3.3 Peel coloration and external appearance

In 'Triunfo de Viena', applying 74%~60% and 48%~27% ETc during the rapid fruit growth stage resulted in no significant differences at harvest in peel chlorophyll, carotenoid content, or overall color index compared with 100% ETc (Vélez-Sánchez et al., 2021).

By regulating vegetative growth, deficit irrigation can indirectly improve external appearance. For example, in 'Bartlett' under the Tatura system, applying RDI at 46% Eps during vigorous vegetative growth reduced shoot and structural growth without affecting fruit growth. This may improve light distribution within the canopy, thereby enhancing color uniformity and reducing russeting, although color parameters were not directly measured in that study (Mitchell et al., 1984).

3.4 Effects on fruit uniformity and commercial grading

In high-altitude tropical 'Triunfo de Viena', under postharvest deficit treatments of 25% and 0% ETc, the largest diameter and volume were observed in the fully irrigated treatment 2 days after harvest. However, subsequent evaluations did not show a decline of fruit below market standards, and all quality parameters remained within commercially acceptable ranges (Bayona-Penagos et al., 2017).

In contrast, when continuous deficit was applied throughout the entire growing season, some trade-offs occurred. In field trials in Kosovo, compared with 100% ETc drip irrigation, a simplified 50% ETc treatment reduced yield per tree by about 38%, but improved fruit grading quality: 92.30% of fruits reached the extra class under 50% ETc, compared to 85.41% under full irrigation (Lepaja et al., 2024). Average fruit diameter and length did not differ significantly between treatments, indicating that the higher proportion of top-grade fruit was mainly due to improved uniformity, shape, or peel quality rather than larger fruit size.

4 Effects on Fruit Chemical Quality

4.1 Soluble solids content (ssc) and sugar accumulation

In pears and other woody fruit trees, mild to moderate deficit irrigation generally increases SSC and enhances sugar concentration. This may result from reduced fruit water content leading to solute concentration, or from restricted water inflow while maintaining or even increasing carbohydrate supply, or a combination of both.

In sparsely planted mature pear orchards in Xinjiang, regulated deficit irrigation (RDI) at 40%~60% of pan evaporation (Ep) applied during the cell division stage or slow fruit expansion stage significantly increased total soluble sugar content compared with full-season irrigation at 80% Ep. Meanwhile, fruit growth and yield were maintained or even improved under some treatments (Wu et al., 2013). In 'Conference' pear, applying deficit irrigation (0% followed by 20% ETc) during stage II increased SSC at harvest and after storage, and combining deficit irrigation with fruit thinning further enhanced SSC (López et al., 2011).

The mechanisms may include increased dry matter content under stress, osmotic adjustment promoting sugar accumulation, and reduced energy consumption for fruit growth, which lowers sugar use in glycolysis (Bai et al., 2022; Toumi et al., 2022). These findings are consistent with observations in Abbé Fetèl and mature pears, indicating that moderate water deficit generally increases sugar concentration and potential sweetness, especially after storage in climacteric cultivars.

4.2 Organic acids and sugar-acid balance

Direct measurements in 'Williams' pear showed that irrigation (adequate water supply) reduced malic acid, citric acid, fumaric acid, and shikimic acid contents, and also decreased SSC. In contrast, non-irrigated fruits had higher sugar and acid contents, indicating that water limitation concentrates primary metabolites, including organic acids (Hudina and Stampar, 2005).

In 'Conference' pear, moderate preharvest deficit irrigation during stage II increased titratable acidity at harvest and maintained higher levels during storage. Together with higher SSC, this resulted in a richer and more complex flavor (López et al., 2011). Postharvest deficit (irrigation stopped while maintaining stem water potential above about -1.5 MPa) generally had little effect on acidity, although in one season SSC slightly increased while acidity remained unchanged (Marsal et al., 2011).