

Research Insight

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Study on the Biological Characteristics and Efficient Management Techniques of the New Fruit *Akebia trifoliata*

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International Journal of Horticulture, 2024, Vol.14, No.6 doi: [10.5376/ijh.2024.14.0042](https://doi.org/10.5376/ijh.2024.14.0042)

Received: 11 Nov., 2024

Accepted: 15 Dec., 2024

Published: 28 Dec., 2024

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Preferred citation for this article:

He Z.J., and Tong P.Y., 2024, Study on the biological characteristics and efficient management techniques of the new fruit *Akebia trifoliata*, International Journal of Horticulture, 14(6): 426-437 (doi: [10.5376/ijh.2024.14.0042](https://doi.org/10.5376/ijh.2024.14.0042))

Abstract As a novel fruit with both medicinal and edible uses, *Akebia trifoliata* (commonly known as August melon) has garnered significant market attention in recent years due to its unique nutritional value and economic potential. Achieving high-yield and efficient cultivation of *Akebia trifoliata* requires scientific management and technical support. This study focuses on the biological characteristics, optimal cultivation environment, and high-yield management techniques for *Akebia trifoliata*, aiming to provide a scientific basis for its large-scale cultivation. The study found that through systematic optimization of techniques such as site selection, propagation and transplanting, field management, and pest and disease control, the yield and fruit quality of *Akebia trifoliata* were significantly improved. Proper water and fertilizer management, precise pruning, and timely harvesting effectively enhanced the marketability and competitiveness of *Akebia trifoliata*. The results indicate that the crop holds great potential for widespread cultivation, offering substantial benefits for rural economic development and providing new insights and practical approaches for the sustainable development of modern ecological agriculture.

Keywords *Akebia trifoliata* (Thunb.) Koidz.; Biological characteristics; High-yield cultivation; Pest and disease control; Sustainable agriculture

1 Introduction

Akebia trifoliata (Thunb.) Koidz., commonly known as “Ba Yue Gua (August melon)”, is a deciduous woody vine in the family Lardizabalaceae, and it has recently gained market attention. *Akebia trifoliata* exhibits unique growth habits and appearance; its fruit resembles a banana in shape and naturally splits open when ripe, which has led to its local nicknames, such as “Ba Yue Zha” (Niu et al., 2020). Wild varieties of *Akebia trifoliata* are widely distributed across China, particularly in mountainous valleys, sparse forests, and shrublands within regions such as Hebei, Henan, Shandong, Shanxi, southern Shaanxi, southeastern Gansu, and the Yangtze River basin, at altitudes ranging from 250 to 2,000 meters. The species is also found in parts of Japan (Guo et al., 2019, Northwest Horticulture (Fruit), (4): 17-19; Jia et al., 2023). Its fruit comes in a variety of colors, including green, white, and purple, with white flesh and numerous seeds. The flavor and texture, typically tender and sweet, vary significantly among different types. Due to its rich nutritional and medicinal properties, *Akebia trifoliata* is increasingly cultivated as a novel health-oriented fruit.

As research into the health benefits of *Akebia trifoliata* has progressed, its market demand has grown significantly, accompanied by rising sales prices and high cultivation returns. The fruit of *Akebia trifoliata* contains various amino acids, minerals, and trace elements such as calcium, magnesium, zinc, iron, and selenium, which offer health benefits, particularly in enhancing immunity and promoting physical strength and kidney health (Wang et al., 2022; Sun et al., 2023). Additionally, the root, stem, and fruit of *Akebia trifoliata* have medicinal properties, including diuretic, lactogenic, and muscle-relaxing effects (Liu et al., 2018; Wang et al., 2020). *Akebia trifoliata* products such as fruit tea and juice have become popular in the market, further enhancing its economic value.

These attributes have encouraged the development of *Akebia trifoliata* cultivation into an emerging agricultural project, attracting the participation of numerous farmers and agricultural enterprises to meet the growing market demand.

Akebia trifoliata shows considerable potential for yield and quality improvement, and with proper cultivation management, farmers can achieve high economic benefits (Xiong et al., 2007; Guan et al., 2022). To realize high-yield, high-quality cultivation, the Science and Technology Volunteer Service Team of the Chinese Society of Agronomy and the Xinye Family Farm in Zhuji City, Zhejiang, began the domestication and cultivation research on *Akebia trifoliata* in 2015. After years of effort, the farm introduced high-quality germplasm resources in 2018 and conducted grafting experiments with various scions and rootstocks, eventually developing a high-quality *Akebia trifoliata* variety in 2023 characterized by large fruit size, thin skin, few seeds, and a sweet, delicious flavor. According to yield measurements in 2023 and early 2024, the average yield of *Akebia trifoliata* per mu (0.067 hectares) reached 2,000 to 2,500 kg, with maximum yields exceeding 3,000 kg, and individual fruits weighing between 250 and 300 g, with the largest reaching 750 g. This high-quality *Akebia trifoliata* variety sells for up to 50 RMB/kg, with an annual yield value exceeding 100,000 RMB per mu and a net income of over 80,000 RMB per mu. Therefore, systematic research into *Akebia trifoliata* cultivation techniques not only promotes the development of this emerging fruit industry but also contributes positively to local economic growth and agricultural modernization.

This study systematically summarizes high-yield cultivation techniques for *Akebia trifoliata* in Xinye Family Farm in Zhuji City, covering site preparation, seedling planting, trellis setup, providing technical guidance for producers. The study also explores methods to enhance fruit nutritional quality, improve soil health, and promote orchard sustainability. This study aims to enhance the fruit quality and market competitiveness of *Akebia trifoliata* through standardized cultivation practices, making it a sustainable specialty fruit industry that helps farmers increase their income.

2 Biological Characteristics and Value of *Akebia trifoliata*

2.1 Morphological and growth characteristics

Akebia trifoliata is a perennial deciduous climbing woody vine with a distinctive growth pattern. The plant features palmately compound leaves arranged alternately, with leaflets typically ovate or obovate in shape, and a range of vibrant leaf colors that add to its ornamental appeal (Pan et al., 2021). Its branches are flexible and well-suited for climbing, making it ideal for use in trellis or hedge construction. *Akebia trifoliata* has a well-developed shallow root system, making it suitable for growth in loose, well-aerated soils. The plant demonstrates strong adaptability to soil conditions and can tolerate a certain level of drought, which facilitates its widespread cultivation (Maciag et al., 2021; Zhong et al., 2022a). In various regions of China, *Akebia trifoliata* can be found at different altitudes, ranging from lowlands at 250 meters to mountainous areas up to 2 000 meters.

The overall appearance of *Akebia trifoliata* is neat and elegant, making it a suitable plant for adding aesthetic value to natural landscapes. With a fast growth rate and high vine extension ability, it is commonly used in garden design to create natural shading effects. During the growing season, the vines climb up supports or fences, with leaves layered under sunlight, forming a unique visual effect. Apart from being an economic fruit tree, *Akebia trifoliata* is also considered one of the ideal choices for landscaping due to its drought resistance and tolerance to poor soil conditions.

2.2 Flowering period and fruit characteristics

The flowering period of *Akebia trifoliata* typically occurs from March to May, with flower clusters up to 20 to 40 centimeters long, providing significant ornamental value. The flowers come in a variety of colors, including yellow, white, and purple-red, which create a striking visual effect in spring orchards (Nasrullah et al., 2018). The flowering process is gradual, with blooms lasting up to two months, adding vitality and color to the spring landscape. In horticultural design, the long flowering period of *Akebia trifoliata* enhances the layering effect of landscapes, making it a popular choice for courtyard landscaping and ornamental flower arrangements. The long

flower clusters and vibrant blossoms also attract pollinators such as hummingbirds and butterflies, making it an appealing plant in agritourism settings (Erickson et al., 2022).

The fruit of *Akebia trifoliata* ripens from September to October (the eighth month of the lunar calendar) and has a unique appearance. It is elongated and oval, resembling a banana, with a purple or brownish skin. Upon ripening, the fruit skin naturally splits open to reveal milky white or golden-yellow pulp (Figure 1). The pulp is juicy, smooth, and sweet, with a distinctive aroma and delicate texture that is highly favored by consumers. Each fruit usually contains between 100 and 200 seeds (Zhao et al., 2023). Despite the high number of seeds, *Akebia trifoliata* has a high edible rate, and the sweetness of its pulp makes it highly marketable. In addition to being a fruit, *Akebia trifoliata* also possesses certain ornamental qualities. The mature fruit, with its naturally split appearance, draws attention from visitors, adding to the enjoyment of picking activities.

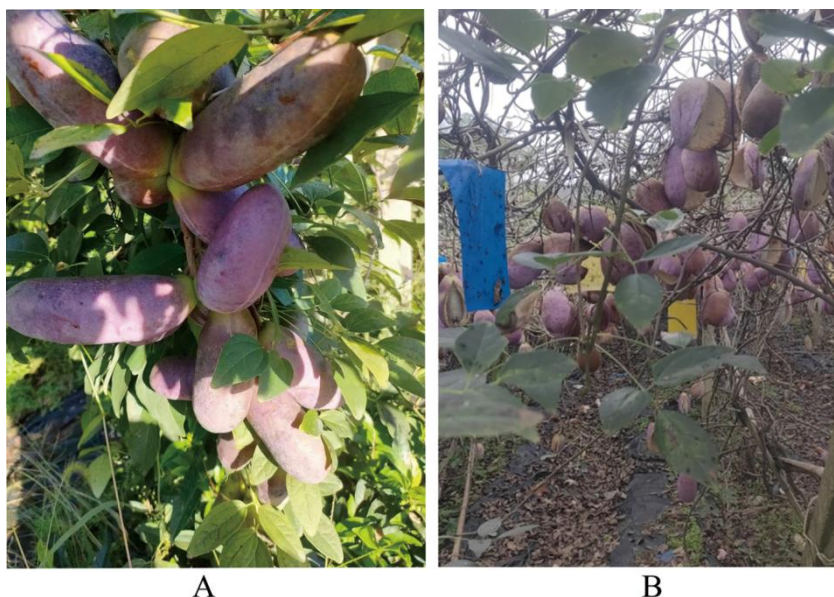


Figure 1 Fruit development stages of *Akebia trifoliata*

Image caption: The figure depicts the fruit of *Akebia trifoliata* at different stages of maturity. (A) Fruits before ripening, showing an elongated, oval shape with a purple hue. (B) Fruits after ripening, with the skin splitting open to reveal the inner pulp

2.3 Nutritional and medicinal value

As a fruit with both nutritional and medicinal uses, *Akebia trifoliata* is increasingly valued for its rich nutrients and significant medicinal effects. Its fruit contains a variety of soluble sugars, as well as essential minerals and trace elements such as calcium, magnesium, zinc, iron, and selenium. It also contains an abundance of amino acids, particularly eight essential amino acids including valine, lysine, methionine, isoleucine, and phenylalanine (Wang et al., 2022; Zhong et al., 2022b). These nutrients help to detoxify the body, boost immunity, and have functions like nourishing the kidneys and strengthening the body. Furthermore, the fruit is believed to offer benefits for skin health and anti-aging, making it a highly nutritious health-promoting fruit (Sun et al., 2023).

Beyond its nutritional value, the stems, vines, roots, and fruits of *Akebia trifoliata* all have medicinal properties and are used in traditional Chinese medicine. Folk medicine uses it for its diuretic, lactagogue, and muscle-relaxing effects to treat ailments such as cough from overexertion, bone fractures, edema, burns, lymphatic tuberculosis, urinary tract stones, and rheumatic joint pain (Liu et al., 2018; Wang et al., 2020). The fruit can also be used for winemaking, and its seeds can be pressed for oil, increasing its application potential in medicine and food processing. Currently, the market has developed various processed products using *Akebia trifoliata* as raw material, such as fruit teas and juices, further expanding its industrial value (Jiang et al., 2020).

3 Orchard Selection and Land Preparation

3.1 Criteria for optimizing orchard selection

Akebia trifoliata is a shallow-rooted species with a broad and shallow root system, making the selection of suitable terrain and fertile soil crucial for its growth. It is best planted in open areas with ample sunlight, especially in wind-protected semi-shaded regions, as excessive shading or intense sun exposure can hinder its growth (Bi et al., 2022, South-Central Agricultural Science and Technology, 43(1): 40-42,60). The study found that climate change has a significant impact on the distribution of *Akebia trifoliata*. Model predictions indicate that under different climate scenarios, the areas suitable for the growth of *Akebia trifoliata* will change. With rising temperatures, its suitable growing areas may gradually shift northward (Zhang et al., 2022). In terms of soil, sandy loam and loam are optimal, as they offer good drainage while retaining moisture and aeration, meeting the plant's needs for water and oxygen (Zhang et al., 2020). If the orchard is selected in low-lying areas with poor drainage, water accumulation may occur, affecting root development and reducing yield. In addition, *Akebia trifoliata* requires a certain amount of calcium in the soil, so choosing calcium-rich soils is beneficial for its healthy growth.

The availability of water sources is another important factor in orchard planning. During the fruit enlargement stage, *Akebia trifoliata* requires sufficient water, so the orchard should be near a reliable water source to facilitate irrigation during dry seasons, ensuring the quality and yield of the fruit. To protect the orchard's ecological environment and fruit safety, the site should be far from sources of pollution such as exhaust gases, wastewater, and waste residues to avoid soil and water contamination, ensuring that the fruits are safe and environmentally friendly (Pan et al., 2020). Furthermore, the orchard should be close to areas with convenient transportation, which facilitates daily field management, fruit transport, and harvesting activities, also contributing positively to agritourism development. A well-chosen orchard can significantly enhance the economic value and market competitiveness of *Akebia trifoliata*.

3.2 Clearing debris and soil preparation

Since *Akebia trifoliata* has a well-developed but shallow root system, it is necessary to provide a clean and loose soil environment for its growth. When clearing the land, weeds, shrubs, and wild vines that may hinder root growth must be thoroughly removed to avoid unnecessary nutrient competition and potential disease risks. The clearing process is usually carried out along the contour lines to protect the topsoil and prevent soil erosion. For larger areas, the land can be cleared in phases to ensure the quality of the land preparation work. This systematic clearing provides favorable soil conditions for subsequent cultivation, helping *Akebia trifoliata* to establish healthy roots and grow well (Jia et al., 2023).

After clearing the debris, deep plowing is required to improve soil structure. The depth of deep plowing should generally be between 30 and 40 centimeters. Through deep plowing, the soil becomes sufficiently loosened, enhancing its aeration and water retention, thus providing ample space for root growth. During the plowing process, combining the application of organic fertilizers, such as decomposed compost or farmyard manure, yields the best results, as it helps to improve soil nutrient content and microbial activity (Maciąg et al., 2021). In addition, drainage ditches should be dug around the plot during deep plowing to prevent water accumulation that may damage the roots of *Akebia trifoliata*. Fine land preparation measures not only ensure the survival rate of seedlings but also provide a stable foundation for later growth, leading to high yield and quality cultivation.

3.3 Design of planting beds and planting holes

In the cultivation of *Akebia trifoliata*, the design of planting beds and planting holes is an important step to ensure tree growth and yield. Typically, the width of the planting beds is recommended to be 2 meters, which facilitates air circulation, sunlight exposure, and daily field management. The design of planting holes should consider the spacing between plants, which is recommended to be 1 × 2 meters, providing ample growth space and allowing approximately 330 seedlings per acre (Bi et al., 2022, South-Central Agricultural Science and Technology, 43(1):

40-42,60; Jia et al., 2023). The planting hole should be 60 centimeters wide and 50 centimeters deep, with sufficient width and depth to support root expansion and growth, ensuring the absorption of nutrients and water supply.

The soil filling method for the planting holes should also be planned scientifically. After digging the hole, the topsoil and subsoil should be piled separately to facilitate refilling. First, a layer of crop stalks, weeds, or leaves should be placed at the bottom of the hole as the base material, with a thickness of about 20 centimeters, which helps to keep the soil moist and provide organic matter. Then, decomposed organic fertilizer (such as compost or well-rotted farmyard manure) should be added to provide nutrients for the initial growth of the seedlings. Drainage ditches should also be designed around the planting hole to prevent water accumulation from damaging the roots. A scientifically designed planting hole not only improves the survival rate of *Akebia trifoliata* seedlings but also ensures a stable supply of water and nutrients throughout their growth, laying a solid foundation for high yield and quality fruit production.

4 Propagation and Planting Techniques

4.1 Propagation methods

The propagation of *Akebia trifoliata* can be done through several methods, including seed propagation, cutting propagation, layering, and root division. Among these methods, cutting propagation is widely used because of its high survival rate, ease of operation, and significant economic benefits (Wang, 2024). Cutting propagation is typically performed in the spring or autumn, using healthy, one- to two-year-old branches that are free from pests and diseases as cutting materials. Branches are cut into 10-20 cm sections, with a slanted cut at the bottom and a flat cut at the top, leaving 2-3 leaves at the top to reduce water evaporation. To promote rooting, the cut branches can be soaked in ABT2 rooting hormone solution before being inserted into the prepared seedbed. With proper scientific treatment, this method can achieve a survival rate of over 95%, providing a reliable source of seedlings for large-scale cultivation.

Seed propagation and layering are suitable for situations where a longer nursery cycle and a higher quantity of seedlings are required. Seed propagation involves seed collection and germination treatment and is often used in breeding experiments or the selection of new varieties. Layering uses the plant's rhizome branches for propagation (Zhang et al., 2023). Root division also has certain applications, especially for the propagation of wild resources, though it requires intensive care and management. The flexibility of *Akebia trifoliata* propagation methods allows growers to choose the appropriate method based on cultivation objectives and planting scale, offering a useful reference for the widespread cultivation of the plant.

4.2 Seedling cultivation and transplanting

In the process of seedling cultivation for *Akebia trifoliata*, the design and management of the seedbed are crucial. The top layer of the seedbed can be made of fine river sand or yellow-red subsoil, with a ridge height of about 15 cm to maintain good drainage and aeration. To ensure seedling survival and growth rate, the seedbed is covered with two layers of shade netting to control direct sunlight exposure and to prevent damage to seedlings due to improper waterlogging, shading, or drought control. *Akebia trifoliata* seedlings generally begin to root in the seedbed after two to three weeks. Once the seedlings reach a suitable height, they can be transplanted on cloudy days to minimize environmental stress, which effectively increases the survival rate of the seedlings and helps them adapt more quickly to their new environment (Zhong et al., 2022a).

Transplanting usually takes place from late February to mid-March in spring, a time when the climate is mild and humid, favoring the growth and root establishment of *Akebia trifoliata*. During transplanting, partially decomposed farmyard manure is added to the planting holes, and a mound of soil is formed at the bottom to allow the roots to spread and fix securely. The seedlings are placed in the hole, the remaining soil is backfilled, lightly compacted, and root-establishing water is immediately applied to ensure close contact between the roots and the soil, further improving the survival rate. The transplanted seedlings grow rapidly, laying a solid foundation for subsequent vine climbing and fruit production.

4.3 Planting orientation and spacing for optimal yield

The planting orientation and spacing of *Akebia trifoliata* have a direct impact on its yield and fruit quality. For planting orientation, it is recommended to use a north-south trellis arrangement to enhance ventilation and light penetration, allowing the branches and leaves of *Akebia trifoliata* to receive even light and avoid excessive shading. Adequate sunlight not only promotes photosynthesis but also helps accumulate sugars in the fruit, thereby improving the quality and yield of *Akebia trifoliata*. The vines of *Akebia trifoliata* naturally tend to climb eastward, so the trellis is usually designed with an east-high and west-low configuration to match its growth characteristics and increase fruit yield (Jia et al., 2023).

In terms of planting spacing, the recommended row spacing for hillside cultivation is 100 × 200 cm, while for flat land cultivation, a spacing of 90 × 130 cm is advised. This relatively large spacing not only provides each *Akebia trifoliata* plant with sufficient room to grow but also facilitates subsequent field management and harvesting. Proper spacing reduces competition between plants, improves overall ventilation, and lowers the incidence of pests and diseases, ensuring healthy growth. The scientific design of planting orientation and spacing provides important support for achieving high yield and quality of *Akebia trifoliata*, ensuring consistent and abundant fruit production during the harvest season.

5 Field Management Measures

5.1 Irrigation requirements and techniques

In the field management of *Akebia trifoliata*, proper irrigation is a key factor to ensure seedling survival and healthy growth. After planting the seedlings, it is important to keep the soil moist, especially during consecutive sunny days, when watering should be done once a week to ensure adequate moisture supply. If feasible, it is recommended to install sprinkler or drip irrigation systems to implement fertigation technology, which not only saves labor but also improves the accuracy of irrigation and fertilization (Li et al., 2021). Fertigation can precisely control the amount of water and fertilizer according to the growth needs of *Akebia trifoliata*, meeting the plant's water and nutrient demands at different growth stages, thus significantly improving production efficiency.

After the establishment of *Akebia trifoliata*, water management should be adjusted based on soil moisture levels, generally keeping the soil moderately moist. Since *Akebia trifoliata* has a shallow root system, a stable water supply is crucial to prevent root damage caused by drought or waterlogging. In addition to regular irrigation, it is important to adjust the water amount promptly based on soil moisture conditions, especially during hot and dry seasons, when watering frequency should be increased appropriately. During the fruit enlargement stage, adequate water supply can enhance fruit weight and quality, making the fruits plumper with a better taste. Therefore, the rational application of irrigation techniques is essential for improving the yield and quality of *Akebia trifoliata*.

5.2 Fertilization strategies for different growth stages

Fertilization management is a crucial aspect of high-yield cultivation for *Akebia trifoliata*, and a scientific fertilization strategy should be developed based on its growth stages and nutritional requirements (Cao et al., 2008). During the seedling stage, it is recommended to apply 100 kg of commercial organic fertilizer or 5 kg of compound fertilizer per acre, diluted in 200 kg of water for irrigation. Fertilization during the seedling stage should follow the principle of "light and frequent" applications, with fertilization once a month to promote the growth and development of roots and leaves. As the plants grow, the amount of fertilizer should be increased, with 10 kg of compound fertilizer per acre during the larger seedling stage. If there is drought or dry soil, the fertilizer can be diluted with water to ensure it reaches the roots effectively.

During the flowering and fruiting stages, to improve fruit quality, it is recommended to apply 15 kg of potassium sulfate per acre. Potassium fertilizer promotes the accumulation of sugars and improves the coloration of the fruit, thereby increasing its sweetness and nutritional value. Additionally, as nutrient demands are high during the flowering and fruiting stages, trace element fertilizers should be applied appropriately to maintain balanced nutrition. Proper adjustments in fertilization strategy help achieve stable and high yields for *Akebia trifoliata*.

5.3 Weeding and soil management

Weed growth in the field competes with *Akebia trifoliata* for nutrients, water, and light, making weeding an important aspect of its field management. Generally, weeding is done manually, avoiding the use of herbicides to prevent contamination of the environment and crops. Weeding should be performed before the seedlings sprout after planting, with the initial weeding thoroughly removing all weeds to prevent them from overgrowing and affecting the normal development of seedlings. Two weeks later, the second weeding can be carried out in combination with cultivation and fertilization to ensure that no new weeds are present on the beds.

In the field management process, pulled weeds can be placed around the plant roots as green manure, which helps to maintain soil moisture and increase organic matter content (Das et al., 2020). Regular cultivation helps to effectively loosen the soil, improving its aeration and water retention, which promotes healthy root growth. Additionally, during management, soil pH and fertility should be monitored, and soil nutrients should be adjusted in a timely manner to meet the growth needs of *Akebia trifoliata*. Scientific weeding and soil management help optimize the growing environment of *Akebia trifoliata*, further improving yield and fruit quality.

6 Vine Training, Pruning, and Fruit Thinning Techniques

6.1 Support system setup and vine training

Since *Akebia trifoliata* is a climbing plant, it requires the installation of a support system during cultivation to guide vine growth. The support system is typically built using cement posts, bamboo, or wood, with prefabricated cement posts being widely used due to their stability and durability (Pan et al., 2020). Standard cement posts are 220 cm in length, with a width and thickness of 10 cm and 8 cm, respectively, and must be embedded 50 cm into the soil to ensure stability. The spacing between posts is set at 400 cm, and wires are left at the top of each post to form a net with horizontal and vertical steel cables. The height of the net is about 170 cm from the ground, allowing for easy vine attachment as well as convenient field management and harvesting (Figure 2).



Figure 2 Concrete support system for *Akebia trifoliata* cultivation

When the seedlings of *Akebia trifoliata* develop new shoots and reach a height of over 30 cm, vine training should be carried out promptly. During vine training, an artificial trellis can be built using branches or ropes to form a fence-like support, guiding the vines to distribute evenly along the support and ensuring that each plant has

sufficient space and sunlight. Proper vine training helps plants receive more light, enhancing photosynthesis, promoting healthy growth, and preventing disordered vine growth.

6.2 Pruning techniques to promote growth and quality

Pruning is an important measure in the cultivation of *Akebia trifoliata* to improve fruit quality and yield. During the growth period, *Akebia trifoliata* requires regular pruning to remove weak, crossing, and dead branches, reducing nutrient consumption and ensuring that the nutrients are focused on healthy branches and fruit development (Xiao et al., 2019). Pruning should be done during the spring sprouting period to promote lateral branch growth, increase fruiting rates, and enhance overall yield. In addition, proper pruning can also improve plant ventilation, reduce the incidence of pests and diseases, and provide a favorable growing environment for fruit development.

During the pruning of *Akebia trifoliata*, the pruning method should be adjusted according to the plant's growth status. For example, overly dense branches should be thinned to ensure even distribution and prevent crowding, which can lead to insufficient light. Proper pruning during the growth period helps shape the plant into an ideal structure, which is beneficial for later fruit harvesting.

6.3 Fruit thinning techniques to improve fruit quality

Fruit thinning is an important technique to ensure the uniform quality and size of *Akebia trifoliata* fruits. During the growth of *Akebia trifoliata*, the inflorescence is racemose, and each inflorescence may bear multiple fruits, making fruit thinning necessary to control the number of fruits, concentrate nutrients, and improve fruit quality (Bi et al., 2022, South-Central Agricultural Science and Technology, 43(1): 40-42,60). Thinning should be done before the first rapid growth phase of the young fruits, typically retaining only two fruits per inflorescence to ensure concentrated nutrient supply. During thinning, it is best to retain fruits that are uniform in size and well-shaped, while removing weak, misshapen, and pest-affected fruits to minimize nutrient loss.

During the thinning process, the distribution of fruits on each branch should be observed to avoid over-dense fruits, which could lead to uneven nutrient distribution. Scientific fruit thinning helps *Akebia trifoliata* fruits achieve the desired size and flavor, thus increasing their market value. During the critical stage of fruit development, thinning effectively enhances the individual fruit weight and overall quality, further meeting the market demand for high-quality *Akebia trifoliata*.

7 Pest and Disease Control

7.1 Common pests and control methods

In the cultivation of *Akebia trifoliata*, no major pests have been found that significantly affect yield, but young shoots and leaves are susceptible to infestations by aphids and other pests. Aphids primarily damage the plant by extracting sap, causing leaves to curl and wither, which affects the plant's normal growth. If aphid damage is observed, a 40% imidacloprid solution can be diluted at a ratio of 1 500 to 2 000 times and sprayed on the affected plants, with 1-2 applications effectively controlling aphid spread (Liu et al., 2023). When using insecticides, adding foliar fertilizers like potassium dihydrogen phosphate to the solution can promote plant growth, making the plants more resistant to pests and reducing the likelihood of infestations.

To minimize the environmental impact of pesticides, it is recommended to adopt eco-friendly methods for pest control, such as manual collection, traps, and the use of natural predators (Murtaza et al., 2019). Regular monitoring of pests in the field allows early detection, which can be managed by manually removing affected branches and leaves to prevent pest spread. In addition, proper soil treatment and weed removal before planting help reduce the habitats of pests, thereby lowering the risk of infestations. These preventive measures contribute to the healthy growth of *Akebia trifoliata* while reducing the need for chemical pesticides.

7.2 Disease control measures

No diseases have been found that significantly affect the growth and yield of *Akebia trifoliata* during cultivation, but preventive measures are still needed to avoid the occurrence and spread of diseases. During humid and rainy

seasons, pathogens are more likely to proliferate on leaves or branches. Therefore, broad-spectrum fungicides such as thiophanate-methyl can be added when spraying insecticides for leaf disease prevention (Smith and Stanosz, 2018). These fungicides can effectively inhibit the growth of fungi and bacteria, thereby reducing the incidence of diseases.

To further enhance disease resistance, applying foliar fertilizers is also important. By spraying nutrients such as potassium dihydrogen phosphate on the leaves, the plant's resistance to diseases can be improved (Glusberger et al., 2023). Good ventilation, proper pruning, and regular weeding during the growth period also help reduce the spread of diseases and create a favorable environment for the healthy growth of *Akebia trifoliata*. The scientific implementation of disease control measures not only increases the yield of *Akebia trifoliata* but also ensures the quality of the fruits.

8 Harvest and Post-Harvest Handling

8.1 Optimal harvest time for ensuring fruit quality

The optimal harvest time for *Akebia trifoliata* is crucial to ensuring the quality of the fruit. If harvested too early, the fruit's sugar content and aroma will not have fully developed, affecting its flavor; if harvested too late, the fruit may naturally crack open, reducing its storability and ease of transport (Zou et al., 2022). Typically, *Akebia trifoliata* matures in mid to late September, and harvesting should be done when the fruit is about to crack but has not yet opened, to ensure optimal sweetness and crispness. Using pruning shears to cut the fruit reduces damage and helps maintain its integrity and market value.

During harvesting, the fruits should be handled gently to avoid bruising or crushing, thereby preserving their appearance and internal quality. In tourism and pick-your-own orchard settings, some fruits can be left to fully ripen and crack open, allowing visitors to enjoy the picking experience themselves, which not only enhances the enjoyment of *Akebia trifoliata* but also attracts more consumers. Timely harvesting ensures not only the flavor of the fruit but also creates favorable conditions for subsequent storage, transportation, and sales.

8.2 Post-harvest handling and storage techniques

Akebia trifoliata requires timely handling and proper storage after harvesting to ensure freshness and marketability. After harvesting, *Akebia trifoliata* should be packed in special packaging boxes. For long-distance transportation, foam boxes are recommended to reduce collisions and compression during transit, extending the storage period (Niu et al., 2021). Temperature and humidity control are particularly crucial in the post-harvest handling process; maintaining a low-temperature environment can effectively slow down the fruit's respiration, delay decay, and enhance storability. Proper refrigeration conditions can extend the shelf life of *Akebia trifoliata*, keeping it in good condition during prolonged transportation and sales.

In addition, cushioning materials should be placed between the fruits during packaging to reduce friction during transport. Poor storage conditions can lead to compression damage, affecting the fruit's appearance and selling price. To meet market demands, especially for long-distance transport, post-harvest handling and storage of *Akebia trifoliata* must be scientifically managed to ensure that the fruit retains its quality upon reaching the market, increasing consumer willingness to purchase.

9 Concluding Remarks

This study systematically analyzed the biological characteristics and cultivation management techniques of *Akebia trifoliata* (August Melon), proposing an effective set of high-yield cultivation practices. These techniques cover aspects such as orchard selection, propagation methods, field management, support system setup, pruning and thinning, and pest and disease control. Through scientific water and fertilizer management and rational pruning practices, both yield and fruit quality of *Akebia trifoliata* have been significantly enhanced. Furthermore, timely harvesting and effective post-harvest handling ensure the marketability of the fruits during transport and sales. The systematic cultivation management measures provide valuable practical guidance to growers, ensuring that

Akebia trifoliata achieves the goal of high-yield and high-quality cultivation. The promotion and application of these techniques will provide a solid foundation for the further development of the *Akebia trifoliata* industry, helping growers achieve sustained yield increases and income growth.

As consumer demand for nutritious and healthy fruits continues to grow, *Akebia trifoliata* is showing great potential in the market due to its rich nutritional content, unique flavor, and medicinal value. As an emerging specialty fruit, its market demand is on the rise, especially in climate-appropriate regions where it has gradually become a high-benefit economic crop. In the future, through variety improvement and continuous optimization of cultivation techniques, the yield and fruit quality of *Akebia trifoliata* will be further enhanced to meet diverse market demands. The future development of *Akebia trifoliata* is not limited to fresh fruit sales; its industrial chain is expected to extend to areas such as fruit processing and agritourism, increasing product added value and expanding market space. With increasingly mature cultivation techniques, the planting and promotion of *Akebia trifoliata* will provide a new growth point for rural economic development and help optimize the structure of the agricultural industry. The development potential of the *Akebia trifoliata* industry lies not only in its economic benefits but also in its high ecological value, providing a new direction for the development of specialty ecological agriculture.

To promote the sustainable development of the *Akebia trifoliata* industry, it is recommended to follow the principles of green agriculture and sustainable development, prioritizing the use of organic fertilizers and biological pesticides to reduce chemical inputs and protect soil and water ecosystems. Scientific water resource management, such as drip irrigation and fertigation, can enhance resource use efficiency and reduce production costs. In post-harvest processing and waste management, developing value-added fruit products can minimize waste, while utilizing plant residues for biodegradation or composting can achieve a green recycling loop. These measures will help improve the yield and quality of *Akebia trifoliata*, promote ecological conservation and efficient resource use, and provide a reference for the sustainable development of modern agriculture.

Acknowledgment

The authors thank the staff of Xinye Family Farm in Zhuji City, for providing photos of *Akebia trifoliata* fruits and the farm. The authors also sincerely appreciate the comprehensive evaluation of the manuscript by two anonymous peer reviewers.

Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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