

Research Insight

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Effects of Temperature Regulation on Growth and Yield of Tomato

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Abstract Temperature is one of the most critical environmental factors regulating tomato (*Solanum lycopersicum* L.) growth, physiological processes, and yield formation. With the increasing frequency of extreme temperature events and the expansion of protected cultivation systems, effective temperature regulation has become essential for achieving stable and high-quality tomato production. This review summarizes the effects and mechanisms of temperature regulation on tomato growth, photosynthesis, reproductive development, fruit quality, and yield formation. Appropriate temperature management promotes seed germination, vegetative growth, root development, and biomass accumulation by optimizing plant metabolic activities and resource utilization efficiency. Temperature regulation also improves photosynthetic performance, antioxidant defense capacity, and nutrient metabolism, thereby enhancing plant adaptation to thermal stress. During reproductive growth, suitable temperature conditions facilitate flowering, pollen viability, fruit set, and fruit expansion, while temperature extremes can cause flower abortion, reduced fruit quality, and yield losses. Furthermore, this review discusses the physiological and molecular mechanisms involved in temperature responses, including hormonal regulation, heat shock proteins, cold-responsive pathways, and temperature-sensitive gene expression. A case study is presented to evaluate the practical effects of different temperature management strategies in greenhouse tomato production. Future research should focus on integrating intelligent environmental control systems, crop growth models, and multi-factor regulation approaches to develop precise and climate-resilient temperature management strategies for sustainable tomato production.

Keywords Temperature regulation; Tomato production; Growth and yield; Thermal stress; Greenhouse cultivation

1 Introduction

Tomato production depends strongly on temperature regulation because tomato is widely cultivated across open-field and greenhouse systems, yet its growth, reproductive success, and fruit quality decline when temperatures move beyond the crop's favorable range. Tomato is one of the world's most important horticultural crops, and rising temperatures are increasingly recognized as a major threat to its productivity under climate change (Luo et al., 2023; Graci and Barone, 2024). This sensitivity is agronomically important because tomato performs best within a relatively narrow thermal window: optimal growth has been placed broadly between 18°C-32°C, while optimal average day and night temperatures for reproductive performance are narrower, around 21°C-30°C and 18°C-21°C, respectively (Luo et al., 2023). As temperatures rise above or fall below these optima, the effects are expressed not only as general stress but also as direct constraints on flowering, fruit set, and marketable yield, making temperature regulation a central component of stable tomato production rather than a secondary environmental concern (Lee et al., 2022).

The importance of regulating temperature is further underscored by evidence that both heat stress and sub-optimal low temperature impair the formation of yield at multiple developmental stages. Temperature has a large effect on all aspects of tomato development, with declining temperatures reducing leaf and truss initiation rates, while sub-optimal conditions also reduce fruit set because of poorer pollen quality. At the high-temperature end, reproductive development is especially vulnerable: exposure above 32/20°C day/night during the reproductive phase reduces fruit set and fruit weight, and temperatures above 35°C can further suppress fruit set and delay normal fruit coloration (Miller et al., 2021; Vijayakumar et al., 2021). These responses explain why temperature regulation is not simply about maintaining vegetative growth, but about protecting the sequence of processes—from floral initiation to successful fertilization and fruit enlargement—that ultimately determines yield.