which heat shock reduces photosynthesis more than transpiration, lowering carbon gain per unit water and contributing to yield losses under hot conditions.

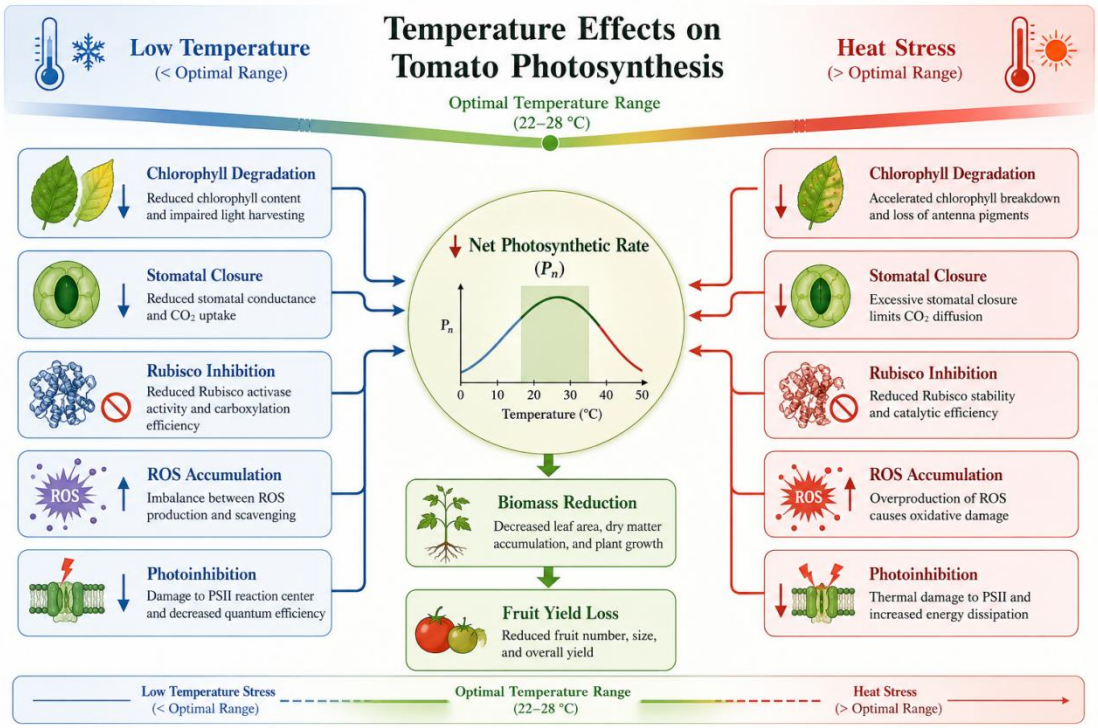


Figure 1 Conceptual diagram illustrating the effects of low and high temperature stress on tomato photosynthesis, photochemical efficiency, and yield formation

### 2.2 Effects of day/night temperature on flowering and fruit set

Tomato reproductive development is particularly sensitive to relatively small increases in mean day/night temperature. When day/night temperatures rose moderately from 28/22 °C to 32/26 °C, vegetative growth and photosynthesis remained largely unchanged, but fruit set, pollen viability and pollen release declined markedly, demonstrating that reproductive processes fail before canopy carbon assimilation under moderate heat (Sato et al., 2006). In controlled phytotron experiments across 20/24 to 27/37 °C night/day regimes, flowering and fruiting were normal at cooler treatments, but fruit set dropped sharply at 24/32 °C and nearly disappeared at 27/37 °C in most genotypes, underscoring the narrow thermal window for successful fertilization (Yadav et al., 2014).

Night temperature emerges as a key determinant of reproductive success. Work separating day and night effects shows that high night temperature (≥26 °C) at flowering is more detrimental to fruit set than a similar increase in day temperature, even when day temperature is already high. Earlier controlled-environment studies with 26 °C days and 18-26 °C nights reported that total and normal pollen production, seed content, and flower and fruit numbers on the first cluster were all higher at 18-22 °C nights than at 24-26 °C, although pollen germination in vitro could be favored at warmer nights, highlighting a complex trade-off between pollen formation and performance. Under fluctuating ambient day/night conditions in hydroponic summer production, early and late summer regimes with lower mean temperatures produced more flower clusters, fruits and higher yields than mid-summer regimes with warmer nights, again indicating that modest nocturnal warming can substantially depress reproductive efficiency and yield.

### 2.3 Heat and low-temperature stress mechanisms in greenhouse tomatoes

High temperatures in greenhouses trigger a cascade of morphological, physiological and reproductive disturbances that reduce yield and fruit quality. Reviews of tomato heat stress describe substantial flower abortion, up to about 80 % loss under severe episodes, along with impaired pollen viability and root growth, which together reduce fruit set and marketable yield (Alsamir et al., 2020). Experimental comparisons of high-temperature and