

2022a). These genes work together to transport sugar and minerals to the fruit. When they operate in balance, the fruit can grow larger at the right time and accumulate more sugar.

This study explores how to better manage macronutrients and trace elements, incorporating the use of bio-organic fertilizers to enhance nutrient regulation. It integrates concepts from plant physiology, molecular research, and agricultural management methods, to identify practical approaches to improve pear quality. Through more scientific management, pear yields can be increased while also enhancing taste and nutritional value. This not only increases income for farmers, but allows consumers to enjoy higher-quality pears.

2 Physiological Basis of Fruit Size Formation

2.1 Mechanisms of cell division and expansion

N and P are key nutrients that influence pear cell growth and division, which directly determine the final fruit size. It has been reported that, providing adequate nitrogen and phosphorus during early fruit growth, can increase the length, width, weight, and overall volume of pears by promoting cell division and expansion (Arba et al., 2017). Field trials have found that pear yield and quality are optimal when farmers apply approximately 337.5 kg of nitrogen and 262.5 kg of phosphorus per hectare (Li et al., 2024).

The nutritional status of plants also affects the function of hormones in the body. Hormones such as auxin (IAA), zeatin nucleoside (ZR), gibberellin (GA), and abscisic acid (ABA) are all related to the number of cell formation and fruit size (Tian et al., 2021; Liu et al., 2024). Research shows that higher levels of ZR and a more ideal balance of IAA/ABA, ZR/ABA and GA/ABA help to produce more cells and promote fruit enlargement. On the contrary, ABA inhibits cell division (Tian et al., 2021).

Nutrient regulation of plant hormones helps maintain a balanced growth process. Furthermore, external application of plant growth regulators (e.g., gibberellins and cytokinins), can further promote cell division and expansion, resulting in larger pear fruits and improving their quality (Mosa et al., 2022; Al-Saif et al., 2024; Liu et al., 2024).

2.2 Vascular structure and sink strength modulation

For pear fruits to grow big and sweet, the sugar in the leaves must be smoothly delivered to the fruit. However, if the transport function of the transport channel, that is, the vascular tissue, is poor, sugar will block the road (Shen et al., 2019; Wang et al., 2022c). The role of K can be manifested at this time: it can make the vascular tissues of petioles and fruit stalks more developed, and also make sugar transport genes, such as *SUT* and *SOT*, more active. Thus, glucose, fructose, sorbitol and sucrose will accumulate rapidly in the fruit (Shen et al., 2019). With the enhancement of transportation capacity, the "reservoir strength" of fruits will also be stronger, the ability to absorb and store sugar will be better, and the fruits will be larger and sweeter (Cheng et al., 2018).

Of course, potassium is not the only key. Calcium (Ca) and boron (B) are also indispensable. Calcium can make the cell walls and cell membranes more stable, supporting the continuous growth of fruits. Boron maintains cell wall structure and vascular function at the back (Pessoa et al., 2022). Only when both calcium and boron are sufficient can the vascular system remain smooth, allowing sugar and nutrients to continuously flow into the fruit, and enabling the pear to grow to the desired size and quality.

2.3 Interactions between nutrition and environmental factors

Water and temperature play a big role in how well pear trees take in and use nutrients. When there isn't enough water, sugars and nutrients can't move into the fruit. When it gets too hot, the tree's normal metabolism is thrown off, and even its nutrient needs can change (Shen et al., 2019). Pear trees will try to adjust by doing things, like boosting root activity or changing how transport proteins work. But if these fixes go on for too long, the fruit won't grow well, and the pears will end up smaller (Shen et al., 2019; Nishio et al., 2021).

Nutritional imbalance is also a problem. Too little fertilizer, or the wrong mix, can slow cell division, and block the growth of vascular tissue. It also weakens the "sink strength", which makes fruits smaller and less sweet (Shen