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Research paper

Seasonal Dynamics of Phylloplane Mycoflora in *Vigna radiata* from Arjuni, Mor Taluka, Gondia District, Maharashtra, India

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ABSTRACT

The present study investigated the seasonal dynamics of phylloplane mycoflora associated with *Vigna radiata* (mung bean) cultivated in the Arjuni/Mor Taluka of Gondia District, Maharashtra, India, in 2022. Phylloplane fungal diversity was assessed across three distinct seasons, summer, monsoon, and winter. Thirteen fungal species were identified, with *Aspergillus flavus* (80%), *Aspergillus niger* (73.33%), and *Penicillium notatum* (73.33%) exhibiting the highest overall frequencies. Seasonal variation influenced both the frequency and relative abundance of fungal taxa. The monsoon season had the highest species richness (13 species) and diversity indices (Shannon-Wiener H' = 2.5142, Simpson's D = 0.9147), indicating peak fungal activity, likely due to favorable humidity and temperature conditions. In contrast, the summer exhibited the lowest species richness (10 species). The dominant fungal genera include *Aspergillus*, *Penicillium*, *Curvularia*, and *Fusarium*, each with varying levels of occurrence across seasons. This study underscores the dynamic nature of phylloplane fungal communities in response to seasonal environmental changes and provides a baseline for future ecological and pathological investigations of mung bean agroecosystems.

1. Introduction

The phylloplane, the aerial surface of plant leaves, serves as a unique microhabitat for a diverse community of microorganisms, including fungi (Ruinen, 1961). These phylloplane fungi play a crucial role in plant health by participating in nutrient cycling, influencing plant-microbe interactions, and sometimes acting as pathogens or antagonists. Understanding the composition and seasonal variability of these fungal communities is essential for effective crop management and disease forecasting, particularly in economically important crops, such as *Vigna radiata* (mung bean) (Lokhande *et al.,* 2024). *Vigna radiata* is a widely cultivated pulse crop in India, valued for its high protein content and nitrogen-fixing ability, making it integral to sustainable agriculture (Tresina *et al.,* 2014). In the Arjuni/Mor Taluka of Gondia District, Maharashtra, mung bean is an important crop that is grown under varying climatic conditions throughout the year.

Despite its agricultural significance, there is limited data on the fungal flora associated with its phylloplane in this specific region, especially with respect to seasonal fluctuations.

This study aims to bridge this gap by analyzing the seasonal dynamics of phylloplane mycoflora in *Vigna radiata* during the year 2022. Through systematic sampling across the summer, monsoon, and winter seasons, the study identified 13 fungal species, with notable genera including *Aspergillus*, *Penicillium*, *Curvularia*, and *Fusarium*. Seasonal diversity indices revealed that monsoon conditions favored higher species richness and fungal diversity, as evidenced by elevated Shannon-Wiener and Simpson's indices (Tresina *et al.,* 2014) (Aliyarukunju *et al.,* 2023). These findings suggest that environmental conditions, particularly moisture and temperature, significantly influence the structure and distribution of phylloplane fungal communities (Tsarelunga and Blagoveschenskaya, 2024) (Gomes *et al.,* 2018).

The phylloplane, or leaf surface, is a complex microhabitat colonized by diverse microbial populations, including bacteria, yeasts, and filamentous fungi (Garg *et al.,* 2019). Among these, fungi constitute a major component of the phylloplane biota and exhibit significant temporal and spatial variability (Dai *et al.,* 2022). The interaction of phylloplane fungi with the host plant can be symbiotic, saprophytic, or pathogenic, influencing plant physiology, disease resistance, and productivity (Goswami *et al.,* 2021) (Pandey *et al.,* 1993). Seasonal variation plays a crucial role in shaping the composition and abundance of the phylloplane mycoflora (Gulati *et al.* 2022) (Pennycook and Newhook 1981). Several studies have reported that environmental parameters, such as temperature, humidity, rainfall, and wind patterns, significantly affect fungal colonization and sporulation on leaf surfaces (Quintero *et al.,* 2010). For instance, higher humidity and moderate temperatures during the monsoon season tend to favor the growth and diversity of phylloplane fungi, whereas extreme temperatures in summer and winter may restrict their proliferation (Longa *et al*. 2024).

Numerous studies have explored the phylloplane mycoflora of various crop plants across different ecological regions. The study conducted by Raithak and Gachande (2011) presents a focused investigation into the phyllosphere mycoflora associated with both healthy and virus-infected tomato plants (Raithak and Gachande 2011). Chanda *et al*. (2022) observed a diverse range of phylloplane fungi colonizing the leaves of eight medicinal plants, notably *Catharanthus roseus*, *Houttuynia cordata*, and *Solanum lycopersicum*, with *Alternaria*, *Penicillium*, and *Aspergillus* species being dominant (Chanda *et al.,* 2022).

Ogwu and Osawaru (2014) investigated the fungal communities present on the leaf surfaces of okra, identifying ten fungal genera, such as *Rhodotorula* and *Aspergillus*, and emphasized the significance of exploring microbial diversity to better understand plant health and disease resistance (Ogwu and Osawaru 2014). Dominant fungi, such as *Cladosporium*, *Alternaria*, *Curvularia*, *Drechslera*, *Nigrospora*, *Sclerotium*, and various sterile forms, were observed on the phylloplane of *Triticum aestivum*, with *Cladosporium* levels peaking before summer (Uddin and Chakraverty 1996).

Phyllosphere microbial diversity, including bacteria and fungi, has been shown to play a vital role in plant health by promoting growth and resilience to stress in crops such as *Vigna radiata*, while simultaneously contending with the harsh leaf surface environment (Mir *et al.,* 2022). Bolarinwa and Ebabhi (2018) reported that the primary fungal species colonizing the phylloplane of *Vigna unguiculata* are *Fusarium oxysporum*, *Alternaria alternata*, *Colletotrichum truncatum*, and *Sclerotium rolfsii*, all of which pose threats to plant health by reducing yield, seed viability, and market value (Bolarinwa and Ebabhi 2018).

Aspergillus, *Fusarium*, and *Penicillium* were found to be the dominant fungal genera in cowpea samples, and their mycotoxin production poses serious risks to both human and animal health, as well as potential consequences for trade and economic systems (Afolabi *et al.,* 2020). Shamsi and Naher (2011) conducted a study on the phylloplane mycoflora of *Vigna sinensis L.*, revealing a diverse fungal community on leaf surfaces and offering valuable insights into plant-microbe relationships that may influence crop management and plant health strategies (Shamsi and Naher 2010). Some phylloplane fungi suppress plant pathogens by outcompeting them for resources, producing antibiotics, or parasitizing them directly, and have shown effectiveness against diseases such as fusarium wilt in bananas, with *Lasiodiplodia theobromae* notably active against *Fusarium oxysporum* (Shara, Basyuni, and Hasanuddin 2023). Zhang *et al.* (2024) emphasized that studying the microbial makeup of the leaf phyllosphere can guide ecological restoration efforts and promote sustainable use of vegetation in desert regions, thereby supporting plant vitality and environmental stability in dry ecosystems (Zhang *et al*. 2024). Understanding fungal communities on orchid leaves through localized, crop-specific studies is crucial for identifying harmful pathogens and implementing precise disease management practices, as these pathogens can lower both the quality and economic value of the crop (Rinchen 2023).

Despite these insights, gaps remain in the regional and crop-specific characterization of phylloplane fungal communities. The current study, therefore,

aims to bridge this gap by exploring the seasonal dynamics of phylloplane mycoflora associated with *Vigna radiata* in the agro-climatic context of Arjuni/Mor Taluka, Gondia District, Maharashtra.

2. Materials and Methods

2.1 Study Area

The study was conducted in the agricultural fields of Arjuni/Mor Taluka, located in Gondia District of Maharashtra, India. The region experiences a tropical climate, with three distinct seasons: summer (March-June), monsoon (July-October), and winter (November-February). The area is characterized by moderate to high rainfall during the monsoon, with average temperatures ranging from 12°C in winter to 42°C in summer. The soil in the region is predominantly black cotton soil, which is suitable for *Vigna radiata* cultivation.

2.2 Sample Collection

Leaf samples of healthy *Vigna radiata* plants were collected during the year 2022 in three different seasons summer, monsoon, and winter to assess seasonal variation in phylloplane fungi. *Vigna radiata* is typically cultivated during the winter and summer seasons, as it is not suited for monsoon cultivation; however, for the purpose of studying its phylloplane mycoflora, the crop was grown under controlled conditions using potted plants. For each season, ten randomly selected plants were sampled from multiple plots. Mature, healthy leaves were collected aseptically, placed in sterile polythene bags, and transported to the laboratory for immediate processing.

2.3 Isolation of Phylloplane Mycoflora

Fungal isolation was performed using both leaf impression and leaf washing techniques. In the leaf impression method, fresh leaves are lightly pressed onto Potato Dextrose Agar (PDA) plates to directly transfer surface fungi for growth and observation. For the leaf washing method, 5 g of leaf material was agitated in 50 mL sterile distilled water containing 0.1% Tween 20 for 20 min. The resulting wash solution was then serially diluted and portions of the dilutions were plated onto PDA to isolate and identify the fungal colonies. All plates were supplemented with chloramphenicol (50 µg/mL) to inhibit bacterial growth and were incubated at 28 ± 2^{0}C for 5-7 days.

2.4 Identification of Fungi

Fungal colonies were examined for morphological characteristics such as colony color, texture, and growth pattern. Pure cultures were obtained by sub-culturing and identified using standard taxonomic keys and manuals (Gautam and Avasthi 2019) (Watanabe 2018). Microscopic examination was conducted by lactophenol cotton blue staining.

2.5 Data Analysis

Fungal frequency and relative abundance were calculated for each species across all seasons. Diversity indices, including the Shannon-Wiener Index (H') and Simpson's index (D), were computed to assess species diversity and evenness using standard ecological formulas. Seasonal occurrences were categorized using a scale based on the observed frequency: +(Rare), ++ (Moderate), +++ (Frequent), ++++ (Very Frequent) and – (Absent).

Table 1 Seasonal occurrence of phylloplane fungi on *Vigna radiate*

Fungal Species	Summer	Monsoon	Winter	Overall Frequency (%)
Alternaria alternata	++	+++	+++	63.33 %
Aspergillus flavus	++	++++	+++	80.00 %
Aspergillus fumigatus	+	+++	++	70.00 %
Aspergillus niger	++	++++	++	73.33 %
Aspergillus terreus	+	+++	++	60.00 %
Aurobasidium pollulans	+	++	++	46.66 %
Cladosporium spp.	-	++	-	30.00 %
Curvularia clavata	+	+++	++	46.66 %
Curvularia lunata	+	+++	++	56.66 %
Dreschlera spp.	-	++	++	40.00 %
Fusarium spp.	+	+++	++	46.66 %
Penicillium notatum	++	+++	++	73.33 %
Penicillium spp.	-	++	+	33.33 %

+ (Rare); ++ (Moderate); +++ (Frequent); ++++ (Very frequent); - (Absent)

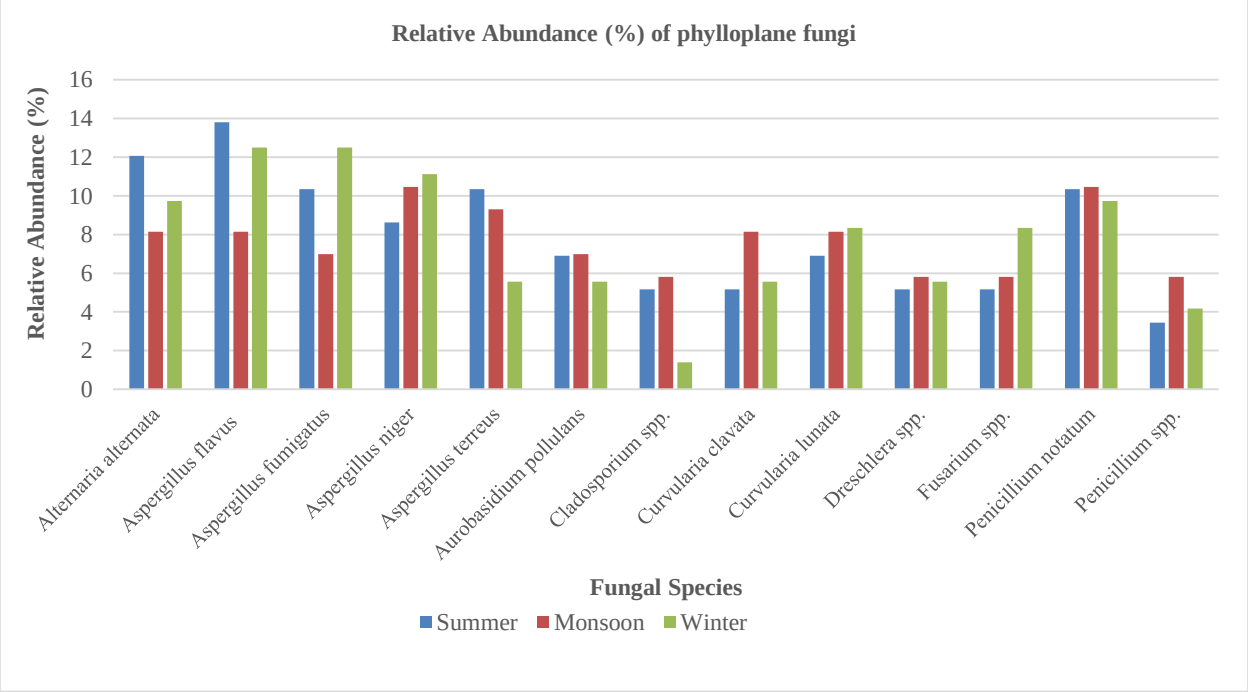

Fig.1 Relative abundance (%) of fungi in different seasons

Table 2 Diversity indices of phylloplane mycoflora per season

Season	Total Species Observed	Shannon-Wiener Index (H')	Simpson's Index (D)
Summer	10	2.4590	0.9062
Monsoon	13	2.5142	0.9147
Winter	12	2.5078	0.9142

3. Results and Discussion

Thirteen fungal species were isolated from the phylloplane of *Vigna radiata* over three seasons in 2022. Occurrence data revealed distinct seasonal trends (Table 1). *Aspergillus flavus* exhibited the highest overall frequency (80%), followed by *Aspergillus niger* and *Penicillium notatum* (each at 73.33%). These fungi were consistently present across all seasons, with a particularly high prevalence during the monsoon and winter. *Alternaria alternata*, *Aspergillus fumigatus*, *Curvularia lunata*, and *Fusarium spp.* were also frequently observed, particularly during the moist monsoon period. In contrast, *Cladosporium spp.* and *Dreschlera spp.* appeared sporadically, primarily during the monsoon and winter, and were completely absent in the summer.

Analysis of the relative abundance (Fig. 1) highlighted that *Aspergillus flavus* was most abundant during the summer (13.79%) and winter (12.5%), whereas *Aspergillus niger* peaked in the monsoon (10.46%) and winter (11.11%). The monsoon season supported the greatest diversity and evenness of fungal species, likely due to elevated humidity and moderate temperatures that favor fungal sporulation and growth. *Penicillium notatum* was highly abundant across all seasons, suggesting its strong adaptability to diverse environmental conditions. *Aurobasidium pullulans* and *Cladosporium spp.* showed relatively low abundance and appeared to be sensitive to high temperatures, as they were either rare or absent in the summer.

As shown in Table 2, the monsoon season recorded the highest fungal diversity (Shannon-Wiener Index H' = 2.5142; Simpson's Index D = 0.9147), followed closely by winter (H' = 2.5078; D = 0.9142). The summer season exhibited comparatively lower diversity (H' = 2.4590; D = 0.9062), likely due to environmental stresses such as high temperature and low humidity. These findings align with those of previous studies, indicating that monsoons provide optimal conditions for fungal colonization on leaf surfaces. The dominance of *Aspergillus* and *Penicillium* species across all seasons highlights their ecological resilience and potential impacts on crop health, including post-harvest spoilage and mycotoxin production. The seasonal appearance of *Curvularia* and *Fusarium* species suggests their potential role in foliar diseases, especially under favorable conditions. Monitoring these dynamics could aid in the early detection and management of fungal pathogens.

This study affirms that the phylloplane mycoflora of *Vigna radiata* in Gondia District exhibits strong seasonal dynamics influenced by climatic factors. Understanding these trends can inform region-specific and seasonally targeted fungal management strategies to safeguard mung bean production.

4. Conclusions

The present study provides a comprehensive analysis of the seasonal dynamics of phylloplane mycoflora associated with *Vigna radiata* cultivated in Arjuni/Mor Taluka, Gondia District, Maharashtra, during the year 2022. Thirteen fungal species were identified, with *Aspergillus flavus*, *Aspergillus niger*, and *Penicillium notatum* being the most frequently occurring taxa. Seasonal variation plays a significant role in shaping fungal diversity, with the monsoon season supporting the highest species richness and diversity indices, followed by winter and summer. These patterns can be attributed to favorable environmental conditions such as increased humidity and moderate temperatures during the monsoon.

These findings highlight the ecological complexity and seasonal responsiveness of phylloplane fungal communities on mung bean leaves. From an agricultural perspective, the persistent presence of potentially pathogenic or toxigenic fungi underscores the need for vigilant monitoring and targeted management, particularly during post-monsoon periods. This study not only fills a regional knowledge gap but also lays the foundation for future research on fungal-pathogen interactions, biological control strategies, and the impact of climate change on phylloplane microflora.

Future studies incorporating molecular identification techniques, multi-year datasets, and climatic modeling could offer deeper insights into the ecological roles and functional impacts of these fungal communities in pulse crop agroecosystems.

Declaration of Conflict

The authors declare that there are no conflicts of interest regarding publication of this paper.

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