

Research Perspective

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Controlled Environment Techniques for Year-Round High-Quality Strawberry Production

Guojia Ni ✉

Jinhua Yudi Family Farm Co., Ltd., Jinhua, 321000, Zhejiang, China

✉ Corresponding author: 290863775@qq.comInternational Journal of Horticulture, 2026, Vol.16, No.1 doi: [10.5376/ijh.2026.16.0004](https://doi.org/10.5376/ijh.2026.16.0004)

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Abstract This study systematically summarizes and analyzes the key environmental factors and precise control technology paths for achieving high-quality year-round production of strawberries, including environmental factors such as temperature, light, humidity, carbon dioxide concentration and nutrient supply. The study found that reasonable day-night temperature difference (18 °C-25 °C), precise lighting measures (such as LED light source to control the ratio of red and blue light), humidity (60%-80%) and carbon dioxide concentration optimization and precise substrate nutrient management have significant effects on improving strawberry yield and fruit quality. Typical cases show that in different regions such as temperate and subtropical zones, efficient year-round high-quality cultivation of strawberries can be achieved through the comprehensive application of facility cultivation and intelligent environmental control systems. In addition, the integration of facility intelligence and green energy systems, and the integration of smart agricultural management technologies of AI and big data will further improve the economic and ecological benefits of year-round strawberry production. This study provides important theoretical support and technical paths for promoting the transformation of the strawberry industry from traditional cultivation to a year-round efficient, stable and environmentally friendly production model.

Keywords Strawberry; Year-round cultivation; Environmental control; Facility agriculture; Smart agriculture

1 Introduction

Strawberry (*Fragaria* × *ananassa*) is one of the most valuable horticultural crops in the world, and is widely favored for its unique flavor, rich nutrition and outstanding economic value. As the demand for high-quality strawberries continues to rise throughout the year, planting systems and environmental control strategies are also constantly innovating.

The worldwide strawberry sector is undergoing a significant shift from focusing solely on yield to equally valuing both quality and productivity. Advances in breeding methods, improvements in cultivation practices, and the growing adoption of climate-controlled farming have all contributed to robust development in strawberry production. Growing techniques have evolved beyond conventional outdoor farming to incorporate various smart greenhouse setups, strengthening the industry's resilience while overcoming natural weather and geographical constraints. Rising consumer expectations for premium, distinctive-flavored strawberries are fueling innovation in both research and farming applications. Currently, parallel progress in genetic enhancement and precision growing techniques has endowed strawberries with wide environmental tolerance and strong market competitiveness, reinforcing their strategic importance and economic worth in contemporary agriculture (Mezzetti et al., 2018; Hernández-Martínez et al., 2023; Kouloumprouka Zacharaki et al., 2024).

Faced with the structural demand changes brought about by consumption upgrades, consumers are increasingly eager for sustainable, localized, high-quality fresh fruits throughout the year, which in turn puts forward more stringent requirements on the production side. At present, producers need to deal with multiple challenges, including precise control of light, temperature and humidity, and build intensive pest and disease control mechanisms and efficient water and fertilizer utilization models. To meet the above needs, modern planting facilities are constantly emerging, including fully functional smart greenhouses, high-coverage facility arch sheds,