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# Exploring the Mycobiota of Asia: Advancements in Fungal Taxonomy and Agricultural Applications

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**Abstract**
The varied environments of Asia provide a wealth of mostly unknown mycobiota that offer special chances for fungal taxonomy and agricultural use. Deeper understanding of fungal biodiversity and the discovery of new species follow from recent developments in molecular phylogenetics, morphological analysis, and high-throughput sequencing that greatly improve fungal categorization. Emphasizing their evolutionary links and biogeographical ranges, this paper investigates the taxonomic advancement achieved in finding new fungus species across several ecological niches in Asia. Acting both as beneficial and dangerous organisms, fungi are vital in agriculture. Although plant-pathogenic fungi seriously jeopardize crop output, beneficial fungus including mycorrhizal fungi and plant development-promoting fungi (PGPF) help to maintain soil health, plant resilience, and sustainable farming methods. Moreover, the possibility of bioactive substances obtained from fungus in industrial biotechnology, biofertilizers, and biopesticides is getting more and more importance. Omics technologies—including metagenomics and metabolomics—have helped us to better grasp fungal interactions within plant and soil microbiomes, therefore enabling creative disease management approaches. Notwithstanding these developments, fully exploiting the agricultural possibilities of fungus still presents difficulties. Large-scale field studies, better taxonomic models, and the use of artificial intelligence in fungal identification and illness prediction should be the main priorities of next studies. Great potential exists for fungal taxonomy to be advanced, sustainable agriculture to be improved, and environmentally friendly biotechnological solutions for world food security by ongoing research of Asia's mycrobiota.

**Keywords:** Mycobiota, Fungal Taxonomy, Molecular Tools, Plant Disease

## Introduction

The accurate classification and identification of fungi are foundational to understanding their ecological roles and potential applications. Traditional taxonomy, based on morphological characteristics, has been augmented by molecular phylogenetic methods, which provide higher resolution in distinguishing closely related species (Cai *et al*., 2021). This integrative approach has been pivotal in describing novel fungal species in South Korea. For instance, the discovery of several new species, including Neocucurbitaria chlamydospora from insect habitats, highlights the ecological and biotechnological potential of South Korean fungi (Hong *et al*., 2023). The country's diverse habitats, such as mountainous forests, coastal regions, and agricultural lands, provide ideal conditions for fungal exploration. Recent studies have demonstrated that these ecosystems harbor not only well-known fungal genera like Penicillium and Aspergillus but also rare and novel taxa, many of which remain underexplored (Lim *et al*., 2024). By documenting and classifying these fungi, researchers are contributing to global databases, enriching our understanding of fungal evolution and distribution. South Korea, with its diverse ecosystems and unique geographical features, serves as an ideal natural laboratory for studying fungal biodiversity. Fungi, as a kingdom, are among the most ecologically significant organisms, playing pivotal roles in nutrient cycling, symbiotic associations, and disease dynamics in both natural and agricultural systems (Hyde *et al*., 2020). Over the past few decades, advancements in fungal taxonomy and molecular biology have revolutionized the understanding of fungal diversity, particularly in regions like South Korea, which have a rich, yet understudied, fungal flora. The exploration of South Korea's mycobiota has unveiled an impressive array of fungal species, ranging from macrofungi, such as mushrooms, to microscopic ascomycetes. These discoveries are not merely taxonomic endeavors but also carry significant implications for agriculture, medicine, and industry (Adhikari *et al*., 2016, 2017, 2018, 2022; Das *et al*., 2023). Agricultural applications, in particular, stand to benefit greatly from understanding fungal diversity, as fungi play critical roles in plant growth promotion, soil health maintenance, and the biological control of pests and diseases. South Korea's agricultural sector is deeply intertwined with fungal research. Fungi are both allies and adversaries in agriculture. While some fungal pathogens cause devastating crop diseases, beneficial fungi contribute to sustainable farming practices. Mycorrhizal fungi, for example, enhance nutrient uptake and stress tolerance in crops, while certain fungal species produce bioactive compounds that can be harnessed as biofungicides (Kirk *et al*., 2021). The growing emphasis on sustainable agriculture has driven interest in fungal biocontrol agents and biofertilizers. Research in South Korea has identified several fungal strains with potential applications in managing soil-borne pathogens and improving soil fertility. For instance, strains of Trichoderma and Beauveria have been studied extensively for their roles in pest and disease management (Das *et al*., 2023). Additionally, fungal secondary metabolites have gained attention for their potential use as natural pesticides and plant growth regulators.

**Advancements in molecular tools for fungal studies**

The adoption of next-generation sequencing (NGS) and metagenomic approaches has significantly advanced fungal taxonomy in South Korea. These technologies allow for the identification of fungal communities at an unprecedented level of detail, enabling researchers to uncover the diversity and ecological roles of fungi in complex environments (Hyde *et al*., 2020). Such studies are instrumental in addressing global challenges, including food security and climate change, by leveraging fungal biodiversity for innovative solutions. For example, studies employing NGS have revealed the dynamic interactions between fungal communities and their hosts in agricultural ecosystems. These findings not only deepen our ecological understanding but also inform the development of targeted strategies for disease management and crop improvement. Despite significant progress, several challenges remain in exploring the mycobiota of South Korea. Many fungal species are cryptic, occurring in niches that are difficult to access or requiring specific conditions for growth and identification. Furthermore, the functional roles of many newly discovered species remain largely unknown. Addressing these challenges will require interdisciplinary collaboration and sustained investment in fungal research. Future efforts should focus on the integration of fungal taxonomy with applied sciences, particularly in agriculture and biotechnology. Understanding the molecular mechanisms underlying beneficial plant-fungal interactions, for instance, could pave the way for the development of novel biofertilizers and biopesticides. Additionally, fostering international collaborations could accelerate the discovery and utilization of South Korea's fungal resources on a global scale. In summary, the exploration of South Korea's mycobiota represents a confluence of taxonomic discovery and practical application. By documenting fungal diversity and leveraging these insights for agricultural innovation, researchers are contributing to sustainable solutions for pressing ecological and agricultural challenges.

The study draws on insights from various research articles to explore the interconnectedness of plant-microorganism interactions, data analytics, and sustainable practices for advancing agriculture and plant biotechnology. Das *et al*. (2025) delve into harnessing plant–microorganism interactions for nano-bioremediation of heavy metals, emphasizing cutting-edge mechanisms and advances. This research highlights how microorganisms work in synergy with plants to detoxify heavy metals, presenting eco-friendly solutions for soil health and crop productivity. By understanding the molecular and biochemical processes involved, this study paves the way for innovative strategies in environmental remediation and agricultural sustainability. The integration of nanotechnology into this paradigm represents a transformative approach to managing soil contamination. Bhuiyan *et al*. (2025) explore the transformation of plant breeding through data analytics and information technology. This study underscores how predictive modeling, machine learning algorithms, and big data analytics have revolutionized traditional breeding practices. By incorporating high-throughput phenotyping and genotyping tools, researchers have been able to accelerate genetic improvements, enhance crop resilience, and optimize productivity. The fusion of data science with plant biotechnology demonstrates the potential for creating climate-resilient crop varieties, addressing the challenges posed by global climate change. Hyde *et al*. (2024) provide an extensive outline of fungi and fungus-like taxa, offering a comprehensive taxonomy. This work is instrumental in addressing the knowledge gaps in fungal biodiversity, particularly in understanding their ecological roles and applications. With detailed classifications, this research supports advancements in fungal biotechnology, plant pathology, and bioremediation. Lim *et al*. (2024) describes the molecular identification of a new species of *Absidia* from Korean soil. This discovery enriches fungal taxonomy and provides insights into the ecological and industrial relevance of the Cunninghamellaceae family. By employing advanced molecular techniques, the study contributes to the growing understanding of fungal biodiversity and its potential applications in biotechnology. Bhuiyan *et al*. (2024) emphasize the use of predictive analytics to drive crop resilience and productivity. The paper highlights how machine learning and big data tools can predict crop responses to environmental stressors, optimize breeding programs, and manage pests and diseases effectively. This integration of technology with plant biotechnology is crucial for meeting the demands of a growing population. Hyde *et al*. (2023) present a global consortium for the classification of fungi, underscoring the collaborative effort in understanding fungal diversity. This research highlights the significance of global partnerships in addressing challenges in fungal taxonomy, biodiversity conservation, and biotechnological applications. Lee *et al*. (2023) examine the rapid apple decline phenomenon in Korea, identifying the factors contributing to this agricultural issue. The study investigates biotic and abiotic stressors, providing valuable insights for managing and mitigating the impacts of this phenomenon on apple production. Rani *et al*. (2023) discuss cutting-edge technologies for plant disease control, focusing on biotechnological advancements, precision agriculture, and sustainable practices. This research emphasizes integrating remote sensing, drone technology, and molecular tools to detect and manage plant diseases more effectively.

## Conclusion

These studies collectively underline the critical role of data analytics, advanced biotechnology, and collaborative research in addressing agricultural challenges. By integrating cutting-edge technologies and sustainable practices, the scientific community can foster innovations that enhance crop resilience, optimize productivity, and ensure environmental sustainability. Investigating mycobiota all throughout Asia has greatly enhanced our knowledge of fungal variety, classification, and their agricultural uses. The huge variety of fungus species found in the area's different habitats many of which are still unidentified or poorly known. Recent developments in molecular phylogenetics together with conventional morphological studies have made exact taxonomy possible, hence clarifying fungal evolution and biogeography. These investigations have not only added to our understanding of fungal taxonomy but also exposed novel species with interesting bioactive qualities. Both as dangerous and beneficial organisms, fungi are quite important in agriculture. Although plant-pathogenic fungus seriously jeopardizes crop output, beneficial fungus includes mycorrhizal species and plant growth-promoting fungi (PGPF) provide sustainable means of improving soil fertility, plant resilience, and disease resistance. Promoting ecologically friendly agriculture, advances in fungal biotechnology have underlined the potential of fungal secondary metabolites in biopesticides, biofertilizers, and industrial uses. Furthermore, the integration of omics technologies—such as metagenomics and metabolomics—has given more thorough understanding of fungal interactions inside plant and soil microbiomes, so opening the path for new approaches of disease management. Notwithstanding these developments, fully using fungal resources still presents difficulties. To fully realize Asia's microbiota, thorough field surveys, better culture-dependent and culture-independent techniques, and more worldwide cooperation are vital. Further investigation including machine learning and big data analytics in fungal taxonomy and agriculture could improve predictive modeling for disease outbreaks and maximize biotechnology uses. Ultimately, the continuous research on the mycobiota of Asia keeps changing the fungal taxonomy and its uses in agriculture. Development of creative, sustainable, and ecologically conscious solutions to worldwide agricultural problems depends on bridging basic taxonomic research with applied mycology.

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