7.4 Improving water use efficiency under climate change

Climate change intensifies the need to improve water use efficiency because higher evaporative demand makes fixed irrigation calendars less reliable. The broad vegetable literature suggests that moderate deficit irrigation often increases water productivity more reliably than severe deficit, but melon-specific work refines that conclusion by showing that deficit intensity must be matched to growth stage. Moderate deficit can be useful; severe, prolonged deficit frequently damages yield or fruit size (Singh et al., 2021; Panda et al., 2025; di Santo and Barrios-Masias, 2026).

Under climate uncertainty, the most resilient strategy for melon is probably a flexible system with three features: drip-based localized delivery, stage-specific irrigation frequency, and real-time adjustment by soil, substrate, or plant indicators. The recent Taiwan greenhouse study is particularly persuasive here because it reduced irrigation by about one-fifth to one-quarter in soil-grown systems without sacrificing yield or fruit quality. That is the kind of evidence needed for climate-adaptation arguments: not abstract efficiency, but water saving with maintained commercial output (Fang et al., 2026).

8 Future Perspectives and Conclusions

8.1 Current limitations in irrigation frequency research

Despite the growing literature, research on melon irrigation frequency still has several limitations. Many studies change both irrigation amount and frequency at the same time, which makes it difficult to isolate the independent effect of frequency. Others are highly system-specific, meaning that results from open-field loam soils cannot be transferred directly to substrate bags or peat-based troughs. Another limitation is that cultivar type is often underemphasized even though climacteric versus non-climacteric behavior, fruit size, netting, and cracking susceptibility may all influence the response to water scheduling (Singh et al., 2021; Xue et al., 2025; Fang et al., 2026).

There is also a regional imbalance in the evidence base. Semi-arid and water-limited regions are relatively well represented, but humid protected systems in eastern China, especially those typical of the Yangtze River Delta, still lack abundant English-language studies devoted specifically to irrigation frequency in melon. As a result, growers in these regions often have to infer management rules from studies designed for other climates or from experiments where water amount rather than frequency was the main focus (Chang et al., 2019; Yue et al., 2023).

8.2 Emerging technologies for irrigation management

The most promising new technologies are those that transform irrigation scheduling into a real-time, stage-aware process. Plant phenotyping, machine learning, soil-water sensors, plant water-status classification, and decision frameworks that combine crop coefficients with physiological thresholds have all reached a point where they can support serious greenhouse management. Their value is not only higher precision. They also make it possible to apply different irrigation frequencies at different stages without relying on intuition alone (Chang et al., 2019; Zapata-García et al., 2023; Fang et al., 2026).

At the same time, these technologies still need simplification. Models that depend on expensive instruments or highly standardized imaging environments are harder to scale commercially. The next practical gains will likely come from lower-cost sensors, easier interfaces, and integrated platforms that link environmental monitoring, crop stage recognition, and fertigation control in one system. For melon, this integrated approach is especially promising because quality and cracking risk respond so strongly to late-season water management (Zapata-García et al., 2025; Fang et al., 2026).

8.3 Future research directions

Future melon research should do three things more clearly. First, it should separate irrigation frequency from total water amount by using experiments in which seasonal water is held constant while interval or pulse structure changes. Second, it should compare responses across cultivars and production systems so that recommendations become more transferable. Third, it should move beyond yield and soluble solids to include cracking rate, firmness, aroma, shelf life, and economic return, because these are often the traits that determine whether a water-saving schedule is commercially acceptable (Sensoy et al., 2007; Xue et al., 2025; Fang et al., 2026).