

help breeders screen varieties with better performance in sugar, organic acids and polyphenols (Zheng et al., 2022). The pollination effect (xenia), can also change fruit size and sweetness, indicating that breeding strategies cannot ignore the interaction between genetic background and reproductive biology (Qiao et al., 2025).

Selecting genotypes with high nutrient utilization efficiency is also a key point. The ability of different rootstock and scion combinations to absorb and utilize nutrients such as nitrogen and potassium varies. Rootstocks such as "Pyrodwarf" and "OHF", have differences in the levels of required nutrients (Jamshidi et al., 2016). Some genotypes exhibit higher nutrient absorption efficiency, such as the nitrogen-efficient "971" selection and potassium-efficient Northeast pear, which is of great significance for sustainable production and quality improvement (Sete et al., 2020; Liu et al., 2023; Yang et al., 2025).

6.3 Genotype × nutrient interaction mechanisms

QTL mapping has identified many key sites related to sugar, organic acid and nutrient utilization efficiency. For instance, in *pyrifolia*, *qSugar-LG6-Chr7* and *qSugar-LG12-Chr3* are closely related to the total sugar content. The candidate genes include sorbitol dehydrogenase (*PpSDH*) and sucrose transporter (*PpSUT*). They play a core role in sugar accumulation (Jiang et al., 2023). GWAS analysis also identified more loci related to fruit quality, involving genes such as stone cell formation, organic acid and sugar accumulation (Zhang et al., 2021), providing a genetic basis for breeding material selection.

Research has also found that different genotypes respond differently to fertilization systems. Some varieties are particularly sensitive to potassium supply. For example, a comparative study of "Crown" pear shows that potassium treatment can change gene expression and sugar accumulation, indicating that the fertilization plan must match the genotype (Shen et al., 2019). In addition, the improvements in sugar content, fruit size and metabolic characteristics brought about by bio-organic fertilizer or canopy structure adjustment vary among different genotypes (Wang et al., 2022a; Liu et al., 2024).

7 Case Studies of Nutrient Regulation in Pear Production

7.1 Practices for pear fruit enlargement

In the pear industry, rational nutrient regulation is key to increasing fruit yield and commercial value. In recent years, researchers have focused on the role of traditional chemical fertilizers and single nutrients, and also incorporated sustainable inputs, such as organic fertilizers and bio-organic fertilizers, into their experiments to explore more efficient and environmentally friendly pathways to increase yield. Wang et al. (2022a) demonstrated that the application of bio-organic fertilizers (BF) provides a new practical example for increasing pear fruit size. Field trials showed that, BF treatment significantly increased per-plant yield (by 10.6%) compared to chemical fertilizers. The fruit also increased in both longitudinal and transverse diameters, resulting in larger fruit size without affecting firmness (Figure 2).

In field trials of Asian pear varieties, including 'Yali' and 'Xinli No. 7', increasing potassium (K) fertilizer application rates has been shown to effectively improve fruit size and quality. Potassium fertilizer increases potassium concentrations in leaves and fruits and enhances net leaf photosynthetic rate, thereby promoting fruit growth. High levels of potassium fertilizer can upregulate the expression of genes involved in sugar metabolism (such as *AIV*, *S6PDH*, *SPS*, *SUS*, and *SUT*), promote soluble sugar accumulation, and increase fruit size during ripening (Shen et al., 2018; 2019).

Multiple foliar potassium sprays during fruit development, such as three sprays of 1.5%-2.0% potassium nitrate (KNO_3) or potassium sulfate (K_2SO_4) during the fruiting period, can further enhance these effects (Prasad and Bora, 2015). Economic analysis also shows that high-potassium fertilization can increase yield by 16%-17%, improve soluble solids and sugar content, and enhance market value and crop profitability. However, the amount and timing of fertilizer application must be precisely controlled to avoid over-investment or diminishing returns (Shen et al., 2016).