7 Identification of Critical Temperature Thresholds in Peach Production

7.1 Optimal temperature ranges for key growth stages

Critical temperature thresholds for vegetative and reproductive development can be described using basal (minimum and maximum) temperatures and thermal sums for successive phenological phases. For 14 peach and one nectarine cultivar, minimum basal temperatures of about 8°C-10 °C were identified for pruning-sprouting and sprouting-flowering, 12°C-14 °C for flowering-fruiting, and 12°C-14 °C for ripening, while maximum basal temperatures were about 28°C-34 °C depending on the phase. These values imply that temperatures below phase-specific bases do not contribute to development, whereas temperatures above the upper limits do not further accelerate progress and may predispose to stress, providing practical bounds for "effective" temperature ranges during each stage.

Thermal-time models further refine optimal temperature concepts by combining cultivar-specific base, optimum, and critical temperatures. A non-linear growing degree hour (GDH) model using a base of 7.5 °C, an optimum of 26 °C, and a critical temperature of 38.5 °C accurately predicted harvest dates (1-4 d error) for cultivars with fruit development periods from 70 to 150 d, and an early forecast could be obtained from GDH accumulated in the first 25-52 d after bloom. Together, these results indicate that peach development proceeds most efficiently within a broad band from the low teens up to the mid-20s °C, with diminishing or saturating developmental gains as temperatures approach the upper 20s and mid-30s °C.

7.2 High-temperature stress thresholds and yield loss

Experimental warming under future-climate CO_2 has clarified high-temperature thresholds for physiological decline. For 'Mihong', a modest rise of +3.4 °C above local averages (with 700 μmol/mol CO_2) increased photosynthetic rate, carbohydrate content, and fruit weight, whereas a +5.7 °C scenario reduced photosynthesis, caused chlorophyll loss, decreased floral bud differentiation, and lowered floral bud density, leading to expected yield reduction in the following year (Lee et al., 2022). These responses suggest that warming within roughly +3-4 °C may still fall within an expanded "optimal" window, while sustained warming approaching +6 °C crosses a physiological threshold where vegetative dominance and early defoliation compromise reproductive potential.

At the orchard and regional scale, heat indicators around harvest identify damaging thresholds for yield. In South Korea, a logistic model using municipal yield data showed that a higher number of days above 30 °C and elevated minimum temperatures during fruit development significantly increased the probability of low-yield years, although higher maximum temperatures earlier in the growth period were linked to improved productivity. The positive association between counts of >30 °C days and low yield, combined with the experimental evidence of performance declines near +6 °C warming, indicates that both the intensity and persistence of temperatures above about 30 °C define critical stress thresholds for peach yield formation.

7.3 Low-temperature injury and recovery mechanisms

On the cold side, storage temperature tightly controls the onset of chilling injury (CI) symptoms and associated membrane damage. During postharvest storage, peaches kept at 4 °C rapidly developed CI, with enhanced expression of membrane lipid metabolism genes, accumulation of phosphatidic acid, and shifts in diacylglycerol and triacylglycerol profiles, whereas storage at 0 °C delayed CI by maintaining higher levels of phospholipids and promoting fatty acid desaturation and unsaturation. These findings indicate that, paradoxically, "moderate" low temperatures around 4 °C may be more injurious than near-freezing 0 °C, and that maintenance of unsaturated membrane lipids is a key protective mechanism at very low temperatures.

Pre-storage conditioning and acclimation treatments define additional functional thresholds for cold tolerance and recovery. Low temperature conditioning at 8 °C for 5 d before 0 °C storage increased ethylene production, accelerated softening, reduced internal browning, and led to higher fatty acid content, desaturation, and phospholipid levels compared with constant 0 °C storage (Song et al., 2022). Similarly, priming 'June Gold' fruit for 48 h at 20 °C before 40 d at 0 °C suppressed CI symptoms relative to fruit transferred directly to 0 °C, with distinct proteomic and metabolomic signatures indicating altered cold responses and a possible role for