

The density that maximizes population yield varies substantially with system and genotype (Figure 1) (Dinh and Dang, 2023). In soilless greenhouse culture, increasing density to 3.5 plants/m² raised yield per square meter in all three cultivars tested. In a spring film greenhouse, the indeterminate hybrid Tobolsk F1 reached its maximum yield of 15.8 kg/m² at 3.5 plants/m² (Sievidov and Sievidov, 2020). In Brazilian processing tomato, yield responses were hybrid-specific: CVR-2909 and N-901 responded positively or quadratically to denser stands up to 40 000 plants/ha, whereas U-2006 did not respond across 20 000–40 000 plants/ha (Evangelista et al., 2025). In contrast, one field study on indeterminate tomato found that increasing density reduced marketable and total yield per plant but did not affect yield per hectare, and the lowest density without pruning tended to be most economical (Maboko and Du Plooy, 2018).



Figure 1 Relationship between sowing densities and plant parameters (Adopted from Dinh and Dang, 2023)

Image caption: a) a sowing density of 50 000 plants/ha and b) a sowing density of 33 000 plants/ha (Adopted from Dinh and Dang, 2023)

4.2 Effects on yield components

Planting density changes yield through its effects on fruit number, fruit size, and mean fruit weight, and these components usually move in opposite directions (Cardoso et al., 2018). Higher density often lowers fruit number per plant and average fruit weight while increasing fruit number per unit area (Maboko and Du Plooy, 2018; Caradonia et al., 2023; Karpe et al., 2024). In the Golestan soilless study, fruit yield per m² correlated strongly and positively with number of fruits per plant but negatively with average fruit weight, showing that total yield gains under denser stands are driven more by fruit number than by fruit enlargement. In the Ukraine greenhouse study, fruit size and the yield of standard fruits declined as plant density increased, even though total yield still increased to an optimum (Sievidov and Sievidov, 2020). The same inverse pattern appears in broader review evidence: decreasing density tends to increase fruit size, whereas increasing density raises total yield only up to a threshold (Haque and Sakimin, 2022).

Several experiments quantify these component shifts under different management contexts. In hydroponic tomato, the highest total yield, 22.61 kg/m², occurred at 11.1 plants/m² with two bunches per plant, confirming that density interacts with pruning and truss number in determining sink load (Cardoso et al., 2018). Earlier processing-tomato work showed that low densities produced the most fruits per plant, but the highest process-fruit yield, 42.5 tons/acre, occurred at 78 408 plants/acre because fruit size remained relatively uniform and the larger plant population compensated for lower plant productivity. That study also found that densities of at least 9 801 plants/acre were needed to reach 30 tons/acre and that wider spacing increased sunburn and sunscald culls because reduced canopy cover exposed more fruits. More recent open-field optimization found an optimum near 45 830 plants/ha, with no significant differences in fruit weight per plant or fruit diameter across densities, underscoring that the dominant yield component can differ by cultivar and environment (Dinh and Dang, 2023).