

density, scientific fertilization, and pest and disease control, the yield and commercial fruit rate can be increased without significantly increasing the cost (Ren et al., 2020; Chandra et al., 2024). Although organic and ecological management has a slightly lower yield per unit area, they are still competitive in the long term because the products can be sold at a higher price and some input is saved (Szeląg-Sikora et al., 2019; Boschiero et al., 2023).

## **6.2 Environmental impacts: soil fertility, biodiversity, pesticide/fertilizer use**

While intensive management increases production, it also brings about some environmental problems, such as the decline of soil fertility, the reduction of biodiversity, and the excessive use of chemical fertilizers and pesticides (Huang et al., 2024). Relatively speaking, organic and ecological management can improve the soil, increase organic matter and microorganisms, make the soil healthier and have better ecological functions (Martinez et al., 2024). Some systematic reviews and life cycle analyses have shown that organic/ecological management is significantly superior to conventional intensive models in terms of greenhouse gas emissions, nutrient loss and water pollution (Boschiero et al., 2023). In addition, hybrid management, such as precise fertilization, integrated pest and disease control, and crop cover, can balance yield and environmental protection. This type of approach can reduce the usage of chemical fertilizers and pesticides by 20% to 40%, while increasing soil organic matter and biodiversity (Martinez et al., 2024; Peng et al., 2024). However, some ecological measures may lead to a decrease in output in the short term, and the relationship between the economy and the environment needs to be balanced through technological improvements and policy subsidies (Szeląg-Sikora et al., 2019; Boschiero et al., 2023; Huang et al., 2024).

## **6.3 Farmer adoption, labor requirements, and policy support**

Whether farmers are willing to adopt new management methods is influenced by multiple aspects such as income, labor force, technical threshold and policy environment (Huang et al., 2024). The intensive approach has high requirements for labor and technology and is more suitable for large-scale operation. The demand for ecologically-managed labor force is high, but it can be shared through cooperatives or socialized services (Chandra et al., 2024). Policy support is also important, such as green subsidies, technology promotion, insurance, etc., all of which will affect farmers' choices. At present, the main difficulties for farmers to adopt the new model are large initial investment, insufficient technical services and high market risk. Therefore, to promote the sustainable development of characteristic fruit trees such as Changshan Huyou, it is necessary to strengthen training, increase policy support, and improve the market system (Szeląg-Sikora et al., 2019; Chandra et al., 2024; Huang et al., 2024).

# **7 Case Study: Cultivation Management of Changshan Huyou**

## **7.1 Background: study location, orchard characteristics, and climatic conditions**

Changshan Huyou is a geographical indication fruit tree in Quzhou City, Zhejiang Province, with high ecological and economic value (Tan et al., 2012). Quzhou has a subtropical monsoon climate. The annual average temperature is about 17 °C, the precipitation is about 1 500 millimeters, the light conditions are good, and the soil is mainly red soil and yellow soil, which is very suitable for the growth of citrus fruit trees (Yu et al., 2012). Most orchards are located in hilly areas with undulating terrain and smooth drainage. The management methods of local orchards vary greatly. Some are still using the traditional extensive mode, while others have adopted modern and precise methods (Tan et al., 2012). In recent years, industrial upgrading has promoted the application of some new technologies and new varieties, such as natural tetraploids and superior grafted strains, to increase yield and fruit quality (Figure 2) (Du, 2001; Huang et al., 2025).

## **7.2 Methods: cultivation management treatments, monitoring, and data collection**

This case study selected typical Changshan Huyou orchards in Quzhou City and designed multiple cultivation and management models, including: conventional management (control), optimized fertilization (controlled-release fertilizer or organic fertilizer combination), dense planting and sparse planting, scientific pruning, irrigation regulation, and the introduction of superior varieties (such as natural tetraploid, preferred grafted strains) (Tan et al., 2012). The experiment adopted a random block design, with duplicate cells set for each mode. The monitoring contents include yield per plant, yield per unit area, fruit size, color, shape, soluble solids, acidity, commercial