



REVIEW ARTICLE

Belowground Biodiversity: AM Fungi Research Trends in Maharashtra

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ABSTRACT

Arbuscular mycorrhizal (AM) fungi are ubiquitous soil microorganisms that form symbiotic associations with most terrestrial plants, playing a crucial role in nutrient uptake, stress tolerance, and soil health. Maharashtra, with its diverse agroecological zones and soil types, provides a unique opportunity to study the diversity, distribution, and functional roles of AM fungi. This review synthesizes research on AM fungi in Maharashtra, focusing on their ecological significance, biotechnological applications, and future research directions. Surveys across the state have identified over 40 AM fungal species, with genera such as *Glomus*, *Acaulospora*, and *Gigaspora* being predominant. These fungi have been isolated from a wide range of crops and native tree species. Field inoculation studies demonstrate the efficacy of AM fungi in improving crop yield (10–40%), enhancing nutrient uptake, and mitigating biotic and abiotic stresses. Integration of AM fungi with other biofertilizers, such as *Rhizobium* and phosphate-solubilizing bacteria, has shown synergistic effects on crop productivity and soil fertility. Despite the promising results, AM fungi research in Maharashtra faces challenges, including methodological limitations, short-term studies, and geographical gaps. Future research should focus on molecular and metagenomic approaches, climate change interactions, indigenous knowledge integration, and policy support for widespread adoption. By harnessing the potential of AM fungi, Maharashtra can develop sustainable and resilient agroecosystems that address pressing agricultural and environmental challenges.

Keywords: Arbuscular mycorrhizal fungi, Soil biodiversity, Crop productivity, Nutrient uptake, Agroecological zones, Soil fertility, Sustainable agriculture

INTRODUCTION

Soil biodiversity forms the foundation of terrestrial ecosystem health and productivity, playing an essential role in nutrient cycling, plant development, and overall ecosystem resilience (Bardgett & van der Putten, 2014). Among the diverse soil biota, arbuscular mycorrhizal (AM) fungi are particularly significant due to their symbiotic associations with more than 80% of terrestrial plant species (Smith & Read, 2008). These fungi enhance the uptake of immobile nutrients such as phosphorus, zinc, and copper through the formation of specialized root structures and extensive extraradical hyphal networks that enlarge the effective surface area for nutrient absorption (Parniske, 2008). Furthermore, AM fungi play a critical role in improving soil aggregation through the secretion of glomalin, a glycoprotein that contributes to soil structure stability and water retention (Rillig, 2004).

In the context of global challenges such as land degradation, climate change, and biodiversity loss, AM fungi are increasingly recognized as pivotal agents in sustainable agriculture and ecological restoration due to their ability to enhance plant tolerance to abiotic stress, suppress soil-borne pathogens, and reduce dependence on synthetic fertilizers (Bender et al., 2016). Maharashtra, with its wide range of agroecological zones—from the high-rainfall Western Ghats to the drought-prone regions of Marathwada—provides a unique natural laboratory for studying AM fungal diversity and function. These ecologically varied landscapes host a mosaic of soil types, vegetative cover, and agricultural practices, all of which influence the composition and distribution of AM fungal communities (Deshmukh et al., 2012).

Although Maharashtra is a leading agricultural state in India, it faces persistent issues such as soil nutrient depletion, salinity, and erratic rainfall patterns. Integrating AM fungi into cropping systems offers a viable strategy to improve soil fertility and boost crop resilience, especially in resource-limited and rainfed areas (Kumar et al., 2020). In this context, the present review aims to (i) provide a comprehensive overview of AM fungi research conducted in Maharashtra, (ii) document the diversity and ecological distribution of these fungi across various agroecological zones, (iii) analyze their functional roles in improving soil health and enhancing crop productivity, and (iv) identify critical research gaps and suggest future directions for both scientific research and agricultural policy.

AN OVERVIEW OF ARBUSCULAR MYCORRHIZAL (AM) FUNGI

AM fungi belong to the phylum *Glomeromycota*, encompassing genera such as *Glomus*, *Acaulospora*, *Gigaspora*, and *Scutellospora*. These obligate symbionts form arbuscules, vesicles, and hyphae, each serving distinct roles in nutrient exchange, storage, and soil exploration (Smith & Read, 2008). Their life cycle is intimately tied to that of the host plant, making them ecologically specialized and evolutionarily stable partners.

Ecological Roles

AM fungi perform essential ecological functions, including:

- **Nutrient mobilization:** Enhance uptake of phosphorus and micronutrients (Smith et al., 2011).
- **Stress mitigation:** Improve plant tolerance to drought, salinity, and heavy metals (Miransari, 2010).
- **Disease resistance:** Induce systemic resistance against root pathogens like *Fusarium* spp. and *Rhizoctonia* spp. (Pozo & Azcón-Aguilar, 2007).
- **Soil structure:** Promote soil aggregation through glomalin production (Rillig, 2004).
- **Plant succession:** Facilitate establishment and coexistence of diverse plant communities (van der Heijden et al., 1998).

Global Distribution and Relevance

AM fungi are present in nearly all terrestrial biomes, from tropical forests and savannas to deserts and tundras. Their global ubiquity and integral ecological functions make them valuable indicators of ecosystem health and sustainability (Öpik et al., 2010).

AGROECOLOGICAL ZONES AND SOIL TYPES IN MAHARASHTRA

Maharashtra consists of five major agroecological regions:

- **Western Ghats:** High rainfall, lateritic soils, evergreen vegetation
- **Konkan Coast:** Humid tropics, red loamy soils
- **Deccan Plateau:** Semi-arid, deep black cotton soils (Vertisols)
- **Vidarbha:** Dry sub-humid, mixed red and black soils
- **Marathwada:** Drought-prone, variable soils, low rainfall

This diversity influences AM fungal community composition, richness, and functionality.

Soil Characteristics

Soil pH, organic matter content, and texture are significant determinants of AM fungal diversity. Acidic soils in the Western Ghats foster distinct AM assemblages compared to alkaline Vertisols in Vidarbha (Jite et al., 2011). High organic matter supports greater spore density and species richness.

DIVERSITY AND DISTRIBUTION OF AM FUNGI IN MAHARASHTRA

Institutions such as Mahatma Phule Krishi Vidyapeeth (MPKV), Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), and Forest Research Institute (FRI) have led studies on AM fungal distribution, especially in agroforestry, organic farming, and degraded land reclamation (Deshmukh et al., 2012; Kumbhar et al., 2018).

Reported AM Fungal Species

Over 40 AM fungal species have been identified across Maharashtra's ecosystems (Table No.1), including:

1. *Glomus fasciculatum*
2. *Glomus mosseae*
3. *Acaulospora laevis*
4. *Gigaspora margarita*

These have been isolated from rhizospheres of crops like turmeric, soybean, chickpea, and native trees like *Tectona grandis* and *Shorea robusta* (Patil et al., 2015).

Table No.1 Some Reported AM Fungal Species in Maharashtra

Sr. No.	Genus and Species	Location in Maharashtra	Reference
1	<i>Glomus mosseae</i>	Pune district	Patil et al., 2018
2	<i>Acaulospora scrobiculata</i>	Nashik region	Kulkarni & Deshmukh, 2017
3	<i>Rhizophagus intraradices</i>	Aurangabad	Singh et al., 2019
4	<i>Funneliformis geosporum</i>	Satara	More & Pawar, 2020
5	<i>Gigaspora margarita</i>	Ahmednagar	Shinde et al., 2016
6	<i>Acaulospora scrobiculata</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
7	<i>Diversispora epigaea</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
8	<i>Gigaspora gigantea</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018

9	<i>Glomus gerdemannii</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
10	<i>Glomus versiforme</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
11	<i>Glomus warcuppi</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
12	<i>Scutellospora calospora</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
13	<i>Scutellospora dipurpusescrns</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
14	<i>Gigaspora albida</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
15	<i>Sclerocystis sinuosa</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
16	<i>Glomus hoi</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
17	<i>Glomus occultum</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
18	<i>Scutellospora auriglobosa</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
19	<i>Glomus aggregatum</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
20	<i>Glomus boreale</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
21	<i>Glomus heterosporum</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
22	<i>Glomus segmentatum</i>	Sindhudurg & Ratnagiri	Kamble et al., 2018
23	<i>Glomus tortuosum</i>	Amravati	Naqvi, 2019
24	<i>Acaulospora laevis</i>	Amravati	Naqvi, 2019
25	<i>Acaulospora bireticulata</i>	Amravati	Naqvi, 2019
26	<i>Scutellospora dipapillosa</i>	Amravati	Naqvi, 2019
27	<i>Glomus macrocarpum</i>	Amravati	Naqvi, 2019
28	<i>Glomus fasciculatum</i>	Osmanabad (Marathwada)	Gaikwad, et al., 2013
29	<i>Gigaspora gigantea</i>	Osmanabad	Sarwade, et al., 2010
30	<i>Acaulospora denticulata</i>	Osmanabad	Sarwade, et al., 2011
31	<i>Scutellospora pellucida</i>	Osmanabad	Sarwade, et al., 2011
32	<i>Glomus intraradices</i>	Osmanabad	Sarwade, et al., 2012
33	<i>Claroideoglomus claroideum</i>	Latur district	Sarwade, et al., 2012
34	<i>Glomus etunicatum</i>	Jalna	Sarwade, et al., 2012
35	<i>Acaulospora longula</i>	Beed	Sarwade, et al., 2024
36	<i>Funneliformis mosseae</i>	Parbhani	Bhale, et al., 2011

FUNCTIONAL ROLES OF AM FUNGI IN MAHARASHTRA

Soil Health and Fertility

AM fungi improve soil fertility by enhancing phosphorus availability, promoting microbial interactions, and increasing root biomass. In Vertisol-dominated Deccan

Plateau soils, they improve soil aggregation and reduce erosion (Kumbhar et al., 2018).

Crop Yield and Productivity

Field inoculation trials show increased yields (10–40%) under AM fungal treatment, especially in phosphorus-deficient soils. **Example:** In Rahuri, *Glomus mosseae* inoculation increased turmeric rhizome yield by 28% (Kumbhar et al., 2018).

Drought and Stress Tolerance

In water-scarce zones like Marathwada, AM fungi enhance drought resistance via improved root hydraulics and osmotic adjustment. **Example:** *Gigaspora margarita* improved chickpea yield under drought conditions in Jalna (Deshmukh et al., 2012).

Biocontrol and Disease Resistance

AM fungi mitigate diseases such as Fusarium wilt by enhancing plant immune responses and competitive exclusion of pathogens. **Example:** In Nagpur, tomato plants colonized by AM fungi exhibited reduced *Fusarium* incidence and increased yield (Patil et al., 2015).

APPLICATIONS AND BIOTECHNOLOGICAL ADVANCES

Inoculation Studies and Field Trials

Several trials demonstrate the efficacy of AM fungi in reducing fertilizer dependence and increasing yield. **Example:** At PDKV, Akola, AM fungi with *Azotobacter* improved soybean yield by 22% and reduced NPK input by 25% (Kumbhar et al., 2018).

Commercial Biofertilizers

Maharashtra-based firms like Krushitek and Green Vision produce AM-based inoculants for horticultural and field crops. These are widely used in organic and integrated farming systems.

Integration with Biofertilizers

AM fungi are synergistically used with *Rhizobium*, *Azotobacter*, and phosphate-solubilizing bacteria (PSB). **Example:** In Nashik vineyards, co-inoculation of AM fungi and PSB improved grape yield and soil phosphorus availability (Patil et al., 2015).

CHALLENGES IN AM FUNGI RESEARCH IN MAHARASHTRA

- **Methodological limitations:** Reliance on spore morphology hampers accurate identification; DNA-based methods are underused.
- **Short-term studies:** Longitudinal ecological monitoring is lacking.
- **Geographical gaps:** Remote, tribal, and highland areas remain understudied.

FUTURE RESEARCH DIRECTIONS

Molecular and Metagenomic Approaches- Next-generation sequencing (NGS) and metagenomics can uncover cryptic diversity and functional genes (Öpik et al., 2010).

Climate Change Interaction- Studies are needed on AM fungi's response to changing temperature and precipitation patterns to develop resilient agroecosystems.

Indigenous Knowledge Integration- Traditional practices like intercropping and organic manuring should be integrated with modern mycorrhizal management.

Policy and Extension- State-supported AM fungi promotion through subsidies, training, and farmer networks will ensure widespread adoption.

CONCLUSION

AM fungi play a foundational role in Maharashtra's ecosystems, offering scalable, eco-friendly solutions to pressing agricultural and environmental challenges. Future research must adopt an interdisciplinary and participatory approach, combining molecular ecology, agronomy, and rural development to maximize the benefits of these vital symbionts.

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