

2019; Choi et al., 2023). Low crop load increased single-berry weight, sugar-acid ratio, phenolics, antioxidant activity, terpene and C13-norisoprenoid contents, and sensory scores, showing that this cultivar is highly responsive to source-sink regulation (Li et al., 2023).

3.2 Design of canopy optimization management practices

Canopy optimization in ‘Shine Muscat’ should be designed as a combined system rather than a single operation, integrating training architecture, shoot-vigor control, crop-load regulation, and fruit-zone management. Broader trellis research shows that training-system choice changes canopy architecture, light exposure, photosynthetic activity, yield, and berry composition, and divided or high-canopy systems often improve radiation capture or yield stability relative to dense vertical systems (Del Zozzo and Poni, 2024; Domingues Neto et al., 2024). In table grapes under protected cultivation, trellis and thinning must be coordinated because the SAYM system produced larger leaf area index (LAI) but lower light transmission and photosynthetically active radiation (PAR) than pergola, while heavy berry thinning improved total soluble solids (TSS), TSS/titratable acidity (TA), pH, color density, and skin anthocyanins (Yin et al., 2022).

For ‘Shine Muscat’ specifically, the design of canopy optimization practices should include standardized cluster-length control, precise berry thinning, and carefully dosed growth regulators to synchronize vegetative control with berry development. Thinning clusters to 3~4 cm or about 4 cm improved fruit growth and maintained a more appropriate sugar-acid ratio than 5 cm treatments, which left more berries but smaller berry size and lower ratio (Shin et al., 2019; Choi et al., 2023). PGR programs also require restraint: GA₃+TDZ and GA₃+CPPU can achieve near-complete seedlessness and increase berry size, but excessive CPPU, GA₃, EBR, or high retardant doses can lower soluble solids, increase hollowness, thicken rachises, or restrict leaf and cluster development (Cheng et al., 2025; Yang et al., 2025).

3.3 Evaluation indicators for different canopy management systems

The evaluation of different canopy management systems in ‘Shine Muscat’ should cover three dimensions: canopy structure and physiology, yield stability, and market-oriented fruit quality. Classic canopy-assessment work recommends quick field diagnosis by point quadrat analysis and canopy scoring, together with multiple numeric descriptors of canopy surface, shade, spacing, and fruit-zone exposure. Consistent with this, recent trellis studies assessed budbreak, bearing-shoot proportion, LAI, transmission coefficient, PAR, mean leaf angle, transpiration, and photosynthetic rate as core indicators of canopy performance (Yin et al., 2022).

Yield and fruit-quality indicators should then be tracked together because training systems often shift productivity and quality in different directions. Useful production indices include cluster number, cluster weight, berry weight, total yield, and leaf area-to-fruit balance, while quality indices include SSC, TA, SSC/TA ratio, firmness, peel residual feel, color density, anthocyanins, phenolics, sugars, aroma, and postharvest disease incidence (Shin et al., 2019; Olson et al., 2021; Yin et al., 2022; Yu et al., 2022; Choi et al., 2023). For ‘Shine Muscat’, this expanded indicator set is especially justified because supplementary blue light improved TSS, sugars, berry hue, and monoterpene-driven floral and fruity aroma, rootstocks altered berry weight, TSS/TA, phenolics, and volatile profiles, and rain-shelter plus root restriction reduced disease incidence and postharvest risk (Chen et al., 2024; Ren et al., 2024; Li et al., 2025).

4 Effects of Canopy Optimization on Fruit Development of ‘Shine Muscat’ Grapes

4.1 Effects on plant growth and canopy structure

‘Shine Muscat’ shows a strong tendency toward excessive vegetative growth, and this vigor is a primary reason canopy optimization is necessary in commercial production (Cheng et al., 2026). Dense canopies reduce photosynthetic efficiency, worsen the canopy microclimate, delay maturation, and can also impair flower-bud differentiation and shoot maturation (Cheng et al., 2025). In response, chemical growth-control strategies have been effective at suppressing shoot elongation in ‘Shine Muscat’, with both mepiquat chloride and chlormequat chloride reducing shoot growth, and CCC showing stronger inhibition than MC. A later study similarly found that Pro-Ca alone had limited effect at low concentrations, whereas Pro-Ca 300 mg/L+MC 300 mg/L effectively inhibited shoot elongation and improved canopy branch density. These results indicate that canopy optimization in