

al., 2022). Deficit irrigation and partial root-zone drying can save 48%-52% of water. Although yield losses are approximately 25%, water productivity is improved, making these strategies highly attractive in areas facing severe water scarcity. A study in Tunisia using saline drip irrigation found that deficit irrigation at 50% ET_c and PRD50 produced similar results, with yield reductions of 20%-25%. However, long-term soil salinity remained stable, and significant water savings were achieved, supporting the application of these practices in arid and salinized environments (Toumi et al., 2024).

5 Interaction Between Nutrition and Irrigation

5.1 Water–nutrient coupling mechanisms

Soil moisture is fundamental because nutrients are dissolved in water and transported with soil solution flow to the root surface, where they can be absorbed by trees. In sandy, coarse-textured soils typical of many peach orchards, improving soil moisture in the root zone increases water availability and also enhances solubility and accessibility of nitrogen, phosphate, and potassium (Hamza et al., 2025). Under drip irrigation, higher soil moisture near emitters supports better root function and fertilizer uptake, while drier zones between emitters limit nutrient movement and uptake.

Different irrigation regimes alter nutrient availability and use efficiency. In arid sandy soils, irrigation with magnetized water increased root-zone moisture, improved soil chemical properties, and led to higher nitrogen, phosphorus and potassium use efficiencies compared with non-magnetized water, indicating more effective fertilizer uptake under improved water conditions (Hamza et al., 2025). Supplemental irrigation in young peach orchards increases vegetative growth and total nitrogen removal compared with non-irrigated trees, reflecting higher biomass and nutrient uptake under better water supply (Casamali et al., 2021b).

5.2 Fertigation technology in peach production

Fertigation—applying water-soluble fertilizers through drip systems—directly integrates fertilization and irrigation in the active root zone (Figure 2). Drip irrigation is highlighted as highly efficient in delivering water to roots and enabling precise fertigation that matches crop needs, reducing leaching losses and improving nutrient use efficiency and yield compared with conventional methods (Sharma et al., 2024). Meta-analysis across Chinese crops shows drip fertigation increases yield by about 12%, water productivity by 26%, and nitrogen use efficiency by 34% compared with traditional surface irrigation plus broadcast fertilization, while reducing evapotranspiration (Li et al., 2021).

Optimizing fertilizer concentration and irrigation frequency under drip fertigation is essential to balance high yield with minimal nutrient losses. A review of nitrogen losses under drip systems identifies soil moisture, fertigation, and irrigation regime as core factors controlling nitrate leaching and gaseous losses, and notes a shift from focusing only on application amounts to integrated management of rates, methods, and timing (Wei et al., 2024). In intensive fruit orchards, drip fertigation combined with plant hedgerows reduced total nitrogen and phosphorus runoff losses by about 45% and 37% compared with conventional fertilization, while maintaining high fruit yields, showing that concentrating nutrients in the wetted root zone and using vegetative barriers can both improve efficiency and reduce pollution (Song et al., 2023).

5.3 Effects on yield and fruit quality

Interactions between irrigation and nutrition influence fruit size, weight, and yield per tree. Soil applications of nitrogen, potassium, and calcium in a drip-irrigated sandy peach orchard increased yield and fruit weight versus unfertilized controls; the best macronutrient combination nearly tripled yield from about 37-40 kg to 97-104 kg per tree (Ali et al., 2019a). Mild deficit irrigation (75% ET_c) in semi-arid China maintained total yield equal to full irrigation (100% ET_c) but produced fewer, larger fruits, effectively shifting assimilates to remaining fruit under limited water (Zhou et al., 2017). Under stronger deficit irrigation in arid Tunisia, yields were not reported, but deficit strategies (DI and PRD) at 50% ET_c improved internal quality traits and increased mineral concentrations in fruits, suggesting more concentrated uptake and allocation of nutrients under reduced water (Toumi et al., 2022).