant, grafting onto superior rootstocks reduced bacterial wilt incidence sharply and increased microbial biomass, enzyme activity, and microbial diversity in the rhizosphere, indicating that rootstock effects extend beyond plant anatomy into soil ecological function (Du et al., 2024). This is agronomically important because eggplant is highly vulnerable to persistent soil-borne pathogens, and resistant rootstocks such as *Solanum torvum* are already recognized as effective tools for wilt management where other control methods are unreliable (Sivasankarreddy et al., 2024).

2.3 Physiological and molecular responses induced by grafting

Grafting induces broad physiological changes in eggplant by altering water relations, mineral acquisition, chlorophyll status, and overall vigor through the interaction of the scion with a distinct root system (Musa et al.,