

reasonable planting density and pruning, and green prevention and control of diseases and pests can not only increase the current season's yield, but also maintain soil fertility and ecological environment, reduce yield fluctuations, and extend the high-yield and stable production period of orchards. In suitable ecological areas, Changshan Huyou demonstrates advantages such as strong adaptability and stable yield, with high economic and ecological value, making it suitable for large-scale promotion (Tan et al., 2012). However, if management is lax or soil and ecological protection is neglected, the yield and fruit quality may gradually decline, which requires attention.

5 Effects on Commercial Traits

5.1 Influence on fruit size, shape, and external appearance

Different cultivation and management methods will directly affect the size, shape and appearance of Changshan Huyou. Reasonable water and fertilizer management, appropriate dense planting and pruning can make the fruits grow more evenly, increase the weight of individual fruits, make the fruit shape more regular, and also reduce deformed and small fruits, thereby increasing the commercial fruit rate. Under suitable climate and soil conditions, scientific management can make the fruit skin color brighter, the fruit surface smoother, the fruit dots finer, the fruit look more beautiful and more market-attractive. Meanwhile, the integrated prevention and control of pests and diseases can reduce the spots and damage on the fruit surface and make the fruit appearance better. However, if the planting is overly dense or the management is lax, it is easy to have fruits of uneven size and irregular shape, which will affect the commercial traits (Tan et al., 2012).

5.2 Effects on flavor, sugar-acid ratio, nutritional content, and consumer preference

Cultivation management also plays a crucial role in terms of flavor and nutrition. Scientific fertilization, especially the reasonable combination of nitrogen, phosphorus and potassium, along with water regulation, can help accumulate sugar, adjust acidity, and make the sugar-acid ratio of fruits moderate, resulting in a better taste. The use of organic or bio-fertilizers can increase the content of vitamin C and soluble solids, making fruits more nutritious. Meanwhile, the harvest time and post-harvest treatment are also very important, directly affecting the retention of flavor and nutrition. Consumers usually prefer Changshan Huyou with a well-shaped fruit, bright color, rich flavor and a well-balanced sugar-acid ratio. Scientific management can effectively enhance these characteristics (Tan et al., 2012).

5.3 Postharvest traits: shelf life, storage, and transportability

In terms of postharvest traits, the differences among various management methods are also quite obvious. Moderate water control, reasonable fertilization and pest and disease prevention can enhance the toughness and thickness of the fruit peel, reduce post-harvest rot and mechanical damage, and thereby extend the storage time and shelf life. Seizing the right timing during harvest, along with post-harvest pre-cooling, grading and packaging, helps maintain the freshness and appearance of the fruits and enhance their adaptability during transportation. In addition, the use of biological preservatives or the proper control of storage temperature and humidity can also delay fruit senescence, reduce weight loss and rot, and increase the commercial fruit rate. Therefore, scientific post-harvest management is particularly important for the long-distance transportation and market sales of Changshan Huyou (Tan et al., 2012).

6 Economic and Environmental Considerations

6.1 Production cost and profitability analysis for each model

Different cultivation methods vary greatly in terms of input, output and returns. The input of traditional management is low, but the yield and fruit quality fluctuate greatly and the profit-making ability is limited (Ren et al., 2020; Abisheva and Mussin, 2023). Modern intensive management, such as high-density planting, precise fertilization and intelligent irrigation, can increase the yield per unit area and make the fruits more uniform. However, this approach is more costly and requires more fertilizers, pesticides, labor and equipment. Modern management can increase the yield of citrus and pomelo trees by 30% to 60%, but the cost often rises by 40% to 70%. The final revenue ratio should also be calculated in combination with market prices and policy subsidies (Chandra et al., 2024). Studies have found that if reasonable optimization is carried out, such as moderate planting