

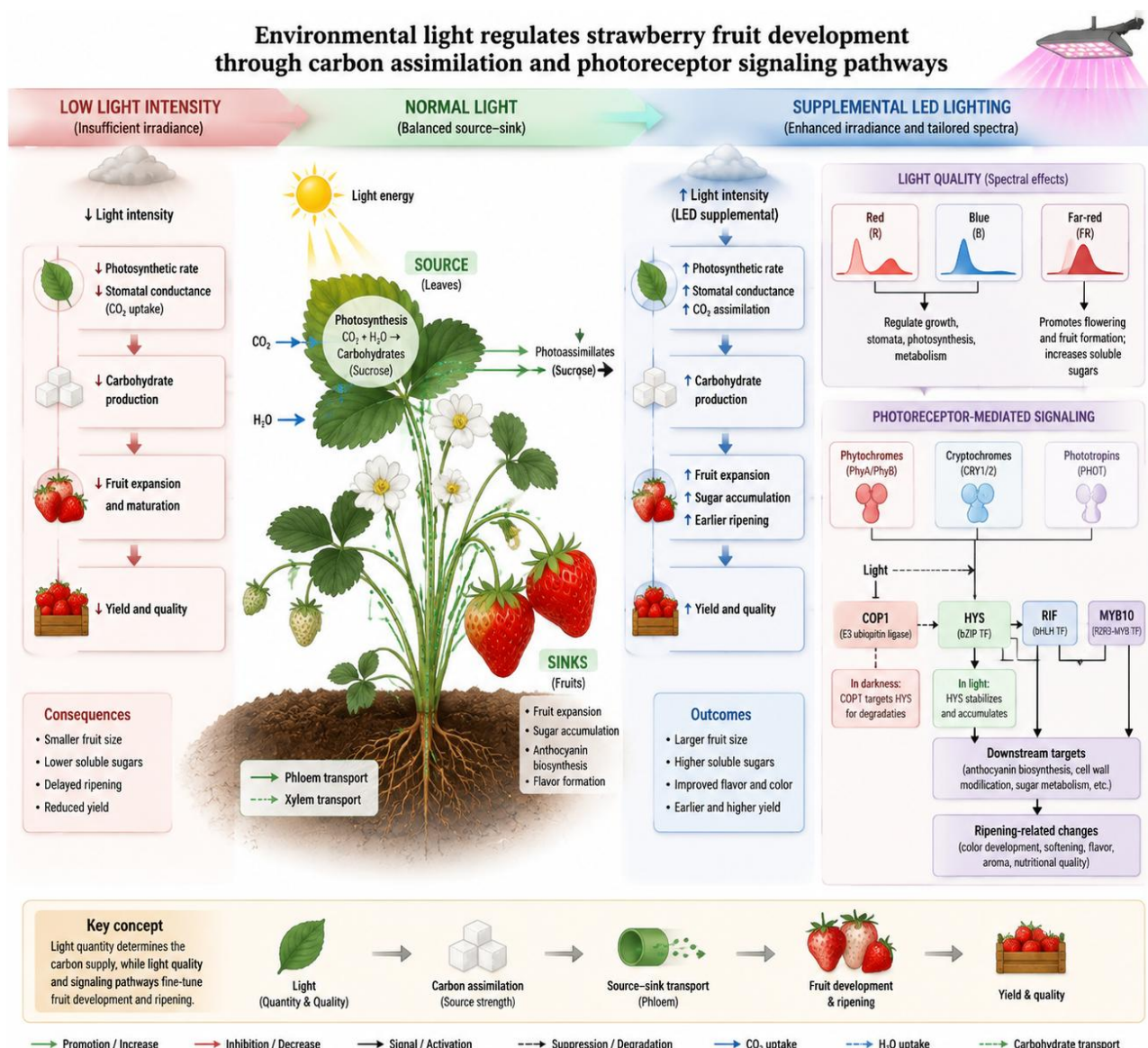


Figure 1 Mechanistic framework illustrating how light quantity and quality regulate strawberry fruit growth, carbon allocation, and ripening processes

Light management also modifies fruit growth indirectly by changing source-sink balance under greenhouse stress or resource limitation. Supplemental light combined with elevated CO₂ increases yield across the production season and improves sweetness, supporting the view that fruit development responds strongly when carbon acquisition is simultaneously enhanced by atmospheric and radiative inputs (Qiu et al., 2023). Similarly, under full or deficit irrigation, supplemental light improves fruit size and elevates quality-related metabolites, indicating that light can partially buffer suboptimal water conditions during fruit development (Xu et al., 2023).

Recent synthesis work indicates that light effects on fruit growth are stage-specific rather than uniform across the crop cycle. Phase-specific strategies that adjust spectral composition from vegetative growth to flowering and maturation appear to improve quality formation more effectively than static lighting, because the developmental roles of light differ across fruit set, enlargement, and ripening (Warner et al., 2021; Wang et al., 2025). This helps explain why responses vary across cultivars and experiments: light acts through interacting effects of wavelength, developmental stage, and preharvest versus postharvest exposure rather than through a single universal mechanism (Warner et al., 2021).