7.2 Integration of potassium fertilization with irrigation management

Potassium use efficiency is highly dependent on soil water conditions. In citrus orchards, potassium is prone to leaching losses, while water deficits and irregular rainfall patterns can alter potassium uptake processes and influence the occurrence of physiological disorders in fruits. A two-year citrus field experiment showed that maintaining 70% soil moisture combined with alginate oligosaccharide application increased yield by 11.93%-13.31%, total soluble sugar content by 15.16%-17.47%, sucrose content by 18.92%-20.81%, fruit potassium concentration by 51.09%-62.21%, and water use efficiency by 12.01%-13.34%. This treatment performed better than both higher and lower irrigation regimes (Li et al., 2024). The same treatment also enhanced net photosynthetic rate and root growth, increased available potassium content in the 0-20 cm soil layer, and reduced potassium movement into deeper soil layers, indicating that suitable soil moisture conditions improve potassium retention in soil and enhance plant potassium utilization.

Similar conclusions were reported by Stagno et al. (2024) in a deficit irrigation study on orange trees. Water-saving irrigation strategies reduced irrigation volume by 25%-49% without reducing yield, while improving water use efficiency and maintaining generally adequate mineral nutrition levels. However, leaf potassium concentrations under these treatments were often below the recommended range. These irrigation regimes also increased fruit vitamin C content, pulp coloration, and sugar concentration, suggesting that moderate water regulation can work synergistically with potassium management to improve fruit quality.

In citrus production, drip fertigation improves fruit TSS and juice percentage, enhances nitrogen, phosphorus, and potassium uptake, and reduces nitrogen and potassium losses through leaching and runoff compared with conventional fertilizer application methods such as broadcasting, hole application, or irrigation-based fertilizer delivery. Ma et al. (2022) found that drip fertigation could still promote citrus growth and development even with a 60% reduction in fertilizer input, indicating substantial potential for improving potassium use efficiency while reducing total fertilizer consumption. Monitoring results from mobile lysimeters in Moroccan citrus orchards further demonstrated that nutrient concentrations in soil solutions fluctuate significantly with irrigation amount, fertilizer input, and soil conditions. Therefore, water and fertilizer management based on real-time monitoring is more effective than fixed fertilization schedules (Zayani et al., 2024).

7.3 Application of precision potassium management in citrus orchards

Precision potassium management requires integration of soil testing and leaf nutrient diagnosis. Ahmad et al. (2022) conducted field investigations in calcareous citrus soils and found that soil potassium concentrations at different soil depths were generally at moderate levels, while deficiencies of nitrogen and micronutrients in leaves were widespread. This indicated that soil fertilization alone may not fully satisfy tree nutrient requirements, and foliar fertilization should be incorporated to improve orchard nutritional status. In recent years, boundary line analysis based on commercial orchard data has provided more accurate reference ranges. The study estimated that suitable potassium concentrations for citrus orchards were 161.4-326.0 mg/dm^3 in soil and 7.8-11.3 g/kg in leaves, which can serve as practical guidelines for precision potassium fertilization recommendations (Lima Neto et al., 2025).

Precision fertilization strategies also need to be adjusted according to cultivar characteristics and developmental stages. In Clementine mandarin orchards, the fertilization requirements of the cultivars ‘Nour’, ‘Orogrande’, and ‘Nules’ differed, and monthly leaf nutrient diagnosis indicated that potassium should be supplemented in a timely manner before and during fruit growth and ripening stages (Zayani et al., 2024). In ‘Magallanes’ pomelo, key growth periods were mainly concentrated in May and August, while April represented the peak period for flowering and fruit set. The two months after fruit set were identified as a critical developmental stage, suggesting that potassium supply should be synchronized with these key physiological periods (Magbalot-Fernandez and Guzman, 2019). This study further showed that potassium application rates recommended based on soil analysis promoted canopy growth, whereas higher potassium inputs further increased flowering intensity, fruit set, fruit