

Case study

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Cold-Resistant Radish Varieties for Winter Production in Southern China

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Abstract With the development of the winter vegetable industry in southern China, climatic factors such as low temperature, cold waves, and frost have become major environmental stresses limiting stable and high-yield radish production. This study focuses on the winter agricultural climate characteristics of southern China and their effects on radish cultivation. It explains the morphological, physiological, and molecular biological basis of cold tolerance in radish and summarizes the mechanisms of osmotic adjustment, antioxidant defense systems, plant hormone regulation, and low-temperature-responsive gene networks involved in cold tolerance formation. At the same time, the study reviews the diversity of radish germplasm resources in China, local cold-tolerant varieties, advances in conventional breeding techniques, and progress in molecular breeding research. The advantages of representative cold-tolerant varieties in terms of yield, quality, and environmental adaptability are also analyzed. Combined with key cultivation practices, including optimization of sowing time, water and fertilizer management, protected cultivation, and integrated pest and disease control, this paper discusses efficient winter radish production systems and typical regional application cases. The coordinated application of cold-tolerant variety breeding and regional cultivation technologies is an important approach to improving the stability and economic benefits of winter radish production in southern China. In the future, greater efforts should be made to integrate genomics with precision breeding technologies, improve cold-tolerance evaluation systems, and promote the application of smart agriculture technologies, providing both theoretical support and technical guidance for the development of efficient, environmentally friendly, and sustainable winter vegetable production systems.

Keywords Radish (*Raphanus sativus* L.); Cold tolerance; Winter production; Germplasm resources; Molecular breeding; Cultivation technology; Southern China

1 Introduction

Winter vegetable production is an important part of the year-round vegetable supply system in China. In regions with suitable accumulated temperature conditions, off-season production can be achieved, creating strong market competitiveness. Southern China is one of the major winter-spring vegetable production regions and has comparative advantages for winter vegetable cultivation because of its favorable climate and resource conditions. However, it still faces the challenge of low-temperature weather events, which can reduce yield stability and product quality (Hou and Wang, 2024). Under these circumstances, improving the adaptability and stress resistance of major winter crops is of great importance for ensuring regional food security and promoting sustainable and intensive agricultural development.

Radish (*Raphanus sativus* L.) is one of the most important root vegetables in China and worldwide. It is widely cultivated across different climate zones and growing seasons. In China alone, the planting area of radish reached approximately 1.2 million hectares in 2016, with a fleshy root production of 44.6 million tons, accounting for about 40%~47% of the global planting area and production of radish (Kurina et al., 2021). According to different planting seasons, radish can be classified into spring radish, summer radish, autumn radish, and winter radish. Among them, autumn and winter radishes are dominant in many regions, accounting for approximately 20%-50% of the total autumn vegetable planting area (Zhang et al., 2019a). Because of its short growth cycle, diverse root shapes and colors, and high nutritional value, radish has become a key crop in intensive vegetable production systems and an important source of income for many small-scale farmers.