

Sustainable Management of Environmental Challenges in Viticulture: The Role of *Bacillus* spp. in Crown Gall Biocontrol and Alleviating Abiotic Stresses

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Abstract

Grapevine cultivation, like other crops, is significantly influenced by environmental factors such as soil conditions and climate, which affect both yield and grape quality. In addition to these challenges, pathogens like *Allorhizobium vitis*, the causal agent of crown gall, severely reduce plant productivity and quality, resulting in substantial economic losses. While conventional plant protection methods remain the primary means of controlling this disease, their limitations and the scarcity of effective chemical products highlight the need for sustainable alternatives. Biological control offers an environmentally safe and cost-efficient approach to managing plant diseases, with *Bacillus* species being among the most promising biocontrol agents. Known for their antimicrobial properties and plant growth-promoting effects, *Bacillus* spp. employ several mechanisms, including the production of antibiotics, extracellular enzymes, siderophores, volatile compounds, nutrient competition, and induced systemic resistance (ISR). Moreover, under environmental stress conditions such as drought, salinity, and heavy metal accumulation, *Bacillus* spp. enhance plant stress tolerance by producing exopolysaccharides, siderophores, and key phytohormones like indole-3-acetic acid, gibberellic acid, and ACC deaminase. This study explores the biocontrol potential of *Bacillus* spp. against crown gall disease and its role in promoting physiological adaptations in plants to combat both abiotic and biotic stresses.

Keywords

Grapevine, Biotic Stress, Crown Gall Disease, Abiotic Stress, Biocontrol, *Bacillus* Spp