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Disease-Resistant Tomato Cultivars for High-Quality Production

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Abstract Tomato (*Solanum lycopersicum* L.) is an important economic and nutritional crop worldwide, but its production has long been heavily constrained by various diseases. This study reviews the major types of diseases affecting tomato cultivation, with a focus on the genetic basis of disease resistance in tomato. It summarizes the main strategies currently used in resistance breeding. Through case analysis of typical resistant varieties and multi-resistant hybrids, it further shows that disease resistance, yield stability, and fruit quality can be improved together. The study also highlights the key role of resistant varieties in integrated disease management systems, as well as their potential value in improving postharvest quality and extending shelf life. Finally, in response to challenges such as pathogen evolution, climate change, and emerging diseases, it is suggested that future research should strengthen the integration of multi-omics, intelligent breeding, and high-throughput phenotyping technologies, so as to promote the coordinated development of disease resistance and high-quality tomato production and achieve sustainable agricultural goals.
Keywords Tomato (*Solanum lycopersicum* L.); Disease resistance breeding; Gene pyramiding; Molecular mechanisms; Quality traits

1 Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most widely cultivated and economically important horticultural crops in the world. In recent years, the global planting area has been about 5 million hectares, with total production close to or exceeding 180–190 million tons. As a high-value crop, tomato not only supports the livelihoods of smallholder farmers but also drives large-scale commercial agriculture. It also contributes to a broad processing industry, including sauces, juices, ketchup, and canned products (Akotowanou et al., 2022).

From a nutritional perspective, tomato is widely recognized as an important component of a healthy diet. It is rich in vitamins (especially vitamin C and provitamin A), minerals, dietary fiber, and various bioactive compounds, including carotenoids (particularly lycopene and β-carotene), tocopherols, and phenolic metabolites. Regular consumption of tomatoes and their products can significantly increase dietary levels of carotenoids, lycopene, vitamin C, and polyphenols, which are closely associated with a reduced risk of cardiovascular diseases, certain cancers, and other chronic conditions (Egea et al., 2022).

Despite its importance, tomato production is severely constrained by a wide range of diseases. These diseases are caused by fungi, oomycetes, bacteria, viruses, viroids, and nematodes, and can infect plants at all stages from seedling to postharvest, often leading to serious yield and quality losses. Major diseases include soil-borne diseases such as Fusarium wilt, Verticillium wilt, bacterial wilt, and root-knot nematodes; foliar and fruit diseases such as early blight, late blight, Septoria leaf spot, and gray mold; as well as viral diseases such as tomato yellow leaf curl virus, tomato spotted wilt virus, and tomato brown rugose fruit virus (Adhikari et al., 2017). These pathogens not only reduce yield but also lower market and processing quality by affecting fruit size, color, firmness, and storage ability, while increasing the risk of postharvest decay.

Traditional disease management mainly relies on chemical pesticides and intensive plant protection inputs. However, this approach brings environmental and health risks, increases production costs, and accelerates the development of pathogen resistance to pesticides. At the same time, climate change, soil degradation, and the