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Modeling the Effects of Temperature on Peach Fruit Yield and Quality

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Abstract Peach production is highly sensitive to variations in air temperature; as a critical climatic factor, temperature plays a pivotal role in the phenological development of peach trees, yield formation, and the regulation of fruit quality. Focusing on the mechanisms by which temperature influences peach yield and quality, this paper systematically analyzes its regulatory effects across different growth stages—specifically, the temperature response characteristics observed during bud break and flowering, fruit development, and the ripening process. Building upon this foundation, and by integrating meteorological data with orchard production records, a predictive model for peach yield and quality based on temperature indicators was constructed. This model places particular emphasis on incorporating variables such as accumulated temperature, extreme heat events, and seasonal temperature fluctuations, while employing a hybrid approach that combines statistical analysis with machine learning techniques for modeling and optimization. Through model performance evaluation and sensitivity analysis, key temperature thresholds and dominant factors influencing yield and quality were identified, thereby further elucidating the mechanisms by which heat stress and low-temperature impacts contribute to yield loss and quality deterioration. Case studies demonstrate that the developed model effectively predicts regional trends in peach yield and quality, exhibiting high applicability and stability. The findings of this study provide a theoretical basis for orchard temperature management, variety selection, and disaster risk management; furthermore, they offer technical support for the advancement of precision agriculture and intelligent decision-support systems, holding significant implications for enhancing the climate adaptability and production efficiency of the peach industry.
Keywords Peach yield prediction; Temperature stress; Fruit quality modeling; Growing degree days; Precision agriculture

1 Introduction

Temperature is a primary abiotic factor shaping peach growth, fruit set, and postharvest value, and its role is becoming more critical under ongoing climate change. Experimental warming studies with early- and low-chill cultivars show that moderate increases in temperature can accelerate development and, in some cases, enhance photosynthesis and fruit mass, whereas stronger warming reduces photosynthetic performance, floral bud differentiation, and subsequent yield (Lee et al., 2022). Temperature during fruit development also alters key quality traits-such as size, sweetness, coloration, and firmness-with high temperatures often hastening maturity but compromising desirable attributes like fruit weight and soluble solids content. These responses highlight the need to understand and predict how temperature regimes across seasons and regions translate into changes in both yield and fruit quality.

Despite extensive physiological and agronomic work, quantitative models linking temperature to integrated peach yield and quality outcomes remain limited. Process-based “virtual fruit” models capture fruit mass and sugar dynamics and are sensitive to environmental drivers, yet they often treat temperature only implicitly through generic weather terms rather than explicitly parameterizing its effects on growth and compositional traits. Recent climate-driven phenological and epidemiological models have projected climate-change impacts on peach blooming, disease pressure, and yield losses at national scales, but they primarily target phenology and disease, not detailed fruit quality responses (Lee et al., 2020). As a result, growers and breeders lack predictive tools that jointly represent how intra- and inter-seasonal temperature variability influences both quantitative yield and multiple quality dimensions.