

4.3 Mechanisms of tomato yield formation under density regulation

The main mechanisms linking density regulation to tomato yield are light interception, leaf area index, dry matter production, and the balance between source supply and sink demand (Higashide, 2022). Total dry matter production is determined by intercepted light, and planting density changes yield chiefly by altering canopy light capture per unit ground area rather than by simply changing the efficiency of individual plants. In controlled tomato canopies, higher density increased plant dry weight per area and intercepted light, but whole-plant dry weight eventually saturated under constant high density, indicating diminishing returns once assimilate availability per plant becomes limiting (Karpe et al., 2024). Modeling and review work likewise identify LAI as a key control point: light interception depends on LAI and canopy extinction, simulated growth is highly sensitive to LAI, and optimal yield requires an LAI matched to solar radiation and crop stage (Figure 2) (Higashide, 2022).

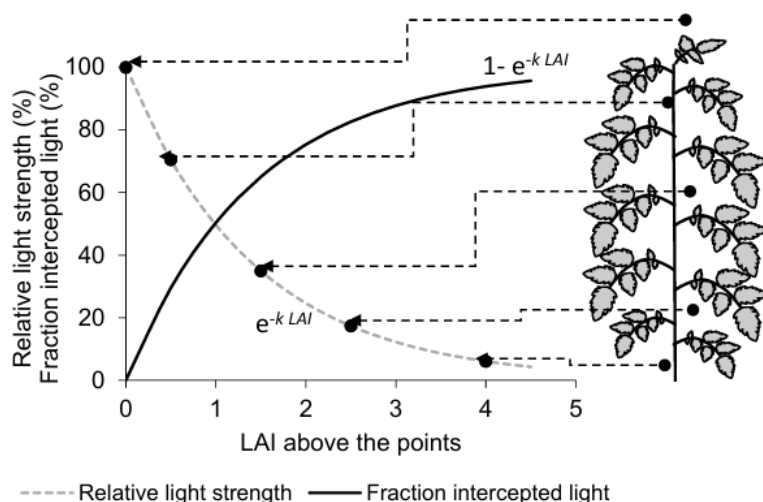


Figure 2 Relative light strength and intercepted light in a plant canopy as a function of leaf area index (LAI) at a light extinction coefficient (k) of 0.75 (Adopted from Higashide, 2022)

Density also regulates yield through dry matter partitioning and fruit sink strength, but the evidence suggests that partitioning responds more to fruit load than to density alone. Under constant high density, dry matter partitioned to fruits was slightly higher, yet fruit number per plant was lower and distal flowers were preferentially aborted, implying stronger sink demand in the remaining fruits but poorer fruit set under local assimilate shortage (Karpe et al., 2024). A classic quantitative analysis similarly found that assimilate supply altered by plant density had no direct influence on dry matter partitioning, whereas partitioning was strongly influenced by the number of fruits on the plant. Independent evidence from branching and light manipulation supports this interpretation: reduced yield can arise from smaller fruit size because of lower fruit sink strength, not necessarily because carbohydrate supply is limiting (Paponov et al., 2023). Under stress, these mechanisms shift further, since high density increased yield per hectare in the field but reduced yield per plant when combined with drought, showing that the outcome of density regulation depends on how canopy light capture interacts with water limitation (Francesca et al., 2026).

5 Optimization of Suitable Planting Density under Different Cultivation Systems

5.1 Differences in density requirements among tomato varieties

Tomato varieties differ in their density requirements because plant architecture, vigor, and sink capacity change how effectively a canopy converts added plants into added yield. In industrial processing tomato, hybrid responses were not uniform: CVR-2909 and N-901 showed quadratic or positive yield responses to increasing density, whereas U-2006 showed little response between 20 000 and 40 000 plants/ha. The weak density response of U-2006 was attributed to its smaller, more compact habit and probably lower leaf area index and light interception (Evangelista et al., 2025). In contrast, greenhouse hydroponic hybrids Dafnis, Izmono, and Hirad all produced their highest yield per square meter at 3.5 plants/m², but the size of the gain differed among cultivars, indicating shared direction but cultivar-specific magnitude.