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EMERGING TRENDS IN BIOTECHNOLOGY

Emerging Trends in Biotechnology

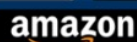


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Emerging Trends in Biotechnology

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Preface

Biotechnology stands at the forefront of scientific innovation, transforming the way we understand and interact with living systems. From advancements in genetic engineering and molecular diagnostics to breakthroughs in sustainable agriculture, environmental management, and personalized medicine, the field continues to evolve at an unprecedented pace. The present volume, *Emerging Trends in Biotechnology*, thoughtfully edited by Dr. Imran Hussain and Dr. Sujeet Pratap Singh, brings together diverse perspectives and cutting-edge developments that reflect the dynamic nature of this discipline.

This book offers a comprehensive overview of contemporary research areas, including synthetic biology, bioinformatics, nanobiotechnology, and translational research. It highlights not only the scientific progress achieved in recent years but also the practical applications that address global challenges such as food security, climate change, and human health. By integrating theoretical insights with real-world applications, this volume serves as a valuable resource for students, researchers, and professionals alike.

Dr. Imran Hussain has meticulously curated contributions that emphasize interdisciplinary approaches and innovation-driven research. The chapters presented in this book underscore the

importance of collaboration between academia, industry, and policy frameworks in advancing biotechnology for societal benefit. Moreover, the inclusion of emerging tools such as artificial intelligence and omics technologies reflects the future direction of the field.

I am confident that this book will inspire readers to explore new ideas, foster critical thinking, and contribute to the advancement of biotechnology. It is a timely and significant contribution that will undoubtedly serve as a reference for years to come. I congratulate Dr. Imran Hussain for his dedicated efforts in bringing together this important work and extend my best wishes for its success.

Editors:
Dr. Imran Hussain &
Dr. Sujeet Pratap Singh

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Chapter - 1

Jasmonic Acid-Mediated Defense in *Vicia faba*: Alleviating Fungicide-Induced Oxidative Stress

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Abstract

Plants are constantly subjected to various environmental stressors that significantly impede their growth and limit agricultural productivity. These stressors are classified as abiotic (such as extreme temperatures, drought, salinity, radiation, and heavy metals) and biotic (including fungi, bacteria, viruses, nematodes, and herbivores). To counter these challenges, plants have developed sophisticated defense mechanisms that involve sensing stress signals, activating signaling cascades, and initiating cellular responses. In agricultural settings, plants frequently face combined stress conditions, intensifying damage and reducing yields. Among the most damaging biotic agents are fungi and oomycetes, which are responsible for substantial global crop losses. The faba bean (*Vicia faba* L.), a widely cultivated legume, is highly susceptible to various fungal diseases such as rust, chocolate spot, ascochyta blight, leaf spots, and root rot complexes, often resulting in severe defoliation and yield decline. Disease management traditionally involves resistant crop varieties, improved cultural practices, and the extensive use of fungicides like mancozeb. While fungicides such as mancozeb effectively suppress pathogens, their overuse leads to oxidative stress due to the accumulation of reactive oxygen species (ROS), which disrupt cellular homeostasis. Plants mitigate oxidative damage through robust antioxidant systems

comprising enzymatic (SOD, CAT, POD) and non-enzymatic (ascorbate, glutathione, carotenoids) components. Plant growth regulators (PGRs), particularly jasmonic acid (JA), have emerged as critical tools in enhancing plant resilience by strengthening antioxidant defenses and regulating stress responses. JA modulates stress adaptation by interacting with other phytohormones and regulating key physiological processes, thereby offering a promising, eco-friendly strategy to reduce the adverse impacts of both environmental stress and chemical treatments.

Keywords: *Vicia faba*, Jasmonic Acid, Mancozeb, Phytohormones, Oxidative stress

1. Introduction

Plants are continually exposed to a diverse array of environmental stressors that significantly hamper their growth and limit agricultural productivity. These stressors are broadly classified into abiotic (non-living) and biotic (living) types. Abiotic stress, encompassing factors like extreme temperatures, drought, radiation, salinity, heavy metals, and flooding, poses a global threat to crop yield. On the other hand, biotic stressors arise from biological agents such as fungi, bacteria, viruses, nematodes, oomycetes, and herbivorous pests.

To withstand these challenges, plants have evolved intricate defense mechanisms that enable them to sense external stimuli, activate signaling pathways, and initiate targeted cellular responses. In real-world agricultural settings, plants often face combinations of stresses, such as drought with heat, or salinity alongside pathogen attacks, intensifying the damage (Suzuki et al., 2014).

Among biotic threats, fungal and oomycete pathogens are particularly destructive, causing widespread crop losses globally. These pathogens have co-evolved with their plant hosts,