International Journal of Horticulture, 2026, Vol.16, No.4, 251-268
http://hortherbpublisher.com/index.php/ijh

Research Insight Open Access

Effects of Potassium Fertilization on Fruit Size, Sugar Accumulation, and Quality of Citrus

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International Journal of Horticulture, 2026, Vol.16, No.4 doi: 10.5376/ijh.2026.16.0022
Received: 06 Jul., 2026
Accepted: 12 Aug., 2026
Published: 28 Aug., 2026

Preferred citation for this article:
Zhang B., 2026, Effects of potassium fertilization on fruit size, sugar accumulation, and quality of citrus, International Journal of Horticulture, 16(4): 251-268 (doi: 10.5376/ijh.2026.16.0022)

Abstract With increasing consumer demand for high-quality citrus fruits, improving fruit size, sugar accumulation, and flavor attributes through nutritional regulation has become an important objective in orchard management. This study reviews the application of potassium fertilization in citrus production and summarizes recent advances in potassium uptake and transport, fruit growth, carbon metabolism regulation, and quality formation. The results indicate that appropriate potassium application can optimize nutrient allocation within citrus trees, promote the transport of photosynthetic assimilates to fruits, enhance fruit enlargement and sugar accumulation, and improve total soluble solids content and sugar–acid balance. However, citrus responses to potassium fertilization vary among cultivars, growing environments, and cultivation practices, while application timing, fertilization methods, and nutrient balance strongly influence management outcomes. Future integration of nutrient diagnosis, precision fertilization, and smart agriculture technologies may further improve potassium use efficiency and promote high-quality and sustainable citrus production.
Keywords Citrus; Potassium management; Fruit quality; Sugar accumulation; Precision fertilization

1 Introduction

Citrus is one of the most economically important fruit crops worldwide, with major production and trade systems concentrated in countries such as China, Brazil, and the United States (Abouzari and Nezhad, 2016; Spreen et al., 2020; Wen et al., 2021). With increasing consumer demand for high-quality fresh fruit, improving and stabilizing citrus yield and fruit quality has become a major objective in modern orchard production. Fruit size, total soluble solids (TSS), sugar–acid ratio, and flavor-related traits directly influence consumer acceptance and market value (Wu et al., 2021; Morales Alfaro et al., 2023). However, citrus production still faces common challenges, including inconsistent fruit size, insufficient sugar accumulation, and a low proportion of premium-quality fruits. Therefore, optimizing nutrient management has become an important approach for improving citrus fruit quality.

Potassium (K) is one of the essential macronutrients required for plant growth and development and plays critical roles in carbon metabolism, photosynthesis, osmotic regulation, and assimilate transport (Hasanuzzaman et al., 2018; Johnson et al., 2022). Unlike nitrogen and phosphorus, which are mainly involved in structural components, potassium primarily regulates plant growth and yield formation through enzyme activation, stomatal movement, and source-sink relationships (Sardans and Peñuelas, 2021). In leaves, adequate potassium supply promotes photosynthetic carbon assimilation and enhances the transport of photosynthetic products to sink organs such as fruits. In contrast, potassium deficiency reduces photosynthetic capacity, restricts carbohydrate accumulation, and ultimately inhibits plant growth and yield formation (Tränkner et al., 2018; Shah et al., 2024). However, excessive potassium application may also reduce nutrient use efficiency and disturb the balance among mineral elements. Therefore, maintaining an appropriate potassium supply level is essential for improving crop production efficiency (Hasanuzzaman et al., 2018).

Citrus has a relatively high potassium demand, and large amounts of potassium accumulate during fruit development. Since potassium in citrus orchard soils is vulnerable to leaching losses, insufficient potassium supply often results in reduced fruit size, lower yield, and impaired fruit quality. Previous studies have