

Special focus should be given to controlling root zone temperature. Research indicates that keeping roots slightly cool helps flower development while boosting overall plant growth and improving adaptation to environmental shifts (Sakamoto et al., 2016). During unfavorable weather, proper watering and shade can effectively minimize stress and maintain steady plant development (Cordoba-Novoa et al., 2022).

The transition from vegetative growth to reproductive growth in strawberries is strictly regulated by environmental factors. Short days and cool temperatures usually induce flower bud differentiation, while long days and high temperatures are more conducive to the germination of vegetative runners (Koskela and Hytönen, 2018). The photoperiod after flowering also affects fruit development and quality: short days may inhibit flower bud differentiation and fruit development, resulting in deformed fruits; long days help plants enhance photosynthesis and accumulate more nutrients, thereby improving fruit quality (Figure 2) (Ren et al., 2024). The physiological processes behind these growth transitions are also affected by both genetic factors and hormonal regulation - this also ensures the feasibility of year-round production through environmental regulation (Koskela and Hytönen, 2018; Chen et al., 2023).



Figure 2 Effects of different photoperiod treatments on the first inflorescence of strawberry fruit appearance (Adopted from Ren et al., 2024)

2.2 Variety requirements and selection criteria for year-round production

Modern strawberry cultivars are mainly divided into two types: photoperiod-insensitive (day-neutral) varieties and short-day varieties. Day-neutral varieties can achieve year-round continuous production under environmentally controlled conditions because their flowering and fruiting are not restricted by a specific photoperiod (Rivero et al., 2022). In contrast, the reproductive development of short-day varieties strictly depends on specific light and temperature conditions. If the environment is not properly regulated, it will be difficult to achieve off-season cultivation (Koskela and Hytönen, 2018).

For year-round production, choosing suitable varieties is crucial, considering their light requirements, consistent yields, and market quality. Day-neutral types adapt well to various conditions with stable outputs, whereas short-day varieties, though producing superior fruit in ideal settings, struggle with environmental changes (Koskela and Hytönen, 2018; Rivero et al., 2022). Different cultivars also react distinctly to control methods like LED lights, root cooling, and humidity adjustments, directly impacting both yield and fruit quality in controlled environments (Sakamoto et al., 2016; Rivero et al., 2022; Ren et al., 2024).

3 Technical Approaches to Regulating Environmental Factors in Strawberry Cultivation

3.1 Temperature control technology

Temperature plays a central role in strawberry development, directly influencing plant metabolism, final yields, and fruit quality. Research confirms most strawberry varieties grow best between 18 °C-25 °C. Certain high-performing types achieve optimal results with daytime temperatures of 20.5 °C-27.4 °C combined with slightly cooler nights (Tang et al., 2020; Sugiyanto and Kasih, 2024). Keeping temperatures within these ranges supports healthy plant functions, encourages flowering, and enhances fruit appearance. Proper temperature management helps overcome seasonal limitations while balancing quality and productivity.