while preventing excessive aboveground vegetative growth. Therefore, moderate deficit irrigation strategies based on drip irrigation or substrate cultivation can generally achieve a better balance between vegetative growth and water-use efficiency.

4 Effects of Irrigation Strategies on Tomato Yield Formation

4.1 Effects of water supply on flowering and fruit set

Water supply is particularly important during flowering and fruit set, which are among the most drought-sensitive stages during tomato yield formation (Zhang et al., 2022; Alomari-Mheidat et al., 2024). Studies across different growth stages have shown that flowering and fruit development are more sensitive to water stress than vegetative growth. Water deficit imposed from the flowering stage can affect both yield formation and subsequent fruit quality (Poomkokrak et al., 2024). During this period, appropriate water management supports reproductive growth by maintaining photosynthesis, promoting nutrient uptake, and ensuring sufficient dry matter supply to flowers and developing fruits. In substrate cultivation systems, Song et al. (2025) found that nutrient supply during the flowering and fruit-setting stages had a particularly strong influence on yield and water-use efficiency (WUE), which was consistent with the high resource demands associated with reproductive organ development.

Water stress during flowering and fruit set affects reproductive success by reducing flower number, fruit set rate, and the survival of young fruits. In a cultivar screening study under 50% reduced irrigation, Grozeva and Ganeva (2024) observed that flower number, fruit number, fruit set rate, and single fruit weight declined as the inflorescence developed from the second to the fifth truss, with large-fruited indeterminate tomato cultivars showing the greatest sensitivity. Other greenhouse studies have also identified flowering and fruit-setting stages as critical periods when tomato plants are highly vulnerable to water stress. However, when plant water status is precisely regulated, moderate stress does not necessarily reduce fruit number. For example, Alomari-Mheidat et al. (2024) reported that irrigation management based on plant water status under moderate water stress conditions generally had limited effects on inflorescence development and fruit number but influenced fruit size. These findings suggest that prolonged or severe water stress is more likely to induce reproductive organ abortion, whereas mild and well-monitored deficit irrigation has relatively limited effects. When severe water stress occurs during fruit truss development, particularly under environments with high evaporative demand, it may delay truss formation, accelerate leaf senescence, and reduce fruit number by approximately 50%. Even after subsequent rewatering, plants can only partially recover from these effects.

4.2 Effects of irrigation levels on fruit enlargement and yield components

In greenhouse tomato production systems using drip irrigation, moderate increases in irrigation amount generally improve fruit weight and fruit size, whereas water stress commonly reduces fruit fresh weight and fruit dimensions. Dirlik et al. (2025) reported that maintaining stable and suitable soil moisture conditions through sensor-based irrigation management increased single fruit weight from 56 g to 85 g, fruit number per plant from 45 to 56, and final yield by 47%. Genotypic differences also influence tomato responses to irrigation levels, with different greenhouse cultivars showing considerable variation in the reduction of single fruit weight under reduced irrigation conditions. Some genotypes exhibited greater sensitivity to water stress than others.

Marketable yield depends not only on total yield but also on the proportion of marketable fruits. Wu et al. (2021) conducted a four-season greenhouse experiment and found that 75% ETc irrigation reduced the proportion of non-marketable fruits and produced larger fruits compared with full irrigation. In contrast, full irrigation during the late growth stage tended to promote the formation of more small fruits, thereby reducing commercial value. Studies on moderate water stress have also shown that fruit size is often the most sensitive yield component, whereas fruit number can remain relatively stable under moderate deficit conditions (Alomari-Mheidat et al., 2023). Under hydroponic conditions, different deficit irrigation strategies significantly affected single fruit weight, fruit number, and water-use efficiency during the fruiting stage, with the PRD85 treatment achieving the highest single fruit weight and water-use efficiency (Hooshmand et al., 2019).