MINI REVIEW

Dynamics of Phylloplane and Rhizoplane Mycoflora in Sustainable Crop Management of Green Gram and Black Gram

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Abstract

The phylloplane and rhizoplane mycoflora play crucial roles in the health and productivity of black gram (*Vigna mungo* (L.) Hepper) and green gram (*Vigna radiata* L.), two major legume crops grown extensively across the globe. The present comprehensive review examines the multifaceted interactions between these mycoflora and their host plants, focusing on their contributions to plant health. The review synthesizes current research findings on the diversity, composition, and ecological functions of phylloplane and rhizoplane mycoflora in green gram and black gram ecosystems. Furthermore, it elucidates how mycoflora communities enhance plant growth, disease suppression, nutrient uptake, and stress tolerance in their host plants. Moreover, the review discusses how agricultural practices, environmental factors, and microbial interactions affect mycoflora dynamics. This review underscores the importance of understanding the intricate relationships between phylloplane and rhizoplane mycoflora and their host plants for enhancing the health and resilience of green gram and black gram crops in agroecosystems.

Keywords: Phylloplane, Rhizoplane, Mycoflora, Sustainable management, Agroecosystems.

Highlights

- Phylloplane and rhizoplane mycoflora are vital for the health and productivity of black gram and green gram.
- This review explores the diverse interactions between mycoflora and host plants.
- It synthesizes research findings on the diversity, composition, and ecological functions of mycoflora in green-gram and black-gram ecosystems.
- The review shows how mycoflora communities enhance plant growth, disease suppression, nutrient uptake, and stress tolerance.
- It discusses how agricultural practices, environmental factors, and microbial interactions affect mycoflora dynamics.

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Introduction

The terms phylloplane and rhizoplane refer to specific niches within the plant microbiome. The phylloplane mycoflora refers specifically to the fungal communities that inhabit the above-ground parts of plants, like leaves, stems, and flowers. On the other hand, the rhizoplane mycoflora refers to the fungal communities that inhabit the root surfaces of plants. These mycoflora are crucial parts of the plant microbiome and play important roles in plant health and productivity (Kirichuk and Pivkin, 2015) (Andrews and Harris, 2000).

Green gram (*Vigna radiata* L.), is a member of family Leguminaceae. This short-duration grain legume typically matures within 65 to 90 days and is cultivated across over 6 million hectares globally, primarily in warm regions. Originating from the Indian subcontinent, where it was domesticated as early as 1500 BC, its cultivation spread to other regions through migration and trade routes. Presently, green gram is grown in various parts of the world, including the United States of America, Thailand, Indonesia, Malaysia, Pakistan, South Europe, China, Bangladesh and Africa. Notably, the Asian continent leads global production, with India accounting for over 50% and China for 19% of the total output (Muchomba *et al.*, 2023). The common green gram fungal diseases are: Cercospora leaf spot (*Cercospora canesens* Fresen.), anthracnose (*Colletotrichum* spp.), powdery mildew (*Erysiphe polygoni* DC), late blight (*Colletotrichum* spp.) (Gitonga and Githae, 2021)

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Rajasthan tops the list of green gram producers in India, with Karnataka, Maharashtra, Madhya Pradesh, Bihar, and Andhra Pradesh trailing behind (Table 1). Over the past two decades, the area cultivated in Madhya Pradesh and Rajasthan has increased, while it has declined in Karnataka, Maharashtra, Bihar, and Andhra Pradesh.

A highly esteemed legume crop of the Leguminosae family, black gram (*Vigna mungo* (L.) Hepper), is widely cultivated in the Indian subcontinent and commonly referred to as "Urad dal." Its cultivation extends to countries such as Bangladesh,

Table 1: Area, production, and yield of leading green gram producing states in India

States	*2000-01*		*2010-11*		*2015-16*		*2020-21*		*2021-22*		
	A	*P*	*A*	*P*	*A*	*P*	*A*	*P*	*A*	*P**	*Y*
Andhra Pradesh	±520	±184	±167	±52	±212	±137	±105	±82	±97	±83	±856
Bihar	±187	±108	±172	±104	±169	±94	±110	±73	±110	±73	±664
Madhya Pradesh	±90	±23	±99	±35	±295	±131	±157	±117	±164	±121	±741
Maharashtra	±714	±244	±558	±374	±366	±69	±394	±154	±378	±147	±390
Karnataka	±451	±185	±402	±111	±348	±44	±440	±162	±420	±155	±369
Rajasthan	±458	±79	±1050	±653	±1364	±597	±2090	±1170	±2147	±1202	±560
India	±3008	±1023	±3610	±1862	±3828	±1593	±4238	±3090	±40.38	±3150	±729

Source: www.indiastat.com and https://eands.da.gov.in/ (A)=Area -000'ha, (P)=Production -000'tonnes, (Y)=Yield kg/ha*provisional figures, (Andhra Pradesh-Final Advance Estimates, 2021-22)

Afghanistan, Myanmar, and Pakistan. Black gram grows best in temperatures of 27 to 30°C, with moderate rainfall, and in loamy soil that retains water well. As the third most significant pulse crop, it is grown under diverse conditions such as irrigated, rice fallow and rainfed areas, spanning the summer, rabi and kharif seasons. Its growth cycle spans 90 to 100 days, during which it contributes to soil nitrogen enrichment. India serves as both the primary producer and consumer of black gram (Swaminathan *et al.,* 2023). The common black gram fungal diseases are cercospora leaf spot (*Cercospora cassiicola*), powdery mildew (*Erysiphe polygoni* DC), late blight (*Colletotrichum* spp.), anthracnose (*Colletotrichum* spp.) (Madhuri and Sagar, 2020).

According to 1st advance estimates of production of food grains for 2022-23, all India Black gram production gradually increased from 17.7 to 35.6 lakh tonnes during the year 2011-12 to 2017-18 and again, there is a decline in the production from 35.6 to 28.4 lakh tonnes during the year 2017-18 to 2021-22 (Fig. 1).

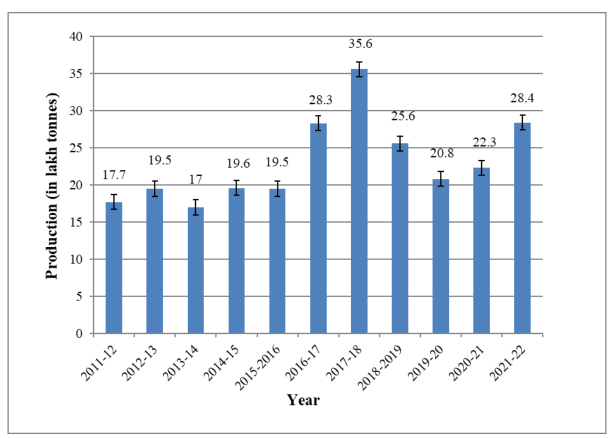
Black gram and green gram are cultivated worldwide for their high nutritional value, adaptability to various agro-climatic conditions, and multiple end-uses (Kakati *et al.,* 2010). Both crops are rich sources of minerals such as iron, magnesium, potassium protein, vitamins (particularly B vitamins), and dietary fiber. The mineral and protein profile of some Indian pulses is listed in Table 2 (Venkidasamy *et al.*, 2019). They are considered important components of vegetarian diets, especially in regions where meat consumption is limited (Sudhakaran and Bukkan, 2021). Black gram and green gram are versatile ingredients used in a wide range of culinary dishes, salads, soups, stews, desserts, and curries. They are also sprouted and consumed as nutritious snacks (Nasir and Sidhu, 2012). These legume crops exhibit adaptability to diverse agro-climatic conditions, including tropical, subtropical, and temperate regions. They can thrive in a variety of soil types, making them suitable for cultivation in different geographical regions (Singh *et al.,* 2018). Green gram and black gram contribute significantly to food security, particularly in regions where they are staple food crops. They are important for delivering essential nutrients and calories to millions of individuals, especially in developing nations, where they serve as a cost-effective protein source (Das *et al.*, 2016). Cultivation of green gram and black gram has economic significance for farmers, providing them with a source of income and livelihood. In addition to domestic consumption, these crops are also exported to international markets, contributing to agricultural trade (Khine *et al.,* 2021). Green gram and black gram are commonly used in crop rotation systems because they can fix atmospheric N2, thereby enhancing soil fertility, improving soil structure, and decreasing the necessity for synthetic fertilizers in future crops (Srinivasarao *et al,*. 2019).

Overall, green gram and black gram hold significant importance worldwide as staple food crops, sources of nutrition, and contributors to agricultural sustainability and economic development. Their versatility, nutritional value, and adaptability make them indispensable components of global food systems.

The interactions between phylloplane and rhizoplane mycoflora of these two crop plants are multifaceted and play vital roles in the health, development, and yield of these legume crops (Pathma *et al.,* 2020).

Nutrient Cycling

Phylloplane and rhizoplane mycoflora are involved in nutrient cycling within the plant-soil ecosystem. Fungi in these niches can decompose organic matter, releasing nutrients that are then available for uptake by the plants. This nutrient cycling enhances soil fertility and meets the nutritional requirements of crops (Manoharachary and Mukerji, 2006) (Goswami *et al.,* 2021a).



Source: Directorate of Economics and Statistics (DES)

Fig. 1: Black gram production in India (in lakh tonnes) (All the values are means of 3 replicates with ± S.E. bars)

Table 2: Protein and mineral composition of pulses (per 100 g of sample) (- denotes minerals is absent ± S.E.)

S. No	*Pulses*	*Mineral composition (mg)*										*Proteins (g)*
		Na	*Fe*	*Cu*	*Mn*	*K*	*Ca*	*Zn*	*Mg*	*P*	*Se*	
1.	Chickpeas	±11.5	±4.7	±0.6	±1.7	±477	±80.4	±2.5	±78.7	±276	±6.1	±50.4
2.	Soya bean	±0.29	–	±0.328	±1.4	±15.93	±2.62	±2.53	±2.80	±5.70	±3.8	±33.54
3.	Black gram	±79	±15.67	±2.031	±3.161	±2035	±286	±6.93	±553	±785	±17	±52.18
4.	Green Gram	±0.24	±5.41	–	±4.92	±1601	±495	±2.19	±415	±297	–	±22.91
5.	Pigeon peas	±8	±2.4	±0.161	±0.69	±698	±63	±1.25	±61	±181	±1.8	±9.12
6.	Pea	–	±9.7	±0.9	±0.1	–	±0.08	±0.04	±1.1	±0.39	±0.41	±21.2
7.	Peanuts	±26	±6.69	±1.67	±2.82	±1029	±134	±4.77	±245	±549	±10.5	±37.67

Symbiotic Relationships

Some fungi in the rhizoplane form symbiosis with the roots of green gram and black gram crops. For example, arbuscular mycorrhizal fungi (AMF) form symbiotic relationships with plant roots, aiding in nutrient absorption, especially phosphorus, in return for photosynthetically fixed carbon from the plant. These symbiotic interactions enhance nutrient acquisition and promote plant growth and development (Linderman, 1988).

Disease Suppression

Certain fungal species inhabiting the phylloplane and rhizoplane can act as biocontrol agents, suppressing the growth and activity of plant pathogens. These helpful fungi may produce antimicrobial compounds or outcompete with pathogens for space and resources, thus decreasing the incidence and severity of diseases in black gram and green gram crops (Blakeman and Fokkema, 1982).

Plant Growth Promotion

Phylloplane and rhizoplane mycoflora can promote the growth and development of green gram and black gram crops through various mechanisms. These include the production of substances that promote plant growth, such as cytokinins and auxins, enhancement of nutrient uptake efficiency, and modulation of plant hormone levels. Additionally, some fungi can improve soil structure, water retention, and aeration, creating favorable conditions for plant growth (Mwashasha *et al.,* 2017).

Stress Tolerance

Fungal communities in the phylloplane and rhizoplane may enhance the stress tolerance of black gram and green gram crops against environmental stressors such as drought, salinity, and heavy metal toxicity. These fungi can induce systemic resistance in plants, activate stress-responsive genes, and facilitate the accumulation of osmoprotectants, thereby mitigating the adverse effects of stress and improving crop resilience (Guo *et al.,* 2024a).

The interactions between phylloplane and rhizoplane mycoflora of green gram and black gram crops are dynamic and complex, contributing to the overall health, productivity, and sustainability of these important legume crops in agroecosystems. Understanding and harnessing these interactions can inform strategies for optimizing crop management practices and enhancing yield and quality in green gram and black gram cultivation.

Gogisetty *et al.,* (2023) identified several fungal species from phylloplane of Arhar (*Cajanus cajan* (L) Millsp.) such as *Alternaria* spp., *Aspergillus flavus*, *A. niger*, *Collectotrichum* spp., *Chaetomium* spp., *Fusarium solani*, *F. oxysporum*, *F. proliferatum*, *Penicillium* spp., *P. digitatum*, *P. expansum*, *Paecilomyces marquandii*, *Hypocrea* spp., *Neonectria* spp. Fungal species such as *Cladosporium* spp., *Mucor spp.*, *Trichoderma* spp., *F. solani, F. oxysporum*, *Curoularia* spp., *Penicillium* spp., *Pestalotiopsis* spp., *Fusarium* spp., *Pythium* and *Aspergillus* spp. were observed on rhizoplane of cowpea (Odunfa and Oso, 1979). Bolarinwa and Ebabhi, (2018) reported eleven phylloplane fungi in the cowpea (*Vigna unguiculata* (L.) Walp., namely *A. alternate, P. chrysogenum, A. niger, F. pallidoroseum, C. truncatum, F. oxysporium, Aspergillus* spp., *Curvularia lunata*, *Microphomina phaseolina, A. wentii, Rhizoctonia solani,* and *Sclerotium rolfsii*. *F. culmorum*, *F. solani, Alternaria* spp., *Penicillium* spp., and *Stachybotrys* spp. were identified from the rhizoplane of lentil (Abdel-Hafez *et al.*, 2012).

The dynamics of phylloplane and rhizoplane mycoflora are influenced by a combination of agricultural practices, environmental factors, and microbial interactions.

Agricultural Practices

Crop Rotation

Changing crops in a field can alter the microbial communities in the soil and on plant surfaces. Different crops host different microbial communities, and rotation can affect the abundance and diversity of phylloplane and rhizoplane mycoflora (Xiong *et al.,* 2021).

Tillage

Intensive tillage can disrupt soil structure and microbial habitats, potentially affecting the composition and abundance of mycoflora. Reduced tillage or no-till practices may preserve microbial communities better (Moussa *et al.,* 2023).

Use of Pesticides and Fertilizers

Chemical inputs like pesticides and fertilizers can directly impact mycoflora populations by selectively killing or promoting certain microbial species. They can also indirectly affect mycoflora by altering nutrient availability and soil pH (Chaudhary *et al.,* 2017).

Organic vs. Conventional Farming

Organic farming practices generally promote greater microbial diversity in soil and on plant surfaces due to the absence of synthetic chemicals. This can lead to differences in phylloplane and rhizoplane mycoflora dynamics between organic and conventional farming systems (Hartmann *et al.,* 2015).

Environmental Factors

Climate

Temperature, humidity, and precipitation influence the growth and activity of microbial communities. Different mycoflora species may thrive under different climatic conditions, leading to variations in their abundance and diversity.

Soil Type

Soil texture, pH and organic matter can shape microbial communities. Certain mycoflora species may prefer specific soil types, affecting their presence on plant surfaces (Mukerji and Subba Rao, 1982).

Water Availability

Moisture levels in soil and on plant surfaces affect microbial growth and survival. Wet conditions can promote fungal growth, while drought may suppress it.

UV Radiation

Exposure to ultraviolet (UV) radiation can affect the survival of surface microbes. Mycoflora may exhibit adaptations to UV exposure, influencing their distribution and abundance (Carvalho and Castillo, 2018).

Microbial Interactions

Competition

Different microbial species compete for resources such as nutrients and space on plant surfaces and in the rhizosphere. Competitive interactions can influence the composition and structure of mycoflora communities.

Symbiosis

Mycoflora can form symbiotic relationships with plants, providing benefits such as nutrient uptake or disease resistance. These symbiotic relationships can influence the function and composition of microbial communities (Pathak and Nallapeta, 2014).

Predation and Parasitism

Predatory and parasitic microbes can influence the dynamics of mycoflora populations by consuming or infecting other microorganisms. This can lead to shifts in community structure and diversity.

Conclusion

This study provides a comprehensive overview of the crucial roles played by phylloplane and rhizoplane mycoflora in the health and productivity of black gram (*Vigna mungo* (L.) Hepper) and green gram (*V. radiata* L.), two significant legume crops cultivated globally. This review synthesizes current research findings on the diversity, composition, and ecological functions of these mycoflora in the ecosystems of green gram and black gram. Additionally, it elucidates how these mycoflora communities contribute to plant health through mechanisms such as stress tolerance, disease suppression, nutrient uptake, and growth promotion.

This review article discusses the influence of agricultural practices, environmental factors, and microbial interactions on the dynamics of phylloplane and rhizoplane mycoflora. It also emphasizes the need for future research and sustainable agricultural management strategies to better understand and utilize the intricate relationships between these mycoflora and their host plants. The study highlights the importance of comprehending the complex interactions between phylloplane and rhizoplane mycoflora and their host plants to enhance the health and resilience of green gram and black gram crops in agroecosystems.

Conflict of Interest

None

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