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Effects of Rain Shelter Cultivation on Cherry Fruit Cracking and Quality

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Abstract Sweet cherry (*Prunus avium* L.), as a high-value fruit crop, has long been constrained by rain-induced fruit cracking, while fruit quality is highly dependent on canopy microenvironment and cultivation practices. This study focuses on rain-shelter cultivation systems and systematically analyzes the integrated mechanisms by which canopy structure, rainfall exposure, water relations, and light distribution influence fruit cracking and quality formation. Fruit cracking is mainly driven by factors such as skin structural properties, water absorption processes on the fruit surface, and the duration of surface wetness. Meanwhile, canopy structure significantly affects cracking risk by regulating rainfall interception, ventilation conditions, and fruit spatial distribution. Planar and well-ventilated canopy architectures help reduce fruit wetting duration and lower the incidence of cracking. Although rain-shelter facilities can effectively block precipitation, they also alter microenvironmental conditions such as light, temperature, and humidity. By properly configuring canopy architecture, optimizing pruning and fruiting zone management, and integrating scientific water and nutrient regulation, it is possible to reduce cracking risk while maintaining or improving fruit market quality. This study provides a systematic theoretical basis and integrated management strategies for efficient sweet cherry production in rainy regions.

Keywords Sweet cherry; Fruit cracking; Rain-shelter cultivation; Canopy structure; Fruit quality

1 Introduction

Sweet cherry (*Prunus avium* L.) is one of the most economically valuable temperate fruit crops. It is widely favored for its bright appearance, unique flavor, and rich content of bioactive compounds such as anthocyanins, vitamins, and minerals (Correia et al., 2018). The market price of sweet cherries largely depends on fruit appearance and firmness, so it is considered a high-value crop, and even slight quality deterioration can lead to significant economic losses for growers (Toivonen and Manganaris, 2020).

Commercial cherry production is seriously limited by rain-induced fruit cracking, which is widely regarded as one of the most important agronomic problems in sweet cherry production (Knoche and Winkler, 2017). Cracking usually occurs from the early coloring stage to full maturity, and it becomes more severe when rainfall or prolonged surface wetness coincides with fruit ripening. Under unfavorable conditions, losses can exceed 80% (Quero-García et al., 2021). Cracked fruits not only quickly lose market value due to damaged appearance, but are also more susceptible to fungal decay, and their storability and shelf life are significantly reduced (Xu et al., 2025). This phenomenon is highly complex, involving multiple factors such as cultivar differences, skin characteristics, fruit size, water relations, and surface wetness (Knoche, 2019).

Fruit quality traits of sweet cherry-including color, firmness, sugar and acid content, and bioactive compounds-are highly sensitive to canopy microclimate and cultivation practices (Mineață et al., 2024). Rain protection facilities, such as plastic covers, high tunnels, and rain shelters, can effectively reduce direct contact between rainwater and fruit, thereby significantly lowering cracking incidence in most cases (Suran et al., 2019). However, these facilities also change light, temperature, and humidity conditions within the canopy, typically reducing solar radiation by 40%~60% and altering air temperature and relative humidity (Blanco et al., 2021). These changes may negatively affect fruit coloration, firmness, soluble solids content, and pigment accumulation (Muñoz-Alarcón et al., 2025). In contrast, some complementary measures, such as reflective ground mulches or the application of biostimulants, have been shown to improve or make fruit color, firmness, and sugar content more uniform under covered conditions (Afonso et al., 2024).