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# Deciphering Role of Endophytes in Plant Defences and Biotic Stress Resilience Across Families

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## ABSTRACT

Plant families generate distinct repertoires of specialised metabolites that govern their biotic interactions. Endophytes strengthen host plant defence mechanisms and tolerance to biotic challenges by upregulating metabolite biosynthesis, modifying precursor compounds into more potent forms, or by directly synthesising analogous defence metabolites themselves. This review examines the complex relationships between endophytes and their host plants, with a focus on their colonisation strategies, interactions, and contribution to plant immunity. It explores the diverse mechanisms through which endophytes augment plant defences, including the production of specialised metabolites, induction of systemic resistance, and direct antagonism against pathogens and herbivores. Accordingly, this study provides a comprehensive account of role of endophytes in protecting plants against multiple biotic stressors, rather than isolated threats. It further addresses a critical knowledge gap by highlighting how synergistic interactions between endophytic microbes and plant family-specific specialised metabolites shape plant immunity. By examining these unique plant-endophyte interactions across different plant families, the review offers deeper insight into the ecological and functional significance of endophytes in plant defence. Thus, it paves the way for targeted applications of endophytes in sustainable agriculture, where specific microbial strains can be harnessed to naturally improve plant protection and productivity.

## 1 | Introduction

In their natural habitat, plants are exposed to a wide array of environmental stressors that challenge their growth and survival. These stressors significantly hinder plant growth and productivity, limiting their ability to reach their full genetic potential. Biotic stressors, primarily pests such as herbivores, insects, nematodes and pathogens including bacteria, fungi and viruses, often pose significant threat to their growth and development. They are of particular concern not only because they cause direct tissue damage and resource reallocation from growth and reproduction towards defence, leading to reduced yield and quality, but also because their constant co-evolution and resistance development undermine plant defence strategies. The severity of biotic stresses is further aggravated by unfavourable climatic conditions, such as drought or excessive rainfall, which often promote pest outbreak and pathogen spread (Ofuya et al. 2023).

Upon insect attack, plant quickly perceive issue damage, along with herbivore-associated molecular patterns (HAMPs), including salivary elicitors. Recognition triggers membrane depolarisation, $Ca^{2+}$ influx, and activation of MAPK cascades, initiating immune signalling (Erb and Reymond 2019). These early signalsearly events promote jasmonate accumulation and JAZ degradation, enabling MYC2-dependent transcriptional activation of defence genes (Marqués-Gálvez et al. 2025). Jasmonate responses are further integrated with SA- and ET-mediated signalling through shared transcriptional regulators such as NPR1, ERFs and WRKYs, enabling differential