

Research Insight

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Effects of Planting Density on Plant Architecture, Fruit Setting and Yield Performance of Tomato

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Abstract Planting density is an important cultivation factor affecting tomato plant architecture, fruit set characteristics, and yield performance. This study analyzed the effects of planting density on tomato population structure, reproductive characteristics, and yield formation. Previous studies showed that planting density regulated tomato canopy development by influencing plant height, internode length, stem diameter, leaf area index, and canopy light distribution. Moderate increases in planting density generally improved light interception per unit area and land-use efficiency, whereas excessive density intensified plant competition, resulting in reduced biomass accumulation per plant, canopy closure, and decreased photosynthetic efficiency. During the reproductive growth stage, an appropriate planting density maintained the balance between vegetative and reproductive growth, maintained favorable fruit set, and enhanced fruit development. However, excessive planting density increased the risk of flower and fruit abortion due to insufficient assimilate supply and negatively affected fruit quality. In terms of yield formation, planting density regulated yield per unit area by balancing individual plant productivity and population productivity. Future tomato density management should integrate cultivar characteristics, environmental conditions, and cultivation practices, and utilize canopy monitoring, modeling prediction, and intelligent regulation technologies to achieve dynamic and precise density management. This study provides a theoretical basis for efficient tomato cultivation, population structure optimization, and precision production in protected agriculture.

Keywords Planting density; Tomato; Plant architecture; Fruit set characteristics; Yield formation

1 Introduction

Tomato production depends strongly on planting density regulation because density determines how efficiently a crop captures light, water, nutrients, and cultivation space, while also shaping fruit yield, fruit quality, and economic return. Tomato is a major crop for fresh and processing markets worldwide, and growers increasingly seek management practices that raise productivity per unit area without compromising marketability (Caradonia et al., 2023; Francesca et al., 2026). Across production systems, planting density is recognized as a core agronomic factor because excessive crowding intensifies intraspecific competition for solar radiation, water, nutrients, and physical space, whereas overly sparse stands underuse the available land area (Sievidov and Sievidov, 2020; Ayarna et al., 2021). Proper density selection can optimize light interception, improve resource-use efficiency, and increase water productivity, which is especially important in greenhouse, high-tunnel, hydroponic, and organic systems where input costs are high and production efficiency is critical (Chau and Chinh, 2021; Torres-Quezada and Gandini-Taveras, 2023). At the same time, density management also affects canopy microclimate, including shading and relative humidity, with implications for disease pressure, fruit health, and the use of plant protection inputs (Ansari et al., 2017).

The importance of density control is further reinforced by the physiological responses that tomato plants show when neighboring plants are close. Competition can begin as soon as plants detect proximity signals such as reduced light intensity, altered red:far-red balance, and leaf contact, which trigger shifts in morphology and assimilate partitioning even before severe resource depletion occurs (Karpe et al., 2024). Under dense canopies, tomato plants often express shade-avoidance traits and low-light adaptations, including stem or internode elongation, higher slenderness, thinner leaves, and increased senescence, all of which can alter plant architecture