2.3 Common irrigation patterns in pear production

Common irrigation patterns in pear orchards mainly include the following. The most widely used is regulated deficit irrigation (RDI), which applies full irrigation during sensitive stages and reduces irrigation to a certain proportion of ETc or Ep during non-sensitive stages. Typical schemes include: 40%-60% Ep in early stages and 80% Ep later; 50% adjusted ETc in Stage I or II for young trees; 60%~80% ETc at specific stages and 100% ETc at other times; or 67%~55% ETc only during the rapid growth stage. Another method is partial root-zone drying (PRD), where irrigation alternates between the two sides of the root system.

At the orchard scale, irrigation patterns are also influenced by irrigation systems and soil moisture thresholds. In northern China, drip irrigation (surface, ring, subsurface, single-line or double-line) is commonly combined with a lower limit of 60%-80% FC, and subsurface double-line drip at 60% FC performs best (Wang et al., 2021). In Xinjiang fragrant pear, 30 cm subsurface drip irrigation with a moderate irrigation amount shows the best performance in yield, water use efficiency, and economic return, while traditional flood irrigation uses more water but has low efficiency (Wang et al., 2024).

In semi-arid regions of Brazil, drip and micro-sprinkler irrigation were tested at 60%~120% ETc, and the highest yield was achieved at about 92% ETc. Both excessive and insufficient water reduced gas exchange and affected carbohydrate metabolism (Gomes et al., 2023). In Kosovo, 50% ETc reduced yield per plant but increased the proportion of high-quality fruit and saved half of the irrigation water (Lepaja et al., 2024).

2.4 Indicators for monitoring water deficit

For soil monitoring, gravimetric methods, capacitance sensors, or tensiometers are commonly used, with indicators including volumetric water content, percentage of FC, or soil water potential. In the “Triunfo de Viena” study, combining ETc with soil moisture monitoring achieved water savings of up to 73% while avoiding severe drought (Vélez-Sánchez et al., 2023).

In plants, leaf and stem water potential (Ψleaf, Ψstem) are widely used indicators, usually measured in the early morning or at midday with a pressure chamber. In the Abbé Fetèl cultivar, the 60% ETc treatment significantly reduced water potential and gas exchange, but fruit size was maintained and postharvest soluble solids increased on BA29 rootstock, indicating that moderate decreases in water potential are acceptable (Venturi et al., 2021). Under tropical high-altitude conditions, Ψpdl, Ψstem, Ψpdf, and Ψf showed no significant differences among different RDI treatments (-0.25 to -1.03 MPa) (Vélez-Sánchez et al., 2022). Other indicators include maximum daily trunk shrinkage (MDS) and pressure–volume curve parameters.

3 Effects on Fruit Physical Quality

3.1 Fruit size and single fruit weight

In the cultivar Abbé Fetèl, trees grafted onto the more dwarfing quince rootstock (SYDO) produced significantly smaller fruits under 60% ETc compared to 110% ETc. In contrast, on the more vigorous BA29 rootstock, final fruit size remained essentially unchanged among 110%, 80%, and 60% ETc treatments (Venturi et al., 2021). On both rootstocks, moderate irrigation reduction increased fruit dry matter content, indicating that water inflow through the xylem (and also the phloem under stronger deficit) was reduced, leading to lower fruit water content, while carbohydrate supply did not decrease proportionally.

Under field conditions, in ‘Conference’, complete irrigation was stopped for 3 weeks at the beginning of the second growth stage, followed by deficit irrigation at only 20% ETc during the remaining period. This reduced fruit size at harvest but improved internal quality. Thinning under deficit conditions partially restored fruit size and fresh-market yield (López et al., 2011). In postharvest deficit irrigation (DI) studies of ‘Conference’, stopping irrigation after harvest for 3~4 consecutive seasons did not cause a sustained reduction in fruit size in subsequent years. In some years, a “carry-over effect” was observed, where fruit number decreased but individual fruit size increased. This reflects changes in crop load rather than a direct limitation of fruit growth by water stress (Marsal et al., 2011).