

## Research Insight

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# Modeling Fruit Weight Formation in Watermelon Based on Environmental Factors

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**Abstract** Watermelon (*Citrullus lanatus*) fruit weight is a crucial indicator for assessing both yield and commercial value, and it is subject to the combined influence of various environmental factors. To elucidate the regulatory mechanisms by which environmental factors govern watermelon fruit weight formation, this study—grounded in the biological processes of fruit development—systematically analyzed the impact patterns of key environmental variables (including temperature, light, water, and soil nutrients) on fruit expansion and dry matter accumulation. Building upon this foundation, field experiments were conducted across multiple environmental settings to acquire data on watermelon fruit weight and related growth parameters; subsequently, utilizing a combination of statistical analysis and modeling techniques, a fruit weight formation model applicable to diverse cultivation conditions was constructed. The model was further employed to simulate and validate watermelon fruit weights under various ecological environments; the results demonstrated that the model possesses high predictive accuracy and stability, effectively capturing the dynamic responses of fruit weight formation to fluctuations in environmental factors. Furthermore, through case studies, the potential applications of the model in irrigation scheduling, fertilization management, and the optimization of controlled-environment cultivation systems were explored. The findings of this study provide a theoretical basis and technical support for achieving high-yield, high-quality watermelon cultivation, while also offering a valuable reference for the broader application and extension of fruit development models within the field of horticultural crops.

**Keywords** Watermelon (*Citrullus lanatus*); Fruit weight formation; Environmental factors; Model construction; Fruit development

## 1 Introduction

Watermelon is a major horticultural crop worldwide, valued for its large, fleshy fruits and high consumer demand, with millions of hectares under cultivation and China as the largest producer (Gao et al., 2023). Fruit size and weight are central components of yield and directly influence growers' income and market competitiveness. Industry-oriented studies and cultivar evaluations routinely use average fruit weight, fruit size distribution, and total yield as core performance indices, underlining fruit weight as a pivotal target for breeding, grafting, and agronomic management in commercial production systems (Jordana et al., 2023).

Beyond simple count of fruits, multiple analyses show that increases in total yield often arise mainly from higher average fruit weight rather than fruit number. Systematic review of grafted versus nongrafted watermelon demonstrates that grafting can raise total yield and average fruit weight by more than 10%-20%, highlighting fruit weight as the primary yield driver under diverse production conditions (Jordana et al., 2023). Field trials in different regions and seasons similarly evaluate cultivars and management practices using fruit weight, length, width, and fruit weight per plant, confirming their central role in rating economic performance and recommending cultivars to growers (Kumari et al., 2025). Management strategies such as optimizing flower retention or adjusting nitrogen and boron nutrition are explicitly aimed at maximizing individual fruit size and weight to achieve superior yield and quality (Gülüt, 2021).

At the biological level, fruit weight formation is determined by coordinated phases of cell division and cell expansion during early and mid-development. Early work on watermelon showed that after flowering, pollinated and hormone-induced parthenocarpic fruits undergo active cell proliferation in pericarp and ovule tissues, whereas