growing season. In some cases, reduced irrigation can even increase soluble solids content and improve storage performance, although fruit size may decrease slightly.

This study reviews the effects of deficit irrigation on pear fruit quality, summarizes global trends in pear cultivation and irrigation practices, and compiles results from different deficit irrigation strategies (including RDI and partial root-zone drying) under various climates, rootstocks, and cultivars. It focuses on how the intensity, timing, and duration of water deficit affect yield components, fruit size distribution, internal quality traits, and postharvest physiological behavior. Based on this, it proposes design principles for deficit irrigation under different production regions and resource conditions, providing a scientific basis for using deficit irrigation as a practical tool to improve sustainability and fruit quality in modern pear production.

## 2 Implementation of Moderate Deficit Irrigation in Pear Orchards

### 2.1 Irrigation control methods: soil moisture and irrigation interval

In soil moisture-based regulation, irrigation is triggered when soil water content drops below a preset proportion of field capacity (FC). In subsurface drip irrigation studies on Xinjiang fragrant pear, adjustments to total seasonal irrigation (3 750~6 750 $m^3$/ha) and emitter burial depth showed that deeper pipe placement combined with a reasonable irrigation amount can reduce excessive wetting of surface soil and better match the wetted zone with the active root layer (Wang et al., 2024).

In ET- or Ep-based regulation, irrigation is calculated as a proportion of ETc or Ep, and deficit irrigation is achieved by reducing this proportion or extending irrigation intervals. Young pear trees were irrigated at 70% (T70), 100% (control), and 130% (T130) of the FAO water budget. The T70 treatment reduced water use by 30% while promoting trunk growth and increasing fruit number, indicating that “full irrigation” may actually be excessive (Marsal et al., 2002). Later, the control treatment was reduced to 82% of the original irrigation level during mid-growth (Control-82%), and regulated deficit irrigation was applied at about half of this level during specific fruit development stages.

In regulated deficit irrigation experiments with the “Triunfo de Viena” cultivar, irrigation was reduced to 67% and 55% ETc only during the rapid fruit growth period (about two months), while 100% ETc was maintained at other times. This approach saved 33%~45% water without significant changes in yield or fruit quality (Molina-Ochoa et al., 2016). Under desert climate conditions, both RDI and PRD treatments used the same water amount (50% Ep during slow growth and 80% Ep during rapid expansion), and results showed that plant responses were mainly controlled by irrigation volume rather than irrigation method (Wu et al., 2020).

### 2.2 Key application periods of moderate deficit irrigation

Pear fruit growth is usually divided into the cell division stage (Stage I), slow growth stage (Stage II), and rapid enlargement or maturation stage (Stage III/IV). Moderate deficit irrigation can be applied at all stages, but the purpose differs.

In Bartlett pear, irrigation was stopped in spring to dry the root zone, followed by regulated deficit irrigation at 23%-46% of evaporation. This significantly reduced vegetative growth (about 52%) without affecting fruit growth. When irrigation was restored to 120% Eps during the rapid growth stage, fruit growth was promoted and yield increased by about 20% (Chalmers et al., 1986). Applying RDI in Stage I can increase flowering and fruit set, while applying it in Stage II can control fruit size. Adjusting irrigation to an intermediate level (Control-82%) helps balance yield and fruit size. In widely spaced mature pear trees, water deficit during Stage II (slow growth stage) has little effect on yield, indicating strong tolerance to moderate stress and making this stage suitable for deficit irrigation.

In studies on pear jujube and other woody fruit trees, the period from bud break to leaf expansion (Stage I) and the fruit maturation stage (Stage IV) are considered key regulation windows. Applying moderate or severe deficit during these stages can increase yield by 9%~32%, reduce water use by up to 17.5%, improve water use efficiency by up to 41%, and enhance fruit firmness, soluble solids, sugar-acid ratio, vitamin C content, and storage performance (Cui et al., 2008; 2009; Guo and Gao, 2023).