

Research Insight

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Influence of Light Management on Fruit Quality and Sugar Accumulation in Strawberry

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Abstract Light is a critical environmental factor regulating strawberry growth, fruit development, and quality formation. With the expansion of protected cultivation systems, optimizing light management has become an effective strategy for improving fruit yield and enhancing nutritional and sensory attributes. This review summarizes recent advances in the effects of light intensity, photoperiod, light quality, and canopy light distribution on strawberry fruit quality and sugar accumulation. Light regulation influences photosynthetic carbon assimilation, carbohydrate transport, and source-sink relationships, thereby affecting the accumulation of soluble sugars, organic acids, anthocyanins, and flavor compounds. Artificial lighting technologies, particularly LED supplemental lighting, provide precise control of spectral composition and light dosage, promoting photosynthetic efficiency and improving fruit sweetness under low-light conditions. In addition, canopy management practices, including leaf removal, planting density optimization, and reflective mulching, enhance light interception and improve fruit uniformity. At the physiological and molecular levels, light signals regulate sugar metabolism-related enzymes, photosynthetic pathways, and hormone interactions through photoreceptors and transcriptional networks. Case studies demonstrate that optimized light environments can significantly enhance strawberry fruit quality in greenhouse production. Future research should focus on integrating intelligent sensing technologies, environmental modeling, and multi-factor regulation to establish precise and sustainable light management systems for high-quality strawberry production.

Keywords Strawberry; Light management; Fruit quality; Sugar accumulation; LED supplemental lighting

1 Introduction

Strawberry (*Fragaria* × *ananassa* Duch.) is one of the world's most important and widely consumed fruit crops, valued not only for its economic significance but also for its sensory and nutritional attributes, including sweetness, color, aroma, vitamins, fiber, and antioxidant compounds. Current production systems are under increasing pressure to deliver fruit that satisfies consumer expectations for appearance, flavor, firmness, and health-promoting value while remaining profitable under climate instability, pest pressure, and protected-cropping constraints. For this reason, improvement of fruit quality has become a central goal in strawberry research and industry, alongside yield stability and postharvest performance. Sweetness is especially important because it strongly influences consumer acceptance and marketability, yet it is a complex trait shaped by both genotype and environment. Recent advances in breeding and molecular research have improved understanding of quality-related traits, but practical crop-management tools are still needed to consistently enhance sweetness and overall fruit quality under commercial conditions (Hernández-Martínez et al., 2023).

Among environmental factors, light is one of the most decisive regulators of strawberry growth, flowering, ripening, and metabolite accumulation. Light does not act only as an energy source for photosynthesis; its intensity, duration, and spectral composition also function as developmental signals that influence plant architecture, floral induction, fruit coloration, sugar accumulation, and the synthesis of phenolics and other secondary metabolites. In strawberry, inadequate or suboptimal light conditions can reduce fruit quality, causing poor coloration and weaker accumulation of desirable compounds, whereas suitable light exposure promotes soluble sugars and anthocyanins in ripening fruit. Mechanistically, light-mediated quality formation is linked to regulation of photoreceptors and downstream transcriptional networks that control biosynthetic genes associated