

### 7.3 Molecular and omics-based understanding of grafting responses

The molecular basis of eggplant grafting is now moving from descriptive physiology toward integrated omics. Reviews highlight that next-generation sequencing has made it possible to examine genomic interactions across the graft junction, including gene exchange, rootstock-scion communication, and large shifts in scion DNA methylation that may underlie graft-induced changes in vigor, stress responses, and quality. This is important because future rootstock selection is unlikely to become truly predictive until molecular markers are connected to agronomic performance (Tsaballa et al., 2021). Eggplant-specific evidence already shows that grafting can trigger strong epigenetic reprogramming. Heterografting-induced vigor was associated with genome-wide CHH hypomethylation and altered scion gene expression, linking improved plant performance to epigenetic remodeling rather than to anatomy alone. More broadly, epigenetic diversity is now being considered a usable source of phenotypic variability, with potential value for breeding and for designing graft combinations that are more resilient under changing environments (Tsaballa et al., 2021).

Transcriptomics and metabolomics are also clarifying how grafting alters fruit composition and stress biology. In eggplant, integrated metabolomic and transcriptomic analysis showed that the Sm64R rootstock improved fruit size and several nutritional traits, while differential metabolites and genes clustered in phenylpropanoid, phospholipid, and nucleotide metabolism pathways (Yan et al., 2022). Cold-stress transcriptomics further showed thousands of differentially expressed genes between self- and heterografted combinations, with enrichment in hormone signaling and arginine-proline metabolism, indicating that graft-mediated stress tolerance is regulated through broad transcriptional networks rather than single genes. A further frontier is the study of mobile regulatory molecules as direct mediators of rootstock effects. Under cadmium stress, grafting onto *S. torvum* reduced fruit Cd by 76% and identified five key differentially expressed miRNAs whose targets were involved in hormone signaling and ion transport, suggesting a mechanistic link between long-distance RNA signaling and safer fruit production (Chenshu et al., 2026). Together with broader evidence that grafting can involve genetic exchange and methylation changes across the union, these findings indicate that future eggplant grafting technology will increasingly rely on omics-guided rootstock design, not just empirical nursery testing (Tsaballa et al., 2021).

## 8 Conclusions

Across studies, grafting consistently improved eggplant vegetative vigor, root development, and reproductive performance relative to non-grafted controls. Field and greenhouse experiments reported significant increases in plant height, leaf area, chlorophyll status, fruit number, and total yield, showing that rootstocks alter both source strength and sink development rather than only protecting plants from stress. This effect appears strongest when vigorous and compatible rootstocks such as *Solanum torvum*, wild relatives, or selected interspecific hybrids are used, because these combinations enhance biomass production and support earlier or more sustained fruiting. The yield advantage of grafting is mechanistically linked to stronger root systems, improved water and nutrient uptake, and more stable physiology under stress. Soilless and deficit-irrigation studies showed that vigorous rootstocks increased plant dry weight and yield through greater root development, while also improving water productivity and reducing yield losses under drought. Fruit-quality responses were more variable than growth and yield responses, but several studies still found gains in soluble solids, chlorogenic acid, vitamin C, amino acids, antioxidants, and mineral composition when favorable rootstock-scion combinations were selected.

From a production standpoint, grafting is now a practical tool for stabilizing eggplant performance in intensive and low-input systems. It is especially valuable where continuous cropping and soil-borne diseases limit conventional cultivation, because resistant rootstocks can sharply reduce disease incidence while maintaining or increasing yield under commercial greenhouse conditions. This makes grafting relevant not only for yield improvement, but also for lowering dependence on chemical soil disinfestation and supporting more resilient production systems under protected and open-field cultivation. The technology also has clear value for resource-efficient horticulture. Vigorous rootstocks maintained higher biomass and yield even under reduced nutrient supply, suggesting that fertilizer inputs can be lowered without proportional productivity loss, while other studies documented marked gains in water use efficiency under deficit irrigation. In practice, these benefits can be