deficits during blooming had the lowest production, while Yavuz and colleagues found that treatments depriving the crop of stable water during reproductive development significantly reduced yield (Fabeiro et al., 2002; Yavuz et al., 2021).

Even in protected environments where daily irrigation can be precisely delivered, unstable moisture at this stage can be costly. The 2019 net-house experiment showed that more frequent drip events supported stronger vegetative development and higher yield, which likely reflects better protection of early sink establishment as well as better canopy support. More recent physiological work also indicates that flowering to early fruit enlargement is the point at which drops in plant water status can quickly translate into reduced stomatal conductance and weaker assimilate supply (Nut et al., 2019; di Santo and Barrios-Masias, 2026).

4.2 Fruit enlargement and weight accumulation

During enlargement, melon fruits become strong sinks for both water and carbon. This is the stage when irrigation frequency most directly affects fresh weight and marketable size. Field and greenhouse studies are remarkably consistent on this point: adequate irrigation during enlargement increases fruit weight, whereas stronger deficits reduce it. In the Haining greenhouse trial, higher water input increased yield, although the middle irrigation treatment proved better overall once quality and efficiency were considered. In Turkey, the highest average yields were achieved either with full irrigation or with a regime that delayed deficit until ripening, which implies that fruit enlargement was still protected by adequate water (Kuscu and Turhan, 2022; Yue et al., 2023).

Severe deficits during or before enlargement can also shrink fruit in greenhouse systems. The 2025 greenhouse muskmelon study found that deficits applied across both flowering-swelling and maturity stages reduced fresh and dry fruit weight, while field work in Nevada showed that severe deficit at 50% field capacity lowered yield by about 40% relative to full irrigation. These findings suggest that there is little agronomic value in letting fruit experience strong and repeated water shortages while they are still building mass (Xue et al., 2025; di Santo and Barrios-Masias, 2026).

4.3 Fruit maturation and ripening characteristics

The maturation stage is where irrigation frequency changes from being mainly a yield-management variable to being a quality-management variable. Many studies show that reducing irrigation or frequency late in development can raise soluble solids, improve the sugar–acid balance, and reduce disorders such as cracking. In northwestern China, Xue and colleagues found that mild deficit during maturity sharply reduced greenhouse muskmelon cracking while maintaining yield and improving quality. In Turkey, water stress treatments often improved quality traits even when they lowered yield, again indicating that the end of the cycle is the most responsive stage for targeted quality enhancement (Yavuz et al., 2021; Kuscu and Turhan, 2022; Xue et al., 2025).

The effect is not unlimited, however. If late deficit is too strong, fruit size and commercial acceptability can still decline. In Taiwan, Fang and colleagues reported that a plant-based regulated deficit strategy improved sweetness and reduced cracking in soilless systems, but it also reduced yield and fruit size there, while in soil-grown systems the same framework reduced irrigation by 19.3%-25.7% without compromising yield or fruit quality. This contrast is valuable because it shows that the same late-season deficit principle behaves differently in soil and soilless environments (Fang et al., 2026).

4.4 Physiological mechanisms linking water supply and fruit development

The physiological link between irrigation frequency and fruit development can be summarized in four connected steps. First, irrigation rhythm determines how stable soil or substrate moisture remains in the root zone. Second, root-zone stability shapes plant water status, stomatal behavior, and nutrient transport. Third, those whole-plant responses govern the amount and continuity of carbon and water delivered to the fruit. Fourth, fruit tissues translate those inputs into cell division, cell expansion, sugar concentration, acid metabolism, and mechanical integrity. This is why a small change in watering schedule can alter not just fruit size, but also cracking, sweetness, and firmness (Cheng et al., 2022; Gustani et al., 2024; Wang et al., 2025).