

studies likewise show that compost, PGPR, and AMF alleviated drought-induced growth inhibition and increased shoot biomass and fruit yield, while broader synthesis indicates that integrated organic and inorganic fertilization improves water and nutrient uptake and enhances drought tolerance in a cost-effective way (Kazemalilou et al., 2021). For *R. chingii*, this evidence supports testing integrated water-fertilizer schemes as a practical route to improve vegetative growth, biomass accumulation, and resilience, thereby laying the physiological foundation for stable fruit yield and quality.

3 Water-Fertilizer Effects on *Rubus chingii* Yield Formation

3.1 Effects of irrigation methods and water supply on fruit yield formation

Irrigation method and water supply level directly affect fruit yield formation by changing fruit number, single-fruit mass, and the duration of effective fruit filling. In red raspberry, irrigation at 75% ETc produced the highest yield and fruit number, exceeding both the farmer's higher irrigation level and the more severe deficit treatment, which shows that moderate irrigation can support stronger reproductive output than excessive watering. The same raspberry study found that 50% ETc gave the highest water productivity but not the highest yield, indicating that maximizing yield and maximizing water productivity are not identical goals. A later raspberry field study similarly showed that full irrigation at 100% ETc maximized yield per florican and per meter of trellis, while stronger deficits reduced productivity, especially in cultivars sensitive to water shortage (Andelić et al., 2025).

Irrigation pattern also matters, not only total water volume. In red raspberry under drip irrigation, pulse irrigation improved soil water availability and increased fruit production by 1 210~1 230 kg/ha in later harvest periods, with the gain arising mainly from larger fruit in one season and more berries per plant in another (Carroll et al., 2024). In strawberry, fixed partial root-zone drying generally outperformed traditional deficit irrigation, and F-PRD80 maintained yields statistically similar to full irrigation while using less water, whereas stronger water deficits clearly reduced yield and yield-related traits (Kaman et al., 2023). Mango showed the same overall pattern: irrigation amount was the most important factor affecting fruit yield and water-use efficiency, and severe drought constrained production, whereas a moderate deficit could improve comprehensive benefit when aligned with stage-specific fertilization (Sun et al., 2022). For *R. chingii*, these results support the view that fruit yield formation is favored by moderate, stable, and development-matched water supply, while both over-irrigation and excessive deficit can weaken fruit set or limit fruit enlargement.

3.2 Effects of different fertilization strategies on fruit-setting capacity and yield components

Different fertilization strategies influence yield mainly through their effects on fruit-setting rate, fruit number, and single-fruit weight, and the response is usually strongest under balanced rather than maximal NPK input. In Chinese cherry, NPK fertilization increased vegetative growth and positively affected fruit weight, fruit size, internal quality, and fruit set rate, with one intermediate combination giving the best overall fruit set and size rather than the highest nutrient dose. Fruit set rate in cherry was also positively correlated with fruit weight, vertical diameter, and soluble sugars, indicating that reproductive success and fruit filling were regulated together (Guo et al., 2022). In blueberry, fertilization significantly increased yield relative to the unfertilized control, and the best treatment raised yield per plant by 79.26%, while phosphorus and potassium showed particularly strong influence on fruit weight and yield ranking (Zhang et al., 2023).

Fertilizer timing is as important as fertilizer ratio. In peach, NPK supply from 95-65-76 to 165-84-103 kg/ha produced the highest yields, especially when nitrogen supply was high during flowering and fruit set, while higher N and K during fruit development and ripening improved fruit weight and size. In custard apple, split application of N, P, and K across basal, fruit-set, fruit-enlargement, and pre-harvest stages increased fruit yield by 23% and also gave the highest fruit number and fruit weight (Palepad et al., 2025). More broadly, farmers manage water and fertilization because they are the main levers for obtaining economic yield and fruit quality, but the evidence across fruit crops shows that excessive or poorly staged fertilization is less effective than balanced, growth-stage-specific nutrient supply (Maatallah et al., 2024). For *R. chingii*, whose fruits are valued for both medicinal and edible uses, this implies that rational N, P, and K scheduling should improve fruit-setting capacity and yield components while avoiding nutrient waste (Sheng et al., 2020; He et al., 2023; Wu et al., 2024).